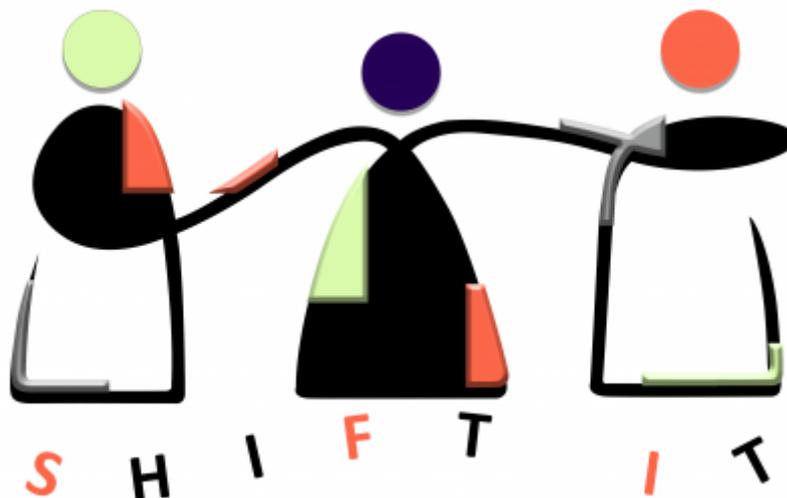


Report

Our city experiences



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Acknowledgement

Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
PUR	Polyurethane
PTFE	Polytetrafluoroethylene
UHMWPE	Ultra-high-molecular-weight polyethylene
PP	Polypropylene
PE	Polyethylene
PS	Polystyrene
PHA	Polyhydroxyalkanoates

Abbreviation	Description
PVC	Polyvinyl chloride
HDPE	High-density polyethylene
ADA	Accessible Design
PDM	Propylene diene monomer rubber
LED	Light-emitting diode
LCD	Liquid Crystal Display

1. Introduction

1.1 Presentation

The European Project Semester (EPS) offers students with engineering and other backgrounds a chance to work together on a project at a partner university of their schools. The EPS project provides a unique opportunity for students of different nationalities and study backgrounds to work together and combine their skills and knowledge to produce a unique and realistic result/solution to a relevant challenge. The project provides an environment similar to what it would be in the real work field when having to collaborate with different people, and offers the chance to learn from each other. The project is completed under scientific supervision for the duration of one semester. This project outcome was created at the “Instituto Superior de Engenharia do Porto” also called “ISEP” by the following team of students, table 1.

Table 1: Team Members and backgrounds.

Group member	Origin	Background
Felix Ljungkvist	Finland	Industrial-engineering & Management
Sander Spaas	Belgium	Electronics-ICT
Lahore Hauspie	South Africa	Product Development
Alicja Faber	Poland	Industrial Biotechnology
Ângelo Torres	Portugal	Mechanical Engineering
Elena Boucher	France	Packaging Engineering

1.2 Motivation

Motivation for EPS

The participation of this team in the European Project Semester program was motivated by the curiosity of working in an international environment, as well as working with people from different fields of study. The goal of coming to Porto was to expand the team's knowledge inside and outside their respective fields of study by learning from each other, develop creative and independent thinking, improve language skills and gain soft skills such as communication and project management. There was a common curiosity to work in a multidisciplinary team on one project to create something realistic for a relevant challenge. After this semester, it is a common expectation to

return home with new experiences, developed skills and good friends made in Porto.

Motivation for choosing the "Our city experiences" proposal

After a lot of thought, many discussions, and a final vote, the team finally chose the topic "Our city experiences". It was difficult to choose because the will was to choose something the whole team was interested in and in which everyone felt they could contribute to with their respective study fields. This topic was chosen because it was considered to be very broad with a lot of freedom in choosing what exactly the focus point of the project would be. Everyone can identify with problems that arise in a city and there are many interesting opportunities that can be worked on to enhance and improve how people experience a city.

The next challenge was of course selecting what exactly the focus point would be within this broad topic. First a list was made of relevant problems or challenges that were identified in familiar cities at home as well as in the city of Porto. A few suggestions and ideas are listed below:

- Garbage/trash pollution
- CO₂ pollution
- Unused spaces
- Creating green pockets
- Safe playgrounds in urban spaces for children
- Smart benches/bicycle racks
- Traffic congestion
- Finding your way and visiting the best spots recommended by locals
- A safe" haven to escape noise and crowds
- Raising awareness on energy preservation and creating a way to generate energy
- Stimulate social interaction between people (embrace the sharing economy and encourage contact/connection)
- Smartify bus stops
- Water quality communication and more efficient drinking points
- Stimulating social interaction in public places

Further research was done on two of the mentioned topics in order to come to a final decision. Water quality communication and water drinking points, as well as Stimulating social interaction in public spaces. We decided to put our main focus on those two topics after discussion on each team member personal preference. This research can be consulted further in the report in the "State of the Art" chapter.

The final decision was based on the results and conclusions obtained from the State of the Art, as well as a personal motivation described below.

Stimulating social interaction and fun in public spaces

It was agreed upon to base our project around the stimulation of social interaction and fun in public spaces. This was considered to be a very relevant challenge in the current society, where everyone is focused on their digital technologies and gadgets instead of the world around them. People are together in a public space but hardly say hello or appreciate the place in the city where they are sitting or walking. With this project, the aim is to encourage people to interact with each other and have some fun in public spaces in the city. In this way the goal is to provide positive experiences for

people, during which they appreciate their environment and the people surrounding them. The aim is to encourage contact, interaction and fun. The thought was that a lot of fun can be obtained by creating something unique that could bring smiles to peoples' faces.

1.3 Problem

People in the city are becoming increasingly more disconnected from one another, isolating themselves in their own digital world away from social contact. It is difficult to interact with people or get them away from their screens, even when they are in public spaces within the city that are meant to be enjoyed. Older generations are finding it harder to connect with younger people each day as technology continues to advance. For these reasons it was decided to create an interactive, gamified experience that can bring people from all age groups closer together. By taking older classic games and slightly modernizing them, the project is hoping to appeal to a wide array of people and provide positive and fun experiences for all participants.

The final problem that the project wants to address is the **lack of social interaction and participation in public urban areas**. The manner in which people can be stimulated to socially interact with each other and their environment in a fun and unique way is to be explored and investigated and the solution must be as universal as possible.

1.4 Objectives

The main objective of this project is to create the conditions to be able to encourage people who are in public areas to interact with each other and the environment in which they find themselves. It must provide a fun, positive and unique experience to those in contact with it in order to motivate participation in interacting with others. The concept must be applicable to all ages, and hopefully motivate interactions between the young and old in order to decrease the generation gap. The concept must consider disabilities as much as possible.

- Encourage/stimulate interaction between people and their environment
- Highlight key features/public areas that make this city worth visiting (tourist attractions)
- To attract visitors
- Spark curiosity and interest
- Create unique experiences
- making the city more recognizable and identifiable in the collective memory
- Making public space fun
- Create more interactions between people (different generations and behaviours: Introverted or extroverted persons)
- Public space must be stimulating, it must encourage exploration, imagination and sociability

1.5 Requirements

The device must have an intuitive design so it can attract people of all ages and to be easier to control for everyone. During the game the person must have the chance of controlling the height of the top part of the device, with the help of an actuator this will turn out very easy to maneuver and

with this, people with different heights can have their own adjustable height to play the game. After the game, the client/player will have the opportunity to share the result of the game with him or others and will have access to their final score and comparison with other players that played before, with this the game will turn out more social and competitive.

1.6 Functional Tests

To verify the functionality of our project we will have tests for these different parts:

- **Photoresistors** - The readings of the sensors will be tested in the Arduino code to ensure that they are correct and accurate.
- **Camera** - A test picture will be taken that will then be verified by the operator.
- **Display** - The functionality of the display will be verified by a couple of test images to check that the colors are being displayed correctly.
- **Detection of puzzle pieces movement** - The correct detection of puzzle pieces movement will be verified by a set of calibration instructions.
- **Actuator** - The tests are still to be done because it involves insertion on the prototype.
- **Sliding Pieces** - The sliding pieces for the prototype were easily tested using a group member to apply a sliding force to the piece and the result were as expected, the piece slid with no problem at all, although the sliding piece is made out of cardboard and the sides are relatively irregular, the fact that tape was applied on the side made it a lot more regular and easy to maneuver.

1.7 Project Planning

The planning for this project was done according to the SCRUM methodology as seen during the weekly classes of Project Management. Further details ;can be consulted in chapter 3 of "Project Management". More specifically the project plan and sprint planning start from point 3.10.

1.8 Report Structure

All the work done concerning this project is placed in the report. There are several sections in the report relating to different fields of research and development for the various aspects of the team's specific project. The structure of the report containing these different aspects is explained in Table 2.

Table 2: Overview of the report structure

Task	Description	
1:	Introduction	Provides background information about the group members and their motivation for participating in EPS, as well as detailed explanations concerning different aspects of the chosen problem and project concept. Includes the following: presentation, motivation, problem, objectives, requirements, functional tests, project planning and report structure.
2:	State of the Art	Includes all the research that has been done about the chosen problem. Solutions that exist already, similar concepts, background information, different factors, thoughts, feelings, behaviours and people that need to be considered, and inspiration sources.
3:	Project management	Includes the applied methods used by the team for this project as introduced in the module: Project Management.
4:	Marketing plan	Insight into the applied marketing strategy, including the identification of target groups, stakeholders, a business plan and marketing opportunities.
5:	Eco-efficiency measures for sustainability	Measures taken to ensure that the project concept is made to be as environmentally friendly as possible in order to contribute to building and maintaining a sustainable, eco-friendly environment.
6:	Ethical and Deontological concerns	Analysis of the existing Code of Ethics and the specific benefits and concerns regarding the project.
7:	Project Development	An overview of the whole process of the project from beginning until the completion of the prototype and carrying out of the test procedures.
8:	Conclusions	Discussion of the final project outcome and results, including possible improvements and suggestions for further research.
9:	Bibliography	A list of all the references from the sources consulted throughout the project.

2. State of the Art

The chosen topic, “Our city experiences”, is a very broad theme under which many possible directions fall. This was one of the reasons it was chosen. The thought was that it would provide an opportunity to work on something that can to a certain extent incorporate all the respective fields of expertise of the team. To choose on which challenge under this theme the focus would be, was challenging, as there are several potential options.

These options were narrowed down to sub-topics. One being “Communication of water quality and providing a more efficient way of drinking from water fountains and filling water bottles”, the other being, “Stimulating social interaction in public spaces”. In order to come to a decision, research was done into both topics. This includes information gathered from articles as well as looking into what exists already in city societies. This research is not based on a specific city yet, but is more general to obtain a broader perspective of what each topic entails. Once a direction is chosen, more detailed research will be done. The results of this research can be seen below.

After the research for each topic, a decision will be made as to which topic our group will proceed with, followed by more research and methods of gathering information for the chosen topic.

2.1 Communication of water quality and water fountains in the city

The aim of this topic would be to create a communication channel that lets people know whether and where tap water is drinkable in a city within a country. The idea came from the fact that often, when people travel to a new place, they do not know if the water in their new location is safe to drink. This leads to them buying bottled water just to be on the safe side, even if it might not be necessary. Of course, not only non-local people struggle with the issue, but also local people often are not aware of the water quality in their city. Implementing a communication strategy that provides up-to-date information about the water quality and drinking status of a country's tap water to people who are going there, will not only provide them with more certainty of their health and well-being, but also reduce the amount of waste from disposable bottles.

The next part of this challenge, has to do with the fact that one often has no idea where the nearest water point is in a city and usually comes upon it by chance. This leads to people not being able to find one when they need it, or not knowing if there are enough sufficient water points throughout the city where they can drink or re-fill their bottle. This can make some people unnecessarily buy bottled water along the way. A solution to this could be providing a type of map that indicates all the water points in the city-either physically or digitally, or providing a signal/sign system in the city.

Research has been done in the manner of conveying this information in the present day to people in or visiting Portugal.

An explanation of this method follows:

There are online platforms that exist, with interactive maps where consumers can easily find drinking water points. France and Portugal were focused on. There is however not a lot of information about these two countries: it is possible to locate the places but it is not possible to know if the water is drinkable, or whether one can fill their bottle with water or if one can give their pets a drink.

On the following website [[EauPotable.info, 2023](#)][[Marie Veyrenc, 2020](#)], people can locate the points where they can drink water from drinking fountains, and it is also possible for people to add water points that they have come across during their trips through the city, that are not presented on the provided list.

It is noticeable that there are many different types of water fountains within one city, and that they are very often not easy to drink from.

Impracticalities of present water points:

- One has to bend down-craning their neck (ergonomically not efficient)
- One often gets wet in the process - from water spattering everywhere
- Many fountains require one to press somewhere, bend down and drink at the same time which is not always easy to coordinate properly
- Often there is water that goes to waste, spilling down while someone is trying to drink
- Fountains with a push button that releases a certain amount of water at a time waste a lot of water because the person may not need the water to flow for that amount of time
- One has to hold their water bottle at difficult angles in order to fill it and, even then, water is wasted
- Many fountains do not keep in mind disabilities or children or even pets
- People sometimes feel embarrassed to drink because the water drips along their face
- Hygiene of the push button/water mechanism can be an obstacle for people

Different ideas about what our team could create arose, and for a long time the theme of drinking fountains around the city and how they could be improved was discussed. One idea then came up to create a water bottle that made it easier to fill at a drinking fountain. The water bottle would have a special cap/lid that would connect to the drinking fountain in order to transfer the water directly from the fountain to the water bottle without spillage. This adapter would ideally be compatible with as many different forms of water fountains as possible. Research was done to see what had already been done concerning this issue and because water bottles are such a common thing there are many versions that exist already. While reading some articles and browsing the internet, concepts of bottles were found to solve problems similar to what our team wants to approach. Innovation is key to creating something better than what is already on the market.

The team also did field research in Porto itself by walking around the city and hiking trails near it, to see what type of water drinking points are already implemented in and outside the city. There are already many versions, each having its advantages and disadvantages to design and concept, figure 1).

		
<p>Cons: - Not clean - People cannot fill their water bottles - People can get wet - No water information</p>	<p>Pro: - Can fill water bottle or drink without bottle</p> <p>Con: - People who want to use the fountain are forced to turn the tap (lack of hygiene?)</p>	<p>Cons: - Not clean - People cannot fill their water bottles - People can get wet - No water information</p>
		
<p>Pro: - Can fill water bottle or drink without bottle</p> <p>Con: - People who want to use the fountain are forced to turn the tap (lack of hygiene?)</p>	<p>Pro: - There are information on the fountain about water (the origin of the water, the possibility for people to fill their water bottle and the possibility to give water to dogs thanks to the bowl)</p> <p>Con: - Complicated to drink water without a bottle</p>	<p>Cons: - Not clean - People cannot fill their water bottles - People can get wet - No water information</p>

Figure 1: Existing water points in Porto

In order to see what alternative examples of water points already exist and to get inspired by innovative ideas, the internet was browsed and a Pinterest board made. This is not only to stimulate idea generation, but also so that the team knows what is already being developed and does not come to the market with something similar to what exists already, figure 2)

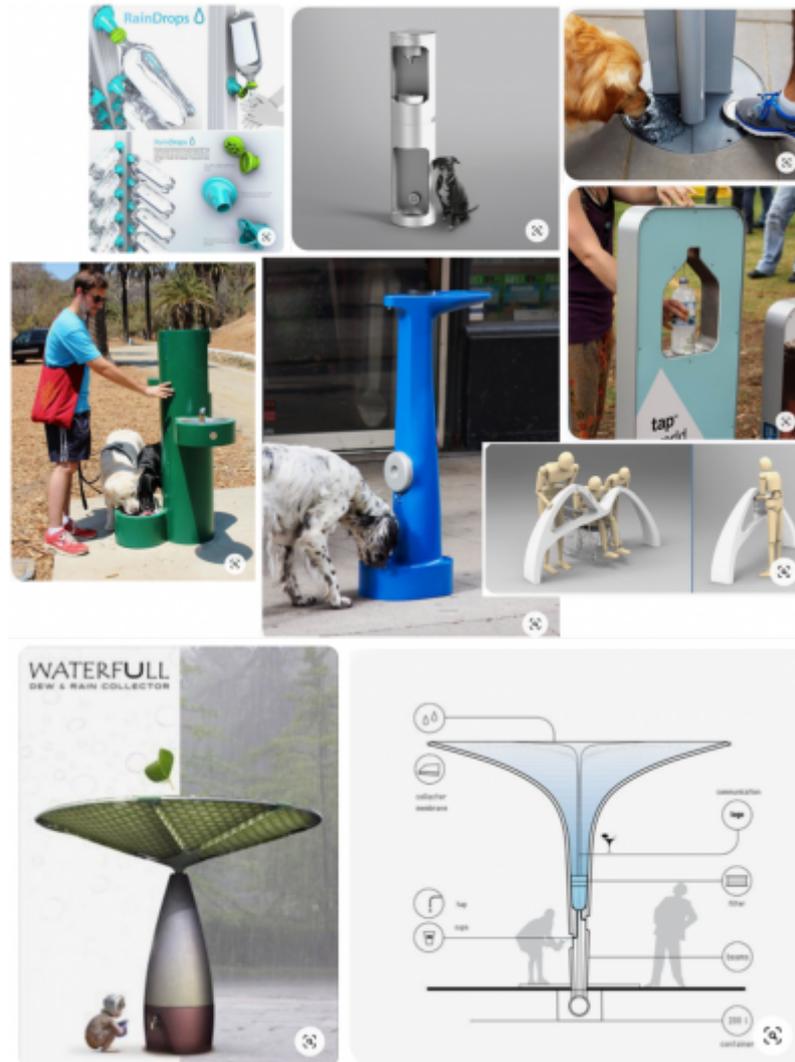


Figure 2: Alternative water point designs, [Lahore Hauspie, 2023].

If this would become the chosen topic, the goal would be to create a communication channel about water quality, as well as design a more efficient and ergonomic water point that wastes less water, allows one to fill their bottle easily, and enables all people, no matter age or disability, to drink easily from the water source.

2.2 Stimulating social interaction and fun experiences in public spaces

This challenge has to do with the fact that people, even when visiting public areas in a city such as parks or open market squares, isolate themselves from other people around them as well as their environment setting, because they are so engrossed in their digital world on their screens. There has been such a rapid development in technology over the past decades that has influenced peoples' behaviors so much, that the social interaction between people, and even the physical interactions between people and their environment have decreased drastically. The effect on today's society is evident as soon as you look at the people sitting in the park, waiting in a queue or even just walking through the street. All one sees is faces glued to screens and ears covered by headphones, instead of friendly greetings, small talk or even just a smile here and there. [Kawin Metsirtrakul, Nuttapol Puntavachirapan, Thananop Kobchaisawat, Sangsan Leelhapantu, Thanarat H. Chalidabhongse, 2016]

Finding a way to deal with this challenge and encouraging social interaction and interaction with the environment, would not only bring some fun into peoples' lives, but could also influence their mental and social well-being as well as provide a means for obtaining positive experiences in the city.

The research done is split into different segments

1. Basic investigation into the topic
2. Research from articles
3. Live research
4. Inspiration

Basic investigation into the topic:

The following link brings one to the mural with a layout of the initial investigation phase of this topic. [\[Lahore Hauspie, 2023\]](#)

Factors to consider:

- Peoples' feelings
- Factors affecting social interaction
- Space/place of the interaction
- Social situation
- Stakeholders
- The solution must...
- Those potentially involved

People are drawn to spaces that offer interest, stimulation, comfort and amenity. These aspects can positively change the reputation and overcome the physical barriers experienced by some users within the public space. Improving the public space for the citizens to have something "different" to do or to look at, sparks interest, curiosity and a desire to investigate and participate. Simple examples being: having musical shows or market stalls.

Peoples' feelings:

People experience a variety of emotions throughout the day that not only depends on their personality and mood, but also on the situation they find themselves in. If they are in a situation that makes them feel ill at ease, looked at or silly, they will experience negative emotions. It is therefore very important to ensure that the social situation and interaction offered to them leads to positive emotions, otherwise they will not participate.

Positive: Intrigued, curious, interested, fun. A feeling of contribution and satisfaction.

Negative:

Shy, embarrassed, uncomfortable, introverted, insecure, unsafe, disinterested, silly, useless.

These feelings and emotions are related to it being unknown experiences which often occur when navigating in public spaces. Behaviors such as jumping or being silly in public spaces could drag people out of their comfort zones which is the opposite intent of the concept we want to implement. Motivating and encouraging people to interact outside of their comfort zone is a goal trying to be achieved through this project, as well as showing people that it is okay to step out of their own comfort zones.

Factors affecting social interaction[(Danlope2016)]:

One of the most important aspects of human existence is social interaction, which can be influenced by a number of things, including:

- Biological factors
- Basic cognitive processes
- Characteristics and actions of others
- Cultural context
- Ecological variables

Space/place of the interaction:

The space in which the interaction is taking place, influences the type and mood of the interaction. The atmosphere, look and feel radiated by a place can affect whether people behave more formally or casual, playful or serious.

The following aspects of the space must be considered:

- The type of social interaction that is most commonly taking place there
- Different interaction types include:
 1. exchange
 2. competition
 3. conflict
 4. cooperation
 5. accommodation
- The amount of space available
- The original purpose of the space
- The location
- The appearance or atmosphere
- Enough privacy

[Karin Peters, Birgit Elands, Arjen Buijs, 2010]

Social situation:

- This has to do with the social status and company of the users.
- People who are alone versus those who are with someone. People who are walking with their

partners, versus people who are with their friends.

- There might be many people present in the public area or very few.
- There might be a big generation gap between the people present.
- People behave differently in the same situation, depending on their culture, nationality and background.
- There are different purposes to visits such as:
 1. Business
 2. Pleasure
 3. Relaxation
 4. Social
 5. Exercise

The frequency that someone visits/goes to or through the space is dependent on the purpose of the space, but also on the location. This is an important factor when considering where one would want to place something that stimulates social interaction. One cannot disrupt the ongoing flow of people, and yet it would be best to stimulate social interaction in a place where many people go in order to reach more of the public [[Dusan Antic, 2019](#)].

Stakeholders:

Split into potential users and those involved.

Potential users:

1. Children, teens, adults, elderly
2. Disabled, blind, deaf, autistic (sensitive to triggers)
3. Inhabitants/locals vs tourists/city-goers
4. Students, joggers/exercise

Take into account different nationalities, different backgrounds, different languages [[Yingyi Zhang, Ge Chen, Yue He, Xinyue Jiang, Caiying Xue, 2022](#)]

Those potentially involved:

- Government
- Local municipality
- Maintenance and security
- Business partners
- Museums
- Parks
- Team building events, festivals etc.

The solution must:

- Not take up too much time to participate in
- Be simple/intuitive to use

- Attract attention
- Spark interest
- Remain fun
- Stimulate social interaction
- Be safe
- Be visually attractive
- Not disrupt the flow of people
- Could incorporate a reward system - something useful
- Could give a feeling of accomplishment
- Might encourage participation by showing others participating
- Be unobtrusive in the space and for those not participating
- Be universal
- Left and right-handed
- No language barrier
- Consider different heights
- Consider disabilities
- Consider different ages

This project is aiming to improve our city experiences and so to help understand how this could be achieved, it is useful to see what the ideal city would be like. For this the team looked at the ideals of a “Restorative city”, figure 3.

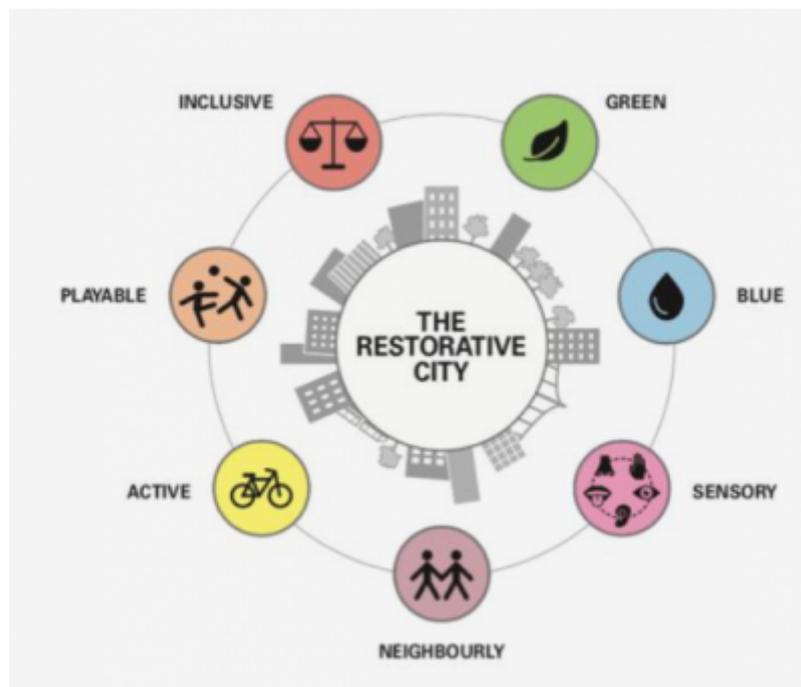


Figure 3: Restorative city

User experience, embodied interaction and dynamic urban spaces to create positive city experiences are upcoming trends that are very interesting to explore when designing for social interaction. [\[Heidi Marshman, 2019\]](#)

Potential starting points:

Human interaction with others is fundamental to life, and there are many strategies to motivate people to engage in social activities. One strategy that works well is to pique curiosity and exude

positivity. People are more likely to want to participate in an activity when they are enthusiastic about it.

The creation of engaging activities is a further crucial element. It might involve something to see or do, like playing a game or figuring out a puzzle. When people are with others, they are more likely to participate, and when they see other people participating, it motivates them to do the same.

There are numerous strategies for encouraging social interaction. One illustration is the traffic jam game, which calls on players to cooperate in order to find a solution. Another thrilling activity is playing hand tennis on a court that is projected by interactive lights. The floor can be projected with instructions, which is another entertaining way to engage people.

A great way to promote social interaction is to work together to complete a task. This can involve undertaking projects like building something or practising balance exercises. Additionally, music has the ability to unite people. Playing an instrument that requires two people to play, or making music with tambourine discs or dominoes, are all enjoyable ways to make music with others.

Sporting events or competitions can be a great way to promote social interaction as can sharing and making art. Another entertaining way to engage people is through games. These can include games with various levels, objectives to complete, a reward or point system, or games with enormous sticks.

And finally, encouraging social interaction can be accomplished through communication. This can include group-based challenges like tests, puzzles, and riddles. In general, there are many ways to design enjoyable activities that promote interpersonal communication and unite people.

Research from articles:

The meaning of a “social interaction”

A social interaction is an exchange between two or more individuals and is a building block of society. Social interactions can be studied between groups of two (dyads), three (triads) or larger social groups. By interacting with one another, people design rules, institutions and systems within which they seek to live. Social interactions are the acts, actions, or practices of two or more people mutually oriented towards each other's selves, that is, any behaviour that tries to affect or take account of each other's subjective experiences or intentions.

Good places for interaction:[Phil Rabinowitz, Andrea Glinn, 2006]

Social interaction is the meaningful contact people have with one another. “Meaningful” is an important word here, because it implies an exchange that includes real communication, even if only for a moment, and leaves each party feeling that he’s shared something with another human being. Good places for interaction are places where people – often from many parts of the community and/or diverse backgrounds – meet naturally and interact comfortably and often pleasurably because of the nature or attraction of the space and/or the activities associated with it.

Good places for interaction are spaces that make people from different areas and backgrounds want to be there. In order for that to be the case, these spaces need four basic characteristics:

1. There has to be a reason for people to go there
2. There has to be a reason for people to want to stay once they have arrived
3. People in the space have to feel safe and comfortable
4. The space has to be welcoming and accessible to everyone

There are many different kinds of spaces: public and private, rural and urban, that can be good places for interaction [Janienke Sturm, Tilde Bekker, Vero Vanden Abeele, Stine Liv Johansen, Mark van Kuijk, Ben Schouten, 2013].

The benefits of social interaction:

- Better mental health – it can lighten one's mood and make a person feel happier
- Lower the risk of dementia – social interaction is good for one's brain health
- Promotes a sense of safety, belonging and security
- Allows a person to confide in others and let them confide in the person [Astrid Kemperman, Harry Timmermans, 2014].

Essential human needs that public spaces fulfill:[Nemanja Memarovic, Marc Langheinrich, Florian Alt, Ivan Elhart, Simo Hosio, Elisa Rubegni, 2012]

1. passive engagement with the environment, where we observe what others are doing
2. active engagement through intellectual challenges posed by the space, or through engagement with the people in it
3. excitement of novel discoveries within the space. An often underused resource in public spaces – public displays – can be used to stimulate these needs.

Live research:

It's crucial to gather information from actual experiences and first-hand witnesses in order to develop insightful conclusions for the project. By getting feedback from current and potential users, the project can be guided towards producing something that will benefit people.

Observation is one technique for gathering this data. Researchers can use methods like “fly-on-the-wall” observation or shadowing to observe people's actions, patterns, purposes, and goals as well as the frequency, volume, and nature of their interactions in public places. Researchers can learn more about how to foster human interactions by determining the best location to implement a social-stimulating concept.

Interviews are another powerful strategy. These interviews can delve further into what individuals believe about public spaces and the difficulty of encouraging more social interaction and enjoyment. Researchers can find out if people would engage in an interactive activity, what deters them from doing so, and what would motivate them.

People may be questioned during interviews about how they feel about public spaces, how frequently they walk through them or visit parks, how long they stay there, why they visit them, and whether they would be interested in meeting others there. Researchers can also find out whether people typically come alone or with others and whether they believe public spaces could use improvement. Researchers can gain important insights into people's perceptions of public spaces and their willingness to participate in interactive activities by gathering information through observation and interviews. Using this data, the project can develop socially stimulating ideas that will enhance people's experiences in public areas.

Inspiration

Any creative process needs to start with inspiration search, and this project is no different. We can

learn a lot about what works and what doesn't by investigating what other people have done in fields that are similar to our own. We have compiled a list of motivational examples that highlight cutting-edge methods for fostering social interaction and designing public spaces to serve as a starting point for this process [Lahore Hauspie, 2023]. We can get ideas and inspiration from looking at these examples, which will help us lead our own project to success.

Digital Message Boards:

Digital message boards could be installed in public spaces such as parks, plazas, and community centers. These message boards could be updated in real-time with information on upcoming events, community news, and personal messages from individuals looking to connect with others. For example, the message board could display messages like "Looking for a running partner in the park at 6am on weekdays," or "Interested in starting a book club for teens in the community center. Anyone else interested?" These types of messages could help connect people with similar interests or goals and encourage them to meet up and interact in person. Digital message boards could also be used to display public art projects, quotes, or images to inspire and engage the community. These message boards could be interactive, allowing people to respond to messages or leave their own messages for others to see.

Interactive Art Installations:

Interactive art installations are a great way to bring people together and encourage collaboration. These installations could be temporary or permanent and could be placed in public spaces such as parks, plazas or street corners. For example, an interactive sculpture could require people to work together to move the pieces and create different shapes or patterns. A large-scale mural could be painted in sections by different groups of people, with each section building upon the previous one. Interactive installations could also be designed to incorporate technology, such as motion sensors, lights, or sound. For example, a musical installation could play different notes or sounds when people move through different areas of the installation. The goal of interactive art installations is to create a shared experience for the community and encourage people to interact with each other in a creative and fun way. These installations could also be used as a backdrop for community events or festivals, bringing even more people together.[Katarzyna Urbanowicz, Lucyna Nyka, 2016]

2.3 Fields to explore

Stimulating social interaction in public spaces means there must be something that engages people to participate. Something fun, unique or intriguing for them to do or observe together. To gather inspiration, the team delved into the various types of fields or activities that exist today, in which people interact or could potentially interact with each other. The fields of interest and inspiration considered for the project concept are sports, music, games and art. These fields are analysed below together with pros and cons and examples.

Sports

Sports always stimulates social interaction in team or competitive sports. Whether it is playing a pickup game of basketball with friends, joining a local recreational league, or attending a professional

sporting event, sports provide a unique opportunity for people to come together and engage in a shared experience. One of the ways that sports can increase social interaction is by creating a sense of camaraderie and team spirit among participants. When individuals work together towards a common goal, whether it is winning a game or improving their skills, they develop a sense of belonging and connectedness that can translate into stronger social connections outside of the sporting context. In addition, sports can serve as a social equalizer, bringing together people from diverse backgrounds and communities who may not have otherwise had the opportunity to interact. This can be particularly beneficial in breaking down social barriers and promoting understanding and empathy among individuals from different walks of life. When playing a sport, background, language or culture do not matter. Only the rules of the game, a mutual respect for each other and the reminder that everyone is in it for the fun or the love for the game. When one takes the facts mentioned above into consideration and how a sport-related game could be implemented in a easy and good way for people to enjoy in a park, there are a few options that came up while doing research. One must keep in mind though that there are:

- more competitive sports versus more friendly sports
- individual versus team sport
- technique versus easy
- fun versus more serious

Each has advantages and disadvantages that can be considered, table 3.

Table 3: Pros and cons of different sport characteristics

Sport characteristic	Example	Pros	Cons	vs Sport characteristic	Example	Pros	Cons
Competitive	Boxing	Motivation, driving force	Frustration, cheating	Friendly	Beach volley	Fun atmosphere, enjoyment	Less purpose
Individual	Surfing	Peaceful, self-control	Lonely, less belonging	Team	Soccer	Camaraderie, belonging	Pressure
Technique	Tennis	Satisfaction, accomplishment	Not everyone is able	Easy	Spike ball	For the wider public	Quickly boring
Serious	Martial arts	Concentration, purpose	Less of a fun aspect	Fun	Bowling	Enjoyment together	Less "useful"

There are many examples of stimulating and fun alternative games. One of them is a Teqball table, figure 4, where the participants play against each other in a similar way as with a Ping-Pong table but with a football. This sport was created in Hungary in 2014 by Gábor Borsányi, Gyuri Gattyán and Viktor Huszár and combines the rules of Table tennis with the use of a football. In an article published on the 7th of December 2022 it states that Teqball has attracted about 5000 players in 100 countries. It is, however, sport that the bigger general public would have difficulties playing, because it requires good foot-ball coordination, which is difficult for people with little or no experience in football. [\[Catherine Jewell, 2019\]](#), [\[Shayan Moghangard, 2022\]](#)



Figure 4: Teqball.

Then searching for more games online there is also a thing called Tic-Tac-Toe football (Refer to Figure 5). Football and the classic game of Tic-Tac-Toe with a digital twist. The aim of the game is the same as with simple Tic-Tac-Toe but instead one is doing it with a football, trying to get three of the same symbols aligned to win the game. When it is the player's turn, he kicks the ball to hit the screen in a certain place where a symbol will then appear. To make this possible one would need a screen with 9 different pressure plates built into it, so that when the ball hits the screen in an area, the symbol is displayed. There would also have to be some programming done to make the visual effects more satisfying and to make the screen able to know when a player has won. It is basically a big touchscreen with a game on it and the ball is the item "touching" the screen. To make this possible to create with the funds that are available to the team it would have to be altered in some way. When searching the internet about information on this game it is hard to find anything on who created it and when it was created but based on the technology it seems to be a very new invention. Youtube video: [\[Patrickbfree, 2022\]](#)



Figure 5: Tic-Tac-Toe football.

Spikeball, (Refer to Figure 6), is a two-on-two team sport (you can also find three-on-three variants) with relatively simple rules. They are closer on some points than volleyball.

The goal of the game is to bounce the ball onto the net so that the opposing team is not able to turn it. A team can make up to three contacts to return the ball to the net. Once the ball is sent to the net, it is the turn of the other team to play the ball. One of the benefits of this sport is that it allows children to develop several different and versatile motor skills. For example, "hand-eye coordination"

is essential to the overall development and academic success of children. In addition, the many training activities related to the practice of Spikeball offer adults many health benefits of this sport practice, ranging from helping to burn calories to improving the cardiovascular system. Finally, this game allows you to work on team cohesion while creating challenges between teams.



Figure 6: Spikeball.

The table that can be consulted by opening the pdf link below, lists examples of sport and sporty games that exist and are played by people, whether competitive or collaborative.

[sport_table.pdf](#)

Music

Music has been around since the very beginning as a medium for communication, entertainment, rituals and pleasure. It is one of the only aspects in life that brings people of all races and backgrounds together because it makes people forget all the things that make them different and reminds them that they share a common love for music. Admitted, there are different genres that people like, and not everyone likes listening to the same thing, but almost everyone in the world likes listening to some form of music. This makes music something that everyone can relate to and appreciate [Elite Areas, 2021]. For these reasons, music is a very good medium for bringing people together and stimulating social interaction. Not only does making music give enjoyment, it also results in something that gives satisfaction and a feeling of pride. With the right tools and environment, anyone is able to make sounds or a simple tune, which makes music universally applicable and not just limited to the practiced or talented. Music in public spaces can be created or simply just enjoyed, which both bring people together.

Creators of sound, table 4: Strings percussion Air Creating sound has to do with making vibrations which can be done by applying actions to different mediums. The space in which the sound is created is also very important. The size and acoustics of an area influences the way sound is perceived.

Table 4: Mediums and examples to create sound.

Medium to create sound	Actions	Examples
Percussion	Hitting, tapping, shaking	Drums, xylophone, bells, tambourine
Strings	Hitting, stroking, finger-picking	Piano, violin, guitar, harp
Air	Blowing, pumping	Trumpet, flute, bagpipes

There is of course also music and sound in nature all around us. Wind through the leaves, birds singing, the sound of the ocean. Incorporating these sounds into music brings people closer to nature and makes them more aware of their environment.

Creating a concept that stimulates interaction in public spaces by making music together or enjoying music created by others is a very interesting direction to explore, but like everything has pros and cons to it, table 5.

Table 5: Pros and cons of music in public spaces.

	Advantages	Disadvantages
Music in public spaces	Common ground	Might get too loud
	Brings people together	People might get annoyed - "disturb the peace"
	Everyone can relate	There are some people who do not like music
	Satisfying to create	People might feel hesitant if they have no musical background
	Can enjoy other peoples' music	
	Simple to make sound	
	Anyone can do it-inclusive	

The songboard: The songboard, (refer to Figure 7), part of the London mayors Look and Celebration program as part of the Olympics, is comprised of 3000 plastic balls. One side of each ball is yellow and the other black, meaning that when played with the public can make shapes, patterns and large scale drawings. Around 300 of the balls are musical; when turned, the ball sets off an individual section of music, it could be a recording of Big Ben or a musical note. Meaning that songs can also be made with a group of friends playing with the songboard. Making the idea happen: William Hardie Design got the opportunity to make the idea happen, do further design work, manufacture all the parts, put all the components together and make it work. It was also important to make the music and electronics part work. The largest of the tasks was to make sure 300 micro-switches were soldered and wired into the correct position, and all the wiring had to be labelled to go into the input boards. With a tight time frame the team managed to complete it only with the help of Brighton Design and Craft Graduates and current students.



Figure 7: Songboard [Chloe Meineck, 2012].

In the Croatian city of Zadar, there is a monument that best celebrates the power of the waves of the sea: it is a staircase that when touched by the waves, emits a very delicate sound produced by the organ built inside. (Refer to Figure 8)

These are obviously “random” sounds, produced by the movement of the waves, but they seem to form a very attractive melody. The staircase is a destination for tourists but also for locals who like to walk along the sea, accompanied by the sound of the sea organ.



Figure 8: Staircase in Zadar.

Games

Games are very effective in getting people to interact with each other, especially if they have a competition side to them. They generally provide a challenge and a fun experience, ending with an outcome of winning or losing. People can get a lot of joy from playing with each other or against each other. Creating a game that can be played in public spaces by passers by can be a very interesting way to get people to socially interact with each other and have a fun time while doing it. There are of course many types of games that require different actions, processes and effort that can be physical or mental.

Examples:

- Brain teasers
- Physical processes
- Body actions
- Strategic thinking
- Levels
- Physical components
- Virtual worlds

Some games require playing boards, others are played digitally on computers or other screens, and still others can be played outside with the help of accessories or simply by using the human body.

Battlekarts: A game not unlike Mario kart. The players get a kart and drive around on a track that is projected onto the ground. They can pick up power-ups and get slowed down by driving in the grass. There are multiple game modes so there is a lot of replayability.

Jenga: This is a traditional game everyone knows about, it consists on a tower made of blocks and each player needs to take one piece of the tower at a time and try to add on the top of the removed

piece without letting the tower fall, figure 9.



Figure 9: JENGA.

For a social interaction purpose, the game would be bigger and very interactive. Pieces would be equipped with sensors and, when removed, sounds would be heard coming out of the block. Sounds like struggle in removing the block and then, after removed, the tower shaking like it is almost falling. To make it more sustainable, the blocks would be made from recycled material and produced without the need of fossil fuels, also taking in consideration that the material of the block is available in every location where the game can be installed, this last feature makes sure the game can be played internationally. All of the above characteristics will make the engineering in it very challenging and the end result very funny to play between a group of people.

It is very interesting to look at what types of games people played in previous decades, because they do not contain technology and screens, and were all about interaction and playing with each other. Because we want to stimulate social collaboration in our concept, old games are very good inspiration sources.

[Pierre Driesmans, 2012]

Puzzles

Puzzles are another fun way of engaging people to do something. A puzzle is fun to do together and yet one feels no pressure to do well, which gives a more relaxing comfort than competitive alternatives. Another positive thing about puzzles, is that they can be done by all ages and people. Completing a giant puzzle with other people in the public space could be very interesting, but one has to ensure that the puzzle changes regularly so that it is not always the same.

Another form of puzzles can be riddles, brain teasers or other forms of mental or word/symbol challenges. Think of Sudoku, word search and crosswords. These challenge the brain and mental processes, and can be very fun when collaborating with each other. They can however also be done individually, so creating a type of puzzle that requires social collaboration would be an interesting direction to go for this project.

Examples of other stimulating games

Rubrics cube: A Rubik's Cube is a 3D mechanical puzzle that was invented by Hungarian sculptor and professor of architecture Ernő Rubik in 1974. The puzzle consists of a cube with six faces, each made up of nine smaller squares of different colors. The objective of the game is to twist and turn the cube's faces to arrange each side of the cube with a single color. The Rubik's Cube gained immense popularity in the 1980s and remains a popular puzzle today. It is considered one of the best-selling toys of all time, with over 350 million cubes sold worldwide.

Connect 4: Connect 4 is a two-player strategy game that was invented by Howard Wexler and Ned Strongin in 1974. The game consists of a vertical board with six rows and seven columns, and each player has a set of 21 colored discs. The objective of the game is to connect four of your colored discs in a row horizontally, vertically, or diagonally, before your opponent does. Players take turns dropping their discs into the columns and the game continues until either player has successfully connected four discs in a row or the board is full, resulting in a tie. Connect 4 is a popular game for both children and adults and has been enjoyed by millions of people around the world.

Classic puzzle with pieces: A classic puzzle with pieces is a type of game that involves assembling various interlocking pieces to form a complete image or pattern. The origins of puzzles with pieces can be traced back to the 18th century, when hand-cut wooden puzzles were first produced. Today, puzzles with pieces come in many different forms, including jigsaw puzzles, 3D puzzles, and brain teasers. They typically consist of a set of individual pieces that are designed to fit together in a particular way to form a larger image or object. The objective of the game is to solve the puzzle by correctly fitting all the pieces together. Puzzles with pieces are enjoyed by people of all ages and skill levels, and can be a fun and challenging way to pass the time.

Art

Art is something that can often be appreciated and enjoyed by all. There are different art styles that people like and dislike, but usually everyone can appreciate the creations of others, even if it is not exactly their taste. Art is also something that anyone can participate in. They do not have to be talented or have a beautiful result because the enjoyment comes more from the process of creating something. The fun they have when making something or getting their hands dirty.

Installing something in public spaces that encourages people to create something might attract a lot of users. It could be interesting if there was a way to motivate people to collaborate and interact with each other to create something together, or maybe just enjoy what others have created. It could be a conversation starter too. It would also liven up the space.

Art can be digitally created and represented, or with physical tools/items and mediums. Such as projections and light versus one's hands and paint.

Forms:

- Drama
- Poetry
- Dance
- Design

Mediums

- Digital (projections)

- Light
- Paint
- Ink
- Markers
- Pencils
- Clay
- Sculptures

Types:

- Illustrative
- Abstract
- Pointillism
- Cartoon/caricature
- Realistic
- Graphic
- Photography

Examples of art:

- Drawing on a big screen
- Playing with colour, lighting, interactive projections and silhouettes
- Using body movements to explode colour onto the screen
- Water sand art, figure [10](#)
- Sand light box, figure [11](#)



Figure 10: Water sand art [\[Klaus Bosch, 2023\]](#).



Figure 11: Sand light box [Amazon, 2023].

2.4 Conclusion

Based on the study of the state of the art, the team decided to adopt the following direction to go with the project: **Creating a type of competitive game** in which people must interact and collaborate in order to participate. This decision was made by evaluating all the other options and listing the pros and cons for each one. This is displayed below.

Games in general bring people together and force people to interact with each other whether it is online or an old-school board game. At least 2 people are needed, especially for a competitive version. For these reasons games were chosen as interaction is the main goal of our project. There are so many different games, old and new, that can be combined or modified based on what one wants to achieve. Old games can be altered with a new technological side to make something unique and interesting.

Similar already existing solutions that could be considered competitors and inspiration were analyzed and a few are compared in Table 6

Different factors were considered to help determine how the team's solution could achieve the best result.

Table 6: State of the art overview.

Name/Feature	Game	Music	Free	Amount of participants/players	For all ages	Educative	Personisable	Multiple variations	Forces interaction between people	Temporary installation	Competitive	Duration of activity	Achievements / rewards
BattleKart	yes	no	no	2	no	no	no	yes	yes	no	yes	15 min	no
The Songboard	no	yes	yes	+10	yes	yes	no	yes	yes	yes	no	undefined	no
Tic-Tac-Toe football	yes	no	yes	2	yes	no	no	no	yes	yes	yes	5 min	no

Name\Feature	Game	Music	Free	Amount of participants/players	For all ages	Educative	Personisable	Multiple variations	Forces interaction between people	Temporary installation	Competitive	Duration of activity	Achievements / rewards
Teqball	yes	no	yes	2/4	no	no	no	no	yes	n/a	yes	5-10 min	no
Jenga	yes	no	yes	+10	yes	yes	no	yes	yes	n/a	yes	5-10 min	no

Below, (refer to Table 7), an overview of the main options investigated in the “State of the art” section, with a summary of the reasons, for and against each option.

Table 7: State of the art overview

Social interaction option	For	Against
Sporty activities	* competitive * strong-collaboration * active * healthy * many players * provides satisfaction	not accessible for all * doesn't appeal to everyone * not for all ages/skill levels/athletic levels * require bigger playing field * could be obtrusive to the surroundings * could spark aminority
Games	competitive * strong-collaboration * provides satisfaction * brain stimulation * accessible for all * playing area is easy to contain to small area	not as many people can play at the same time * harder to keep interesting over time * requires more components * risk of becoming too technical
Music	Common ground * brings people together * everyone can relate * satisfying to make music * brain stimulation * very accesible * very inclusive * many different solutions	might get too loud * disturb the peace in public spaces * not everyone enjoys it * people might feel excluded if they don't know any music
Puzzles/mental challenges	brain stimulation * physically playable by all * they can be quite simple * can be very short	necessary to find different skill level for people * harder to keep interesting over time * not a lot of players * harder to make collaborative * often requires multiple components
Art	brain stimulation * stimulates creativity * common ground * very accesible * calming * it adds to the public space * art is a very broad concept * satisfaction of creating something * attracts participation * very intuitive	doesn't require collaboration * not suitable for everyone * unless you go for a technical solution it requires many materials

After considering all the pros and cons per sub topic, it was decided to focus on creating a type of interactive game, because it was thought that it would encourage more interaction between people than the other sub-topics as competition can be introduced. It is also a more inclusive option and can be made applicable for all ages, languages and backgrounds, as it would not require specific sport or musical skills. Introducing a type of game to play with or against each other has a high chance of attracting the participation of people.

Final decision: A type of competitive/collaborative game/puzzle

Basic requirements:

- Re-playable-improve score
- Involve at least 2 people
- Simple as possible with maximum enjoyment
- Include ages 10-100

- Temporary = possibility to move it if necessary
- Not take longer than 15 min to participate in
- Limited amount of loose pieces
- There must be a driving factor that makes people want to play
- Activate interest and curiosity
- Possibility to install in different types of open public spaces
- Intuitive in use
- Physical/mechanical (limit the use of a graphic user interfaces)

With the help of the state of the art research that was done, the team came up with and discussed several ideas for the final project concept. A brief summary is listed below:

- **Pattern Puzzle** - There is a giant vertical playing board with sliding pieces or disks. The players each get a sequence/challenge to solve of equal difficulty and have to race to finish the puzzle first and get the sequence right. When one has won, the pieces of the other player fall down. The time and score are displayed for them to see.
- **Water bubble game** - Players compete to push controls in order to blow air bubbles in a board containing water. The force and direction of the air bubbles push rings up, which then have to fall around pins at different levels. The first player to get all the rings on a pin wins. Different pins have different scores. The time and score will be displayed.
- **Balancing board** - Players have to work together to maneuver a small ball through a maze. The board has holes that the ball can fall through, making it more difficult. The path of the ball will be lighted up and, in this way different difficulty levels can be achieved depending on the difficulty of the path. Maneuvering the ball only works if everyone collaborates and can be done either by balancing the board or by other control mechanisms. This could be turned into a race between two teams.
- **Photo sliding** - An interactive wall, where people can pose and take photos of themselves together. The photo will be taken, but cut up into pieces-digitally. In order to see the full photo, people have to complete a sliding puzzle. The pieces will be physical, but linked with the digital pieces so that when the person interacts with the physical pieces, the respective digital puzzle piece will also move. The speed and time of completion can be displayed.
- **Racing car game** - There is a racing lane with cars. Players each have their respective car that will move forward by them doing certain actions such as maneuvering levers, or shooting discs through holes, or completing puzzles, etc. The person who is controlling the first car that crosses the line is the winner.
- **Jenga with a twist** - A large scale version of Jenga, but with challenges or questions written on the hidden sides of the pieces. Players will only see them once removed from the tower. Sound effects could be incorporated.

After the group discussed the ideas, the following two concepts were voted for as favorites: the **Balancing board** and **Pattern Puzzle**. During the following days it will be decided which one of these concepts will become the focus of the project.

An interesting addition could be incorporating the collection and display of specific data in the game. For example the game board could measure and display the amount of carbon dioxide in the air in public spaces to raise awareness of air pollution. In this way many people can be reached as many people generally visiting public areas. Frequency of people using the game can be recorded as a promotion strategy. Thought must go into how the installation will be monitored and maintained.

3. Project Management

Any project that is successful will have excellent project management. The report's emphasis in this section is on the methods and strategies that will be used to steer the socially stimulating project towards success and keep it on course. We will cover topics like the project schedule, team member roles and responsibilities, the communication plan, the budget, and the risk management plan in this section. We can guarantee that the project is delivered on time, within budget, and to the desired level of quality by outlining these components.

3.1 Scope

The scope was used to determine the general goals to be pursued. A scope is a tool that helps with defining the project's boundaries and articulates what the project entails. It is divided into project scope, which pictures the work needed for the production, and product scope, which is the extent of what a project will produce.

Here below you can see a picture of our project scope:

This overview gives a clear and easy to read summary of all the individual aspects that have to be incorporated into the project. It describes the different phases in the process and what has to be done in each phase leading up to the final concept and deliverables, figure [12](#).

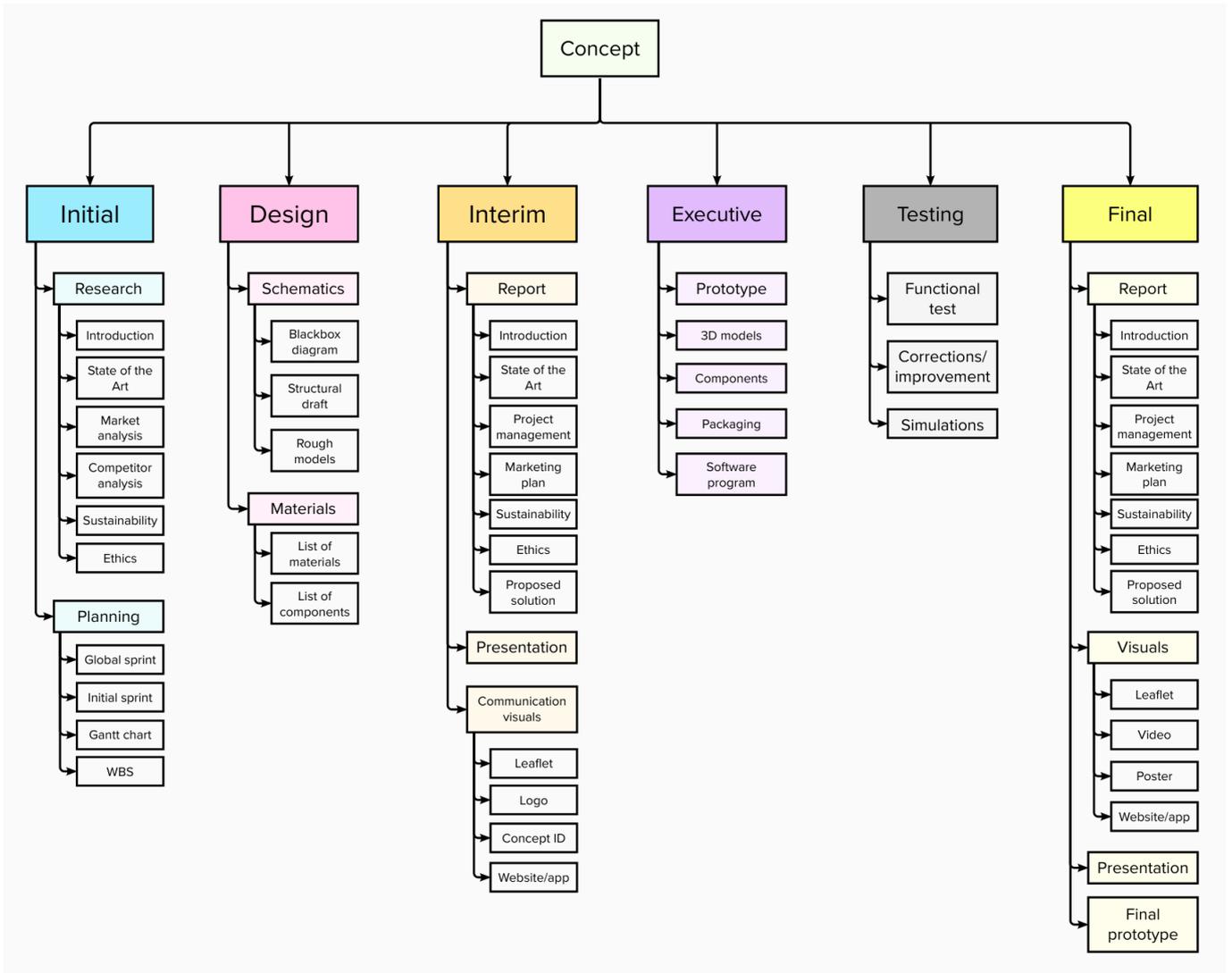


Figure 12: Project scope.

“Shift it” product scope:

The product scope, figure 13, gives an overview of the 3 elements that will be integrated in the concept, and what must be done under each element. It helps identify the tasks that need to be completed.

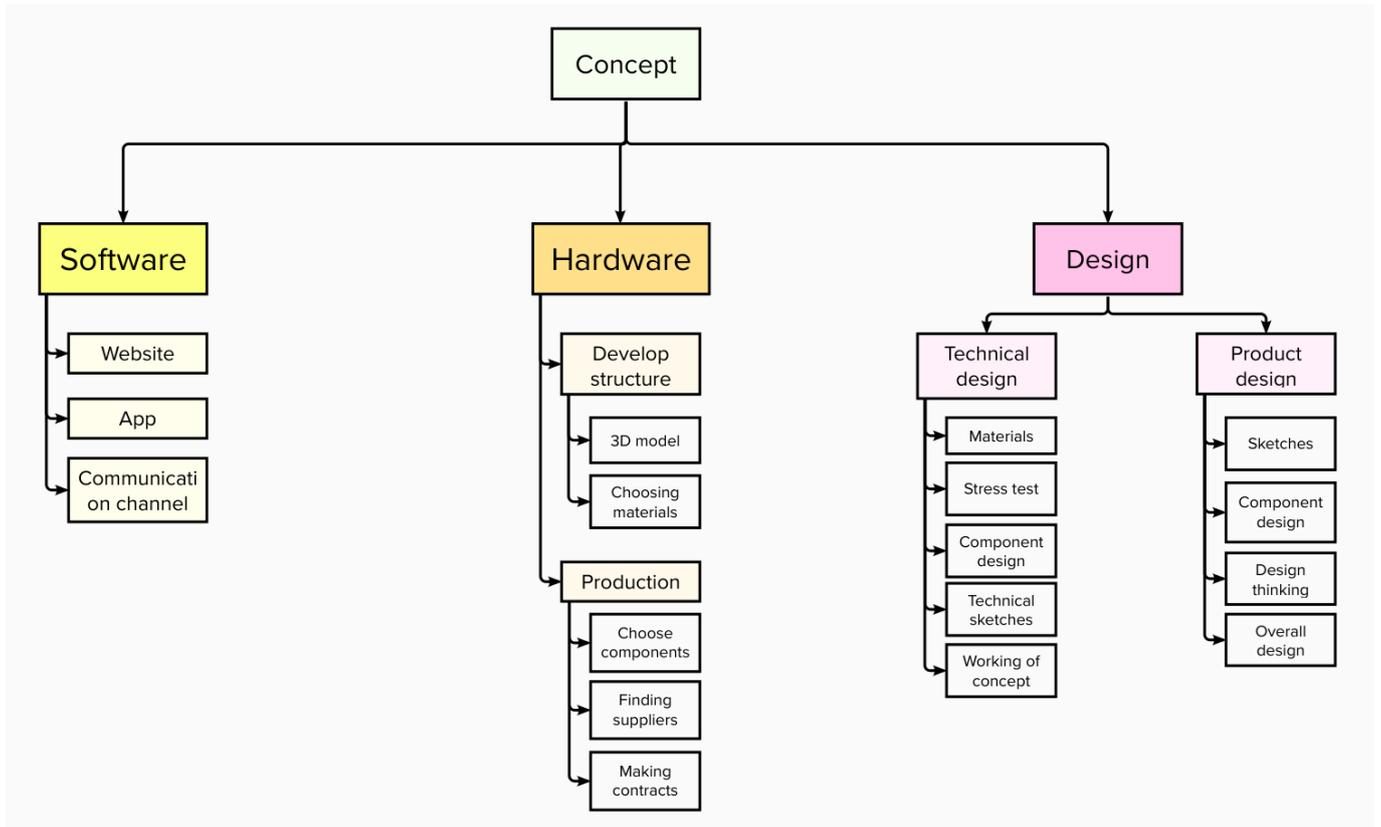


Figure 13: Product scope

Detailed Product Scope:

Figure 14 provides a more detailed overview of the product scope and elaborates on the technological components, the physical components and the promotional channels that will be used for the concept.

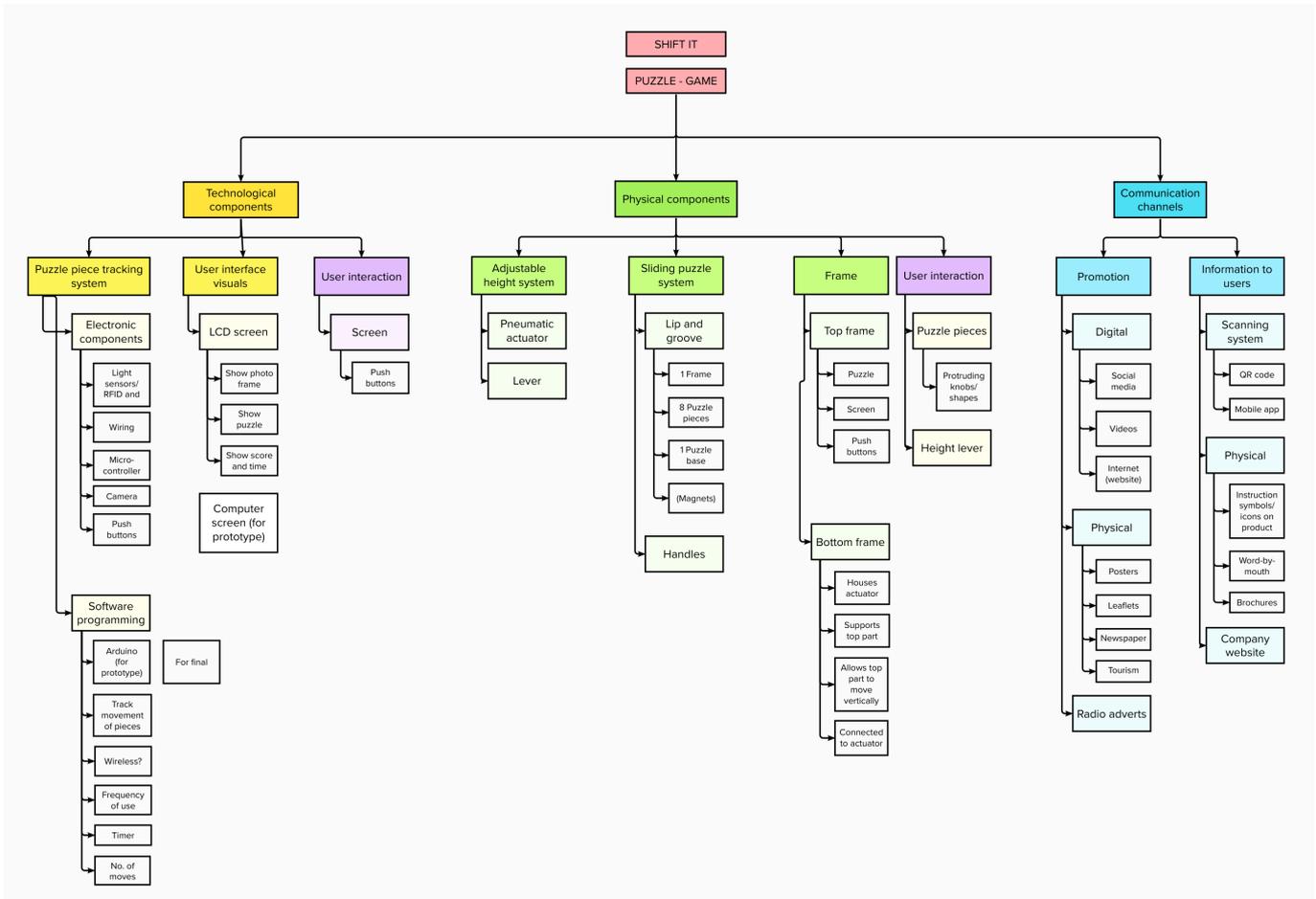


Figure 14: Product scope.

3.2 Time

Time planning is one of the most important first steps of project management. To help us with that, we used a Gantt chart which is an example of a bar chart that shows a project timetable. It displays the beginning and end dates, duration, and interdependencies of various project tasks.

Gantt chart:

Figure 15 displays the duration and interdependencies for the project tasks. This is an essential part to help us manage the project's deadlines and progression:

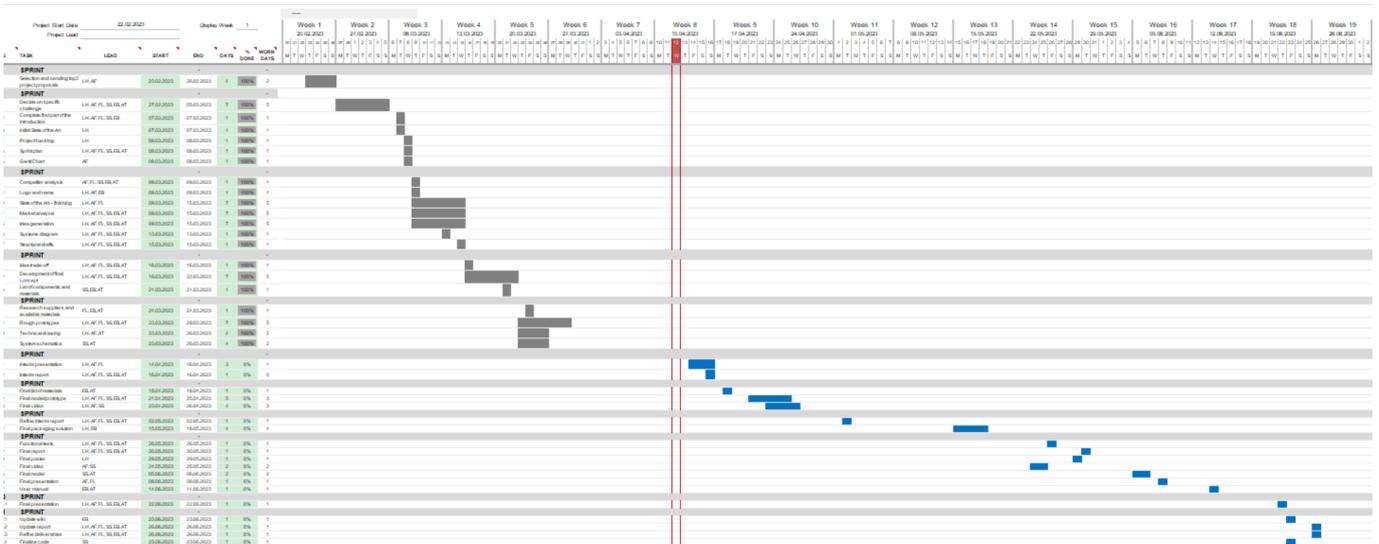


Figure 15: Gantt chart

3.3 Cost

Prototype

For the prototype there were some differences between the initial price planned and the price that ended up being the final one. Initially, a list was made with all the materials and components that would eventually be needed but ISEP had alternatives to some of them, so some components were replaced by the ones ISEP gave, making the final price reducing a lot. After all those changes, the final price came up to 39,03€, including wood boards, handles for the sliding pieces, table feet and screws.

Real Device

For the real model, it is expected to pay a total price of 250€, including all the components and materials needed for the construction of it. This is expected total price in the ideal situation although prices may vary according to costs of transport and possible differences that the price has on the website of the suppliers in comparison with the reality or even taxes that may come up with the implementation of the device on the streets.

Maintenance

This factor will be a very important responsibility of the company because it will require feedback from the device and regular checking of the device so that potential problems can be avoided. The ideal situation would be to send the device for the team who worked on the project in case of some malfunction and the checking of the current state of the device would be made with the feedback of the players and the feedback of the volunteers that are in charge of being close to the device while exposed in public areas. So, for the volunteer there won't be any costs involved and then for the

maintenance team, the only costs involved would be eventual materials or components that would have to be bought again if necessary. For a routine cleaning of the machine, it will be used a screen spray and a brush to keep dust away from the sliding pieces and that job will be done by volunteers.

Assembly of the system

To assemble the system there will be costs in acquiring the tools, fastening features and equipment, such as welding the aluminum profiles. Costs will also go to buying or renting the infrastructure where assembly will take place as well as to bills that come up with it. An average welder in Portugal earns about 7,69 €/hour and the time necessary for the welding of all parts is about 8 hours, so the expected payment will be around 61,52 €. The welding will be made in an outdoor space, and it is expected to have no costs and the electricity bill of the welding machine will cost around 5 € for a machine that consumes 4 kWh for 8 hours because the price of energy in Portugal is around 0,15 €/hour.

Delivery transports

These will vary depending on the distance to the supplier and the way the materials or components required are transported to the company, as well as the person that drives the respective means of transportation.

External work

Other external work that will be useful for the project are web developers and graphic designers because they will take part in the developing of the website, posters, leaflets and other means of social media and promotion that can help the company to grow and present its identity and branding to the target segments. This use of external help for the project will still be evaluated. If the team manages to do this work by itself there will be no need to contract external companies/people to do it and in this way, costs could be reduced.

However, here are the average salaries in Portugal for the professional considered in the last paragraph:

Web developer - 1387 €/month Graphic designers - 1492 €/month

3.4 Quality

Quality is the core of three constraints: Budget/Cost, Scope, and Time/Schedule

Budget/Cost - The product has to be as sustainable as possible. Relating to the 3 constraints, all the materials that were researched had to have certain characteristics that would fit our requirements, the cost of these materials could not be the cheapest as the quality must be guaranteed, and very important: their impact on the planet Earth must be as small as possible in its production, existence and after use. The way to reduce the cost of the product is by using as little material as possible while still maintaining a good structure and functionality.

Scope - Creation of a game design that adheres to industry standards and regulations with a strong communication between the stakeholders to know which requirements are the main ones to achieve, while conforming to a specific budget and being delivered on time.

Time/Schedule - The group must focus on planning, developing, and testing the game. In the planning section the group should identify the resources, equipment and skills needed for the development of the project, also as game mechanics and social interaction features. While developing the team must design the game, develop software and assemble everything together. With the help of a project backlog and sprint planning the team will be more efficient in completing tasks which will in turn ensure that the development part can be completed in a very organized way. The testing consists of testing the functionality of the device, looking for possible errors and fixing them. After all these processes are completed the game is ready to release.

With these 3 constraints defined, the project will be well-guided and have good quality.

The final model will have to satisfy the initial objectives by making social interaction possible and easier, for the ones that are walking by in public space, with a fun experience and good time between the people playing.

In order to make that possible, a good performance of the game will be needed, for that reason, special attention needs to be given to the software development of the game so it can handle all the features thought initially.

To make it even more adaptable to everyone the device must be height adjustable so, as studied, it's expected that the height adjustable system fits everyone perfectly.

With that being set, these are the main quality features that the real model device is expected to achieve at the end of the project.

3.5 People

The participants and relevant stakeholders of our project are mainly the 6 members of the group, all the teachers involved in giving the classes accompanying the project, as well as the professors mentoring the project and giving advice during consult moments. Others involved include external people that help us by giving their opinions and constructive criticism, for instance, other groups members or family and friends.

These are all entities that Shift it has all the interest in keeping a good relationship with because all of them can contribute hugely to the development of the project.

Each entity has its own priority of importance in the project, for that reason, plans on the communication and stakeholder management will be made for better understanding on how to deal with each entity properly.

3.6 Communications

To develop a prototype, we needed fast communication between the group members, so a WhatsApp group was created because everyone has it on the computer and mobile phones and it is an easy way to connect anywhere.

For more important meetings, like discussing an important step for the project, the group either does a video conference on Teams or meets in the classroom available for the EPS in ISEP, the first one is

only chosen if some group members are unable to come to ISEP. The team always comes together to discuss the project and delegate tasks during time given in class. Another communication channel is Trello and Microsoft planner, because here we can communicate to each other what has to be done, what is done and who is responsible without having to ask each other constantly.

For the communication between the group and the teachers the Teams channel created for this purpose is used, all the files are uploaded there so everyone can see it and any important information can be written there to everyone belonging to the EPS. Questions for teachers are written in the chat function on Teams. The consult moments are also moments of communication between teams and professors-during which the wiki report is shown and sometimes Powerpoint presentations.

The following table 8 will configure how and when the communication with a certain entity is done:

Table 8: Communication Planning.

Role	Responsibility	Method of Communication	Stakeholder Information Requirements	Timeframe/Frequency/Trigger
Group members	Information on the second for everyone, quick updates and feedbacks	WhatsApp	Simple and easy to read message for good understanding	Daily
-	-	Presential Meetings	Work as a team, split tasks, quick chat between the group members	Scheduled when necessary
-	-	Teams	Work as a team, split tasks, quick chat between the group members but in an online meeting	Scheduled when necessary
Main mentors	Provide resources to enable project, provide high level requirements and overall approval for project and results, reach agreement with union	Presential Meetings	Updates about the work in progress and the possible bottlenecks that the team is facing	Weekly
-	-	Email or Teams	Tasks to deliver and direct communication with a mentor	Scheduled when necessary

Role	Responsibility	Method of Communication	Stakeholder Information Requirements	Timeframe/Frequency/Trigger
Teachers	Give additional help to the project about areas that are very important and must be included in the development of the teamwork	Email or Teams	Additional tasks feedbacks and delivery of the team's work for the respective subject	Scheduled when necessary

3.7 Risk

Risk management is important to evaluate the possible struggles that the company will face. Therefore a research and study about possible risks, their probability and their impact on the company was made.

Risk Description

- Competition – This risk involves all the other companies that have the same goal as SHIFT IT and focus on the same areas and target groups as this project.
- Water damage – This risk takes into consideration all the damage done to components or materials by water. Electric components cannot have contact with water because they will malfunction and the covering of them has to be impermeable. This is very important because the game will be installed outdoors.
- Dust and Debris – This risk takes into account all the damage that comes from the existence of dust and debris that possibly gets inside the housing to the components through gaps in the device. This is very important to consider because the game will be installed outdoors. This is also important to not for the working of the sensors-because debris can lead to wrong readings from the sensors involved.
- UV exposure - This risk takes into consideration all the damage that comes from the device being exposed to UV rays.
- Physical damage – This risk involves all the possible situations where people or animals damage the device on purpose or accidentally, and the situations where weather conditions could damage the device.
- Theft or vandalism – This risk involves situations where people steal and/or vandalize the device.
- Technological malfunctions – This risk is taking into consideration possible malfunctions the device can have, for example, bugs on the display, game errors, struggling to move the sliding pieces, electrical components not functioning well, glitches in the programming, etc.
- Lack of interest from people – This involves people not wanting to play the game anymore or not trying it out, as well as the feeling that the game does not contribute to the person's well-being and happiness or to stimulating social interaction.

Risk Category

The following table 8), inserts each risk into a category, making it easier to understand what area is in charge of solving the problem.

Table 9: Risk categories and descriptions.

Risk Categories	Risks
Technical	Technological malfunctions, water damage, dust and debris, UV exposure
External	Physical damage, theft or vandalism, lack of interest of people
Organization	Limited funds
Project Management	Competition

Risk Analysis

Risk analysis is made to have an idea of the probability of a risk occurring. There are 4 levels of probability:

1. High probability - (80 % ≤ x ≤ 100 %)
2. Medium - high probability - (60 % ≤ x < 80 %)
3. Medium - low probability - (30 % ≤ x < 60 %)
4. Low probability - (0 % ≤ x < 30 %)

As well as, 3 levels of risk impact:

1. High - Catastrophic (Rating A - 100)
2. Medium - Critical (Rating B - 50)
3. Low - Marginal (Rating C - 10)

The company will focus mainly on risks with high impact and high probability.

For some additional information about the classification of the impact of risks, the following table 10 is presented:

Table 10: Classification of risk impact.

Project Objective	Rating C	Rating B	Rating A
Cost	Additional costs (higher than 0 %)	Additional costs (higher than 5 %)	Additional costs (higher than 10 %)
Schedule	Delay of the project (higher than 0 days)	Delay of the project (higher than 7 days)	Delay of the project (higher than 14 days)
Scope	Scope is practically not affected(no scope creep)	Some areas are affected a little bit	Main scope areas have struggles and does not fit the requirements anymore-wide scope creep
Quality	Practically no difference in the final product quality	The differences seen still fits the requirements for quality	The quality of the final product does not meet the clients' requirements

Throughout the project some risks can upgrade to another level different to where they were placed initially, but that can only happen if the risk is somehow impacted by some of these factors:

- The level of influence or requirements that the client or stakeholders have, change and therefore the risks change with it.
- If the current situation of the project sees some relationships turning weaker, for that reason, the evaluation of the risks must be different to make relationships stronger.
- If some important entity thinks that the risk must be taken into consideration in a different manner.

Risk Exposure

To classify the risks of SHIFT IT with scores and to have a better understanding of each risk level, a matrix of Impact - Probability was built, table 11.

Table 11: Impact/probability matrix.

		Probability			
		1	2	3	4
Impact	A	Score 100	Score 80	Score 60	Score 30
	B	Score 50	Score 40	Score 30	Score 15
	C	Score 10	Score 8	Score 6	Score 3

Risk Occurrence

The following table 12 describes each time frame statement.

Table 12: Risk timeframe statements

Timeframe	Description
Near	Now - Until one month
Mid	Next 2-6 months
Far	>6 months

The table 13 below explains what risks there are to the project and also shows the probability, impact, risk score, time frame and plan. This is to help the company focus on what is important and think about how it could prevent these risks from happening.

Table 13: Risks of Shift it.

Risks	Probability	Impact	Score	Timeframe	Plan
Competition	High	B	50	Mid	Analyze new competition that appears, checking their weaknesses and strengths and then strengthen SHIFT IT to be better than the new competition
Water damage	Medium - High	B	40	Far	Maintenance and waterproof device so the water does not penetrate inside to the components

Risks	Probability	Impact	Score	Timeframe	Plan
Dust and debris	Medium - High	B	40	Far	Maintenance and continuous cleaning of the device with the help of feedback systems, people that play, volunteers and the employees of the company
UV exposure	High	B	50	Far	Maintenance and use of materials that are compatible with UV exposure
Physical damage	Medium - High	A	80	Far	The use of security cameras can help with the process after it happens but there is nothing in our control to prevent other people's actions. The device must be robust and strongly designed to withstand this type of damage
Theft or vandalism	Medium - Low	A	60	Far	The device has to be specifically designed for outdoor use and take precautions to prevent the theft of components
Technological malfunctions	Medium - High	B	40	Mid	To prevent this risk from happening there will be a continuous maintenance of the device to secure that all the components and mechanisms are functioning well. There will be a feedback system and if something goes wrong a quick and efficient response will be given
Lack of interest of people	Medium - Low	A	60	Mid	People, after a while, can find the game boring and not amusing, for that reason, a strategic marketing plan has to be developed in order to keep people interested, some rewards can be given to play and different updates on the game can be done so it is not always the same thing. Artistic picture filters and the fact that the photo is personal will help prevent this risk
Lack of funds	Medium - High	A	80	Far	Because SHIFT IT does not ask the participants for money, there is a risk that it cannot keep affording the maintenance of the game in public spaces, for that reason, there is a need of convincing our stakeholders that the idea is really good and that it will bring more people to play and so to their areas so they can fund us and support us in our idea

3.8 Procurement

The following table 14 summarizes the plan to work with a supplier and additional information like the communication plan, material bought from them and delivery plan and schedule.

Table 14: Supplier overview. All suppliers are Portuguese and have sufficient quality.

Suppliers	Communication Plan	Delivery Plan	Material Bought	Schedule	Stakeholders Approval
BotnRoll	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	Reflective Optic Sensor	2nd Week of May	-
RS	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	Arduino Leonardo	2nd Week of May	-
DigiKey	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	Raspberry Pi 3	After the approval of the final presentation	-
PcComponents	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	Trust GTX Webcam	After the approval of the final presentation	-
Fnac	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	AOC e2270Swn 21.5" Full HD Preto monitor de ecrã plano	After the approval of the final presentation	-
-	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	Aluminum	After the approval of the final presentation	-
-	Depends on the supplier preferences (Mainly website, email and contact number)	Establish a long-term delivery plan (Vehicle transport or post)	White Oak	After the approval of the final presentation	-

There are 2 factors to take into consideration when choosing a supplier to work with a company:

- Lead time - The time that begins when the company contacts the suppliers and asks for the

products required and ends when the company starts to produce those products.

- Delivery time - The time that begins when the production is finished until the time that it reaches the company.

The shorter these times are the better it will be for the company's production and assembly processes. Choosing suppliers and developing good relationships with suppliers is important for the functioning of a company because, especially When there is a need for a fast answer from the supplier to accomplish what the company asks for.

The importance of extra suppliers for the same product

It is very important to do research on more than 1 supplier for each material/component required in the project The reason for that, is that when a supplier does not work as demanded, goes bankrupt, has long waiting times or has something failing in the corporation, the project can always continue with the help of a "Plan B" supplier that is backing the first one in case it fails.

Keep in touch with the supplier

The first step is to get in touch with the supplier and establish a communication method and plan. It will be very important for the future of the project to always have a correct and reliable exchange of information. Apply a delivery plan extended to the future so that the company knows if it is going to fail or not and be ready with another option. Having different supplier sources for the material/component is also important. Having different options available will lead to certainty in the safe and continuous supply of what the company needs to proceed.

Try to make it national so the cost of transport is cheaper and to support the country's economy and local providers.

Why we bought vs Why we did not buy for the prototype

Electrical components were all either bought or borrowed from ISEP because we need them for the digital part of our device The actuator was not bought because the university provided us with it. The PLA materials were already available in the university to realize the 3D printing of certain parts Cardboard and prototyping equipment was also provided by the university so we did not have to buy it One of the team member's laptops will be used as the screen, or a monitor that will be purchased or provided by the school

Why we used a new material vs why we recycled prototype

Although the sliding pieces were initially planned to be made with PLA, it was cheaper and also functional to use cardboard for the same purpose, this way we could have the same thing with a material that had been already provided to us. It is a more sustainable and cheaper option. For the wood and metal (if needed), all the material used will be recycled, this way there will be no need of wasting newborn material that can be used for other important functions. The prototype of our device does not need the materials with their properties at their fullest.

Already made materials/components vs Bought materials/components for prototype

Because the materials for our device are recycled, we have to design and alter them to make them functional for the prototype. For example the connection actuator-lever has to go through certain alterations to have the exact shape and function desired, conforming to the design of the prototype. This could lead to certain costs being made.

3.9 Stakeholders Management

The best way to make stakeholders supportive and become part of the project is to make sure they are communicated with as agreed in the beginning. If they want to frequently be kept up to date with everything happening in the project, the team must make sure this happens. If they only want weekly progress summaries, the team will do it. The main thing is keeping them happy so that they will continue supporting the project.

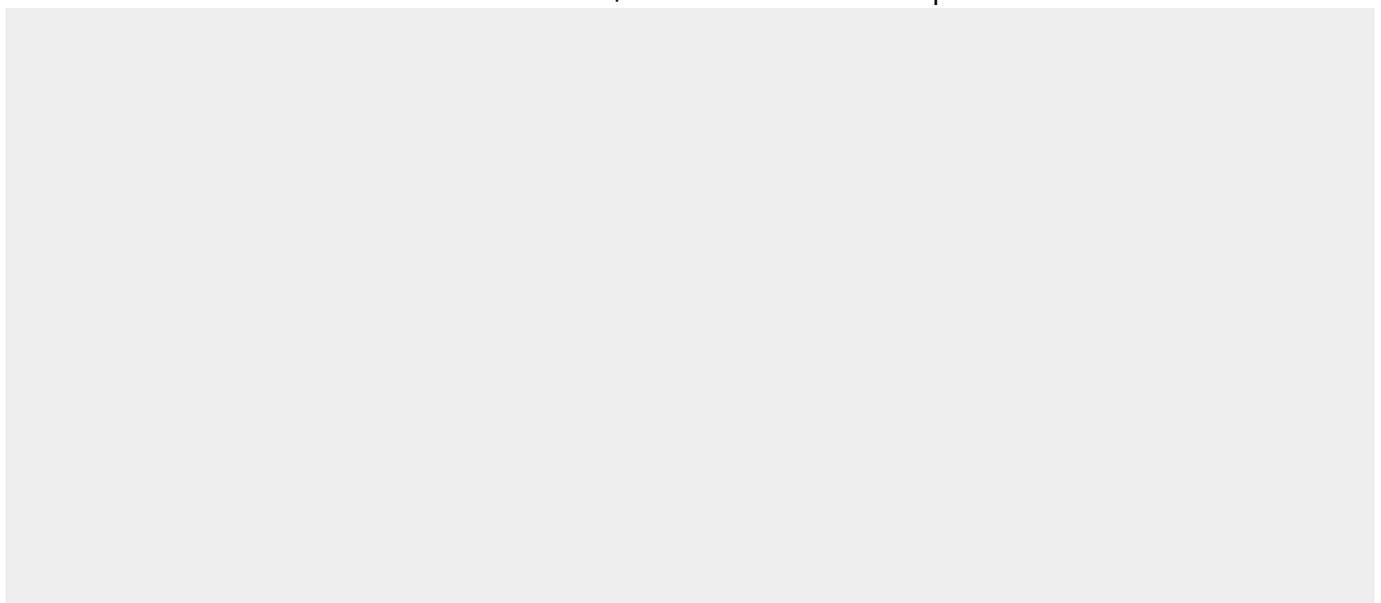
The way of communication between the company and the respective stakeholders is the most important factor to fulfill because it makes the rest of the management part much easier. What they and the company expects and wants from the project must be communicated, understood and agreed upon by them and the company, as well as what their role is in the whole scope of things.

Communication goes way deeper than just summaries about the project progress or some brief text about the situation. Communication can be described by the following points:

- Telling the stakeholders what the company is doing for them and what they are gaining by collaborating with the company.
- Creating a common understanding of the stakeholder's role and desires
- Creating a common understanding of the company's role and desires
- Reporting struggles that were overcome as well as small and big accomplishments that the team made.
- Managing the best time to present a problem that appeared in the making of the project, some stakeholders will want to listen to it as soon as it appears, some will prefer to be notified if the problem is in a situation that is becoming difficult to solve and some only as a last resort.
- Listening to advice or concerns that stakeholders may have is also advisable, although sometimes they might seem useless or inapplicable, the knowledge they might have and inputs from their perspective should be considered. The company has the mission to properly analyze all feedback that comes from the stakeholders and answer with the right information.
- Organization of meetings to talk about issues and challenges to overcome, good and bad things happening in the project and how to continue and to avoid those situations, respectively.

The following table [15](#) summarizes how the relationship with each stakeholder and the company should be.

Table 15: Team/Stakeholder relationships.



STAKEHOLDERS	How to make them happy	How to keep the relationship	Communication Plan	Future Changes
Municipalities	Bringing people to the city, making people come to the streets and enjoy themselves as a community as well as the city	Posters on the streets and continuous promotion of the product with the help of the municipality or even by giving a bonus for the first time a person tries, that will give the first push people usually need to go forward to playing a game that stimulates social interaction	Formal through email	The municipalities will benefit from a better cohesion between their citizens and will promote a happier environment within the city with the increasing number of interactions
Volunteers	Volunteers are happy when they help people so if they can bring joy to the people with giving a little hand, they will be very satisfied	Although volunteers work for free, they can have some rewards/bonus for certain achievements they reach	Informal through WhatsApp or Facebook groups or private message	For a volunteer, what it matters is to see people happy and to feel better after helping someone so the well-being of someone after being in touch with the product will bring joy to the volunteer's life keeping them motivated to help
Parks	Parks are places where people feel free and take some rest from their life in general, if the product can make people have a good time in parks, people will come more often and socialize more each time they return	By introducing the game in parks, parks would be more frequented and a good factor to promote it would be by placing the device with the best background the park has, so the photo is the best the park can offer. Also with the help of promoting the park and what it offers, the relationship will be kept healthy	Through email/WhatsApp/website or any other communication method the park manager prefers	Parks will feel an increased flow of people coming to play the game and to enjoy the nature, both things together will benefit Shift it as well as the park that will be a space that brings people together

STAKEHOLDERS	How to make them happy	How to keep the relationship	Communication Plan	Future Changes
Events	By bringing the people in to an event with the help of our product both of us can win because they have people participating in the event and we have people using our device, this way we can bring together a mix of interests that people have, - playing a game with others and visiting an event, both in the area the event is taking place	With the help of leaflets, posters, social media partnerships between both sides, videos and bonuses, like discounts or coupons. By the continuous posting and promotion of the partnership, people will feel more attracted and more willing to try the game and the event	Through email/WhatsApp/website or any other way of communication the event manager prefers	Events will feel an increased flow of people coming to play the game and to enjoy the program that is planned for it, both things together will benefit Shift it as well as the event owners that will be happy with more people coming to their event
Museums	It will work as an event, the whole point is to bring people to the museum with the help of our device, and the museum brings people to play the company's game so it is a win-win situation	With the help of leaflets, posters, social media partnerships between both sides, videos and bonuses, like discounts or coupons. By the continuous posting and promotion of the partnership, people will feel more attracted and more willing to try the game or the museum	Through email/WhatsApp/website/contact number or any other way of communication the museum manager prefers	Museums will feel an increased flow of people coming to play the game and to enjoy the culture space, both things together will benefit Shift it as well as the museum that will be a space that brings people together

STAKEHOLDERS	How to make them happy	How to keep the relationship	Communication Plan	Future Changes
Restaurants/Coffee Shops	If there is a coupon to a restaurant or a coffee shop after playing the game there will be a beneficial promotion for both sides, SHIFT IT will bring people to the restaurant and the restaurant fans will bring people to the game because they also want a discount	With the help of leaflets, posters, social media partnerships between both sides, videos and bonuses, like discounts or coupons. By the continuous posting and promotion of the partnership, people will feel more attracted and more willing to try the game or the restaurant/coffee shop	Through email/WhatsApp/contact number or any other way of communication the restaurant/coffee shop manager prefers	These ones will feel an increased flow of people coming to play the game and to enjoy the gastronomy or some drinks available, both things together will benefit Shift it as well as the restaurant/coffee shop that will be a space that brings people together
Users(city-goers)	Stimulate social interaction, give them a fun time and positive experience. Keep the game interesting.	Keep on promoting by means of social media and posters of the new versions, different image options available. Make the website very accessible and enable users to see their score ranking and photo. By providing bonuses/coupons for business partners surrounding the public space where the game is installed.	Social media, posters, leaflets, tourism info points, website	The users will be more interested in interacting with other people from then on and will bring on other ones to play the game with them, improving connections between family and friends

With the management of these measures there will be a number of statistics along a certain amount of time, by monitoring those statistics a conclusion will be taken, either the partnership continues because it is beneficial for both sides or the partnership ends.

3.10 Project Plan

Define your optimal sprint duration and plan your sprints until project end using Global Sprint Plan Table 16. The sprint planning is very useful to help create a clear overview of all the tasks that need to be completed by the team and by when. This will help with time management and complying with deadlines so that the team does not fall behind and the project runs smoothly to lead to a successful end-result.

Table 16: Global Sprint Plan

Sprint	Description	Start	Finish
1	Choose project proposal and send in three choices	23-02-2023	26-02-2023
2	Decide on specific project challenge with the help of State of the Art, and complete the first 4 sections of the introduction, as well as the project backlog, global sprint & Gantt chart	27-02-2023	08-03-2023
3	Idea generation and further research, system diagrams and structural drafts	09-03-2023	15-03-2023
4	Trade-off ideas and develop further on one final concept, list of components and materials	16-03-2023	22-03-2023
5	Researching suppliers and available materials, making rough prototypes, technical drawings and system schematics-determine the working of it	23-03-2023	29-03-2023
6	Finalizing all interim deliverables concerning concept (report and presentation)	30-03-2023	16-04-2023
7	Determine the final list of materials,make a 3D model video and produce flyer	20-04-2023	26-04-2023
8	Refine the interim report, work on the packaging solution, start work on software, shop for materials and make corrections and adjustments.	27-04-2023	03-05-2023
9	Work on prototype, adjust paper and make updates and corrections	04-05-2023	17-05-2023
10	Upload final packaging solution make updates and adjustments and finish paper	18-05-2023	24-05-2023
11	Start working on user manual, make updates and corrections	25-05-2023	31-05-2023
12	Finish poster, user manual, work on prototype and make adjustments and improvements	01-06-2023	07-06-2023
13	Hand in all deliverables for final report, finish prototype, carry out functional tests	08-06-2023	18-06-2023
14	Prepare for the final presentation	19-06-2023	22-06-2023
15	Update the wiki, report, paper with all suggested corrections. Refine deliverables and finalize code and drawings	23-06-2023	27-06-2023

Build your project backlog, including all relevant tasks/deliverables, using Project Backlog Table 17. Prioritize all backlog items (PBI), keeping higher priority items at the top, and lower priority at the bottom.

Table 17: Project Backlog.

PBI	Title	Deadline	Status
A	Choose project proposal and send in three choices	26-02-2023	Completed
B	Define project backlog	08-03-2023	Completed
C	Define global sprint	08-03-2023	Completed
D	Define sprint plan	08-03-2023	Completed
E	Release Gantt Chart	08-03-2023	Completed
F	“Black box” System Diagrams	15-03-2023	Completed
G	Structural drafts	15-03-2023	Completed
H	List of components and materials	22-03-2023	Completed
I	Research suppliers and available materials	29-03-2023	Completed
J	Make rough prototypes	29-03-2023	Completed
K	Make structural drawings and system schematics	29-03-2023	Completed
L	Interim report and presentation	16-04-2023	Completed
M	Final list of materials	26-04-2023	Completed
N	Final model/prototype	26-04-2023	Completed
O	Final video	26-04-2023	Completed
P	Refined interim report based on feedback	07-05-2023	Completed
Q	Upload packaging solution	24-05-2023	Completed
R	Functional tests	31-05-2023	Completed
S	Final report and presentation	18-06-2023	Completed
T	Final poster, video and model	18-06-2023	Completed
U	User manual	18-06-2023	Completed
V	Final presentation, Individual discussion and assessment	22-06-2023	To do
W	Update the wiki, report, and paper: Folder with refined deliverables, code, and drawings in MS Teams: Hand in the printed copy of report and poster	27-06-2023	To do
X	Hand in prototype & user manual: Receive EPS certificate	29-06-2023	To do

3.11 Sprint Outcomes

This table 18 provides an overview of the weekly sprints that need to be carried out by the team. Within each sprint there are certain tasks that the team decided to do based on which tasks had the highest priority. This sprint planning makes it clear how much time the team has allocated to complete tasks and who is responsible for each task. This will provide clarity for team members and help with time management.

Table 18: Sprint Planning.

23/02/2023 - 26/02/2023

Sprint	Tasks	Estimated duration (hours)	Actual duration (hours)	Responsible	Involved	Status
1	Selection and sending of top 3 project proposals	24 h	48 h	LH, AF	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 126 h **Planned capacity** = 24 h **Real velocity:** = 48 h

27/02/2023 - 08/03/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
2	Decide on specific challenge	52 h	53 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Sprint plan	1 h	1 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Gantt chart	1 h	1 h	AF	LH, FL, AF, SS, EB, AT	Completed
	Project backlog	1 h	1 h	LH	LH	Completed
	Complete presentation, motivation, problem description and objectives of introduction	3.5 h	3.5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 63 h **Planned capacity** = 62 h **Real velocity:** = 63 h

09/03/2023 - 15/03/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
3	Competitor analysis	5 h	5 h	FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Logo and name	8 h	5 h	LH, EB, AF	LH, EB, AF	Completed
	State of the Art	24 h	21 h	AF, LH, FL	AF, LH, FL	Completed
	Market analysis	24 h	22 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Idea generation	24 h	24 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Systems diagram- software, hardware, design	2 h	4 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Structural drafts	8 h	8 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 106 h **Planned capacity** = 95 h **Real velocity:** = 90 h

16/03/2023 - 22/03/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
4	Research list of components and materials	8 h	11 h	AT, SS, EB	LH, FL, AF, SS, EB, AT	Completed
	Idea trade of	2.5 h	5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Develop final concept	24 h	24 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 46 h **Planned capacity** = 34.5 h **Real velocity:** = 40 h

23/03/2023 - 29/03/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
5	Research suppliers and available materials	12 h	12 h	FL, AT, EB	LH, FL, AF, SS, EB, AT	Completed
	Rough prototypes	12 h	12 h	LH, AF, SS, AT, EB, FL	LH, FL, AF, SS, EB, AT	Completed
	Technical drawings	12 h	12 h	AT, LH, AF	LH, FL, AF, SS, EB, AT	Completed
	System schematics	12 h	14 h	SS, AT	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 120 h **Planned capacity** = 48 h **Real velocity:** = 50 h

30/03/2023 - 16/04/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
6	Interim Presentation	20 h	20 h	AF, FL, LH, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Correction of ethics for interim report	4 h	3 h	FL	FL	Completed
	Correction of sustainability for interim report	4 h	3 h	AF	AF	Completed
	Correction of Project development for interim report	4 h	3 h	LH	LH	Completed
	Correction of introduction for interim report	4 h	4 h	AT	AT	Completed
	Correction of Project management for interim report	4 h	3 h	FL, AT	FL, AT	Completed

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
	Correction of marketing plan for interim report	4 h	4 h	SS, EB	SS, EB	Completed
	Correction of flow charts for interim report	4 h	3 h	AF, SS	AF, SS	Completed
	Correction of table headings for interim report	3 h	3 h	LH	LH	Completed
	Correction of references for interim report	4 h	4 h	FL	FL	Completed

Available capacity-buffer = 106 h **Planned capacity** = 61 h **Real velocity:** = 56 h

20/04/2023 - 26/04/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
7	Final list of materials	5 h	5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Adjust leaflet	3.5 h	3.5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	3D model video	8 h	24 h	LH, AT	LH, AT	Completed
	Adjustments to report	6 h	5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed
	Make flyer	5 h	5 h	LH	LH	Completed

Available capacity-buffer = 156 h **Planned capacity** = 28 h **Real velocity:** = 43h

27/04/2023 - 03/05/2023

Sprint	Tasks	Estimated Duration (h)	Actual duration (h)	Responsible	Involved	Status
8	Refine interim report	12 h	12 h	AF, FL	AF, FL	Completed
	Shop for materials and prices	5.5 h	5.5 h	LH	LH	Completed
	Adjust solidworks model	2.5 h	2.5 h	LH	LH	Completed
	Look for electrical components for SolidWorks	1 h	1 h	LH	LH	Completed
	Adjust list of materials with quantity and prices	3.5 h	3.5 h	LH, SS, AT	LH, SS, AT	Completed
	Adjust Project management section	10 h	11.5 h	FL	FL	Completed
	Work on software for prototype	3 h	3 h	SS	SS	Completed
	Assembly of final product	4 h	4 h	AT	AT	Completed

Sprint	Tasks	Estimated Duration (h)	Actual duration (h)	Responsible	Involved	Status
	Work on the design of different packaging solutions	12 h	12 h	EB	EB	Completed

Available capacity-buffer = 132 h **Planned capacity** = 55.5 h **Real velocity:** = 57 h

04/05/2023 - 17/05/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
9	Work on bottom mechanism for prototype	6 h	6 h	LH, FL	LH, FL	Completed
	Write on paper	5 h	5h	FL	FL	Completed
	Work on software for prototype	6 h	6 h	SS	SS	Completed
	Adjust technical drawings	3 h	3 h	AT	AT	Completed
	Complete renders and user journey	5 h	5 h	LH	LH	Completed
	Make corrections to the report	12 h	9 h	AF	AF	Completed
	Updating and correcting project management	4 h	4 h	FL	FL	Completed

Available capacity-buffer = 144 h **Planned capacity** = 40 h **Real velocity:** = 37 h

18/05/2023 - 24/05/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
10	Final packaging solution	12 h	12 h	EB	EB	Completed
	Update and correct project management	4 h	4 h	FL	FL	Completed
	Write and update on the paper	6.5 h	6.5 h	LH	LH	Completed
	Create user journey sketch	5.5 h	5.5 h	LH	LH	Completed
	Make improvements on exploded views	1 h	1 h	AT	AT	Completed
	Edit pictures for updated leaflet	2.5 h	2.5 h	LH	LH	Completed
	Prepare presentation for marketing plan	4 h	5 h	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Completed

Available capacity-buffer = 138 h **Planned capacity** = 40 h **Real velocity:** = 41h

25/05/2023 - 31/05/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
11	Add references in paper	4 h	4h	FL	FL	Completed
	Update and correct project management	1.5 h	1.5 h	FL	FL	Completed
	Finish 3D model video	9.5 h	9.5 h	LH	LH	Completed
	Fetch materials from store	3 h	3 h	LH, AT	LH, AT	Completed
	Make corrections to Swot analysis in report	2 h	2 h	AF	AF	Completed
	Finish 3D model video	9.5 h	9.5 h	LH	LH	Completed
	Start working on the packaging for gaslift	3.5 h	3.5 h	EB	EB	Completed
	Project management refinement in Wiki report	4 h	4 h	AT	AT	Completed
	Write on user manual	8 h	9 h	FL, AT	FL, AT	Completed
	Fix exploded views for rendered video	0.5 h	0.5 h	AT	AT	Completed

Available capacity-buffer = 60 h **Planned capacity** = 40 h **Real velocity:** = 41 h

01/06/2023 - 07/06/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
12	Finish writing part of user manual	16 h	16 h	AF, AT, FL , LH	AF, AT, FL , LH	Completed
	User manual layout	3 h	4 h	LH	LH	Completed
	Finish poster	5.5 h	5.5 h	LH	LH	Completed
	Edit paper and make corrections	7 h	8 h	AF, AT, FL , LH	AF, AT, FL , LH	Completed
	Build wooden frame for prototype	12.5 h	12.5 h	AT, LH	AT, LH	Completed
	Software development	17 h	17 h	SS	SS	Completed
	Update project management	2 h	2 h	FL	FL	Completed
	Packaging for gaslift	2 h	3 h	EB	EB	Completed
	Write Description of principle for all packaging parts	2 h	2 h	EB	EB	Completed

Available capacity-buffer = 118 h **Planned capacity** = 69 h **Real velocity:** = 72 h

08/06/2023 - 18/06/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
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Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
13	Make final presentation	3 h	5 h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	Completed
	Transfer data from one note to wiki for project management	10 h	11 h	FL	FL	Completed
	Edit and finish wiki report	10 h	13 h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	Completed
	Finish and upload manual	4 h	6 h	LH	LH	Completed
	Finish of software	14 h	17 h	SS	SS	Completed
	Carry out functional tests	3 h	3 h	FL	FL	Completed
	Submit final deliverables	1 h	1 h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	Completed
	Make and submit final video	7 h	7 h	AF, AT, FL , LH, SS,	AF, AT, FL , LH, SS,	Completed

Available capacity-buffer = 176 h **Planned capacity** = 52 h **Real velocity:** = 63 h

19/06/2023 - 21/06/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
14	Rehearse for final presentation	24 h	- h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	To do

Available capacity-buffer = 94 h **Planned capacity** = 24 h **Real velocity:** = - h

22/06/2023 - 28/06/2023

Sprint	Tasks	Estimated Duration (hours)	Actual duration (hours)	Responsible	Involved	Status
15	Make changes according to suggestions of professors	12 h	- h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	To do
	Hand in final code and prototype	1 h	- h	AF, AT, FL , LH, SS, EB	AF, AT, FL , LH, SS, EB	To do

Available capacity-buffer = 100 h **Planned capacity** = 13 h **Real velocity:** = - h

Review each sprint at its end and update each item status on the Progress Register Table [19](#). This table helps the group keep track of what has been done, what still needs to be done and what is in progress. It also helps check that every member is doing what they are responsible for.

Table 19: Project Progress Register for the PBI from table 18.

PBI	Responsible	Involved	Status
A	LH, AF	LH, FL, AF, SS, EB, AT	Done
B	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
C	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
D	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
E	AF	LH, FL, AF, SS, EB, AT	Done
F	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
G	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
H	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
I	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
J	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
K	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
L	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
M	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
N	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
O	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
P	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
Q	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
R	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
S	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
T	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
U	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	Done
V	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	In progress
W	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	In progress
X	LH, FL, AF, SS, EB, AT	LH, FL, AF, SS, EB, AT	In progress

3.12 Sprint Evaluations

By doing sprint evaluations, teams can pinpoint their advantages and disadvantages, take note of their errors, and modify their strategy to perform better in subsequent sprints. Team morale and motivation can be raised by giving teams a chance to reflect on their accomplishments and celebrate their achievement at sprint reviews. Our evaluation can be concluded in the following table 20.

Table 20: Sprint Evaluation

Sprint	Positive	Negative	Start Doing	Stop Doing	Keep Doing
1	Completed all tasks within sprint timeframe.	-	-	-	Communicate on our expectations and abilities

Sprint	Positive	Negative	Start Doing	Stop Doing	Keep Doing
2	Created a well-defined project backlog and sprint plan. Developed a detailed gantt chart	Difficulty in estimating timelines for certain tasks.	Break down larger tasks into smaller ones for more accurate estimates.	-	Monitor our progress with the use of Gantt chart
3	Successfully created a “black box” diagram and structural drafts.	Some difficulty in determining key components of the system.	Conduct more detailed analysis to identify key components.	-	-
4	Completed a comprehensive list of components and materials needed for the project.	Difficulty with making decisions on final materials	Research alternative materials	-	-
5	Conducted thorough research on suppliers and materials. Developed rough prototypes and structural drawings.	Difficulty in sourcing certain materials.	Research alternative suppliers.	-	Continuously monitor availability of materials and communicate with suppliers.
6	We finished all of our work in time and presented a good interim presentation.	We had a few things that could have been changed in the report for the Interim report.	Use the correct way of formatting in the report.	-	Using the planner.
7	We made a great 3D model video for our project and updated our leaflet with better colours.	The collection of list of materials wasn't still done according to the request of the professors.	Plan more ahead to be as efficient as possible.	We have a good team spirit and get along really well together and looking forward to developing the project.	We should stop procrastinating with the electronic schematics.
8	We got a lot of work done this week and made good progress with our project.	We could have inserted more tasks from the backlog into this week but we had one week of holiday and wanted to get the most out of it.	-	-	We should keep up the good communication in the group to be as efficient as possible.

Sprint	Positive	Negative	Start Doing	Stop Doing	Keep Doing
9	We started to work on our prototype and our software is progressing in a nice pace.	We are a bit behind with the packaging solution and are struggling to find some variables that we need to calculate the stress factor for cardboard.	Be a little bit more effective with our work.	-	We should continue to use planner to optimise our sprints.
10	We are progressing with everything and our leaflet is now completed and the marketing section of our report is completed.	We are a bit behind with the packaging solution and are struggling to find some variables that we need to calculate the stress factor for cardboard.	We should start working on the User manual and finish of the paper.	-	We should keep the team morale high and continue with our good work.
11	We went and fetched our materials so we could start working on the upper part of the prototype. We also finished off the bottom part of the prototype.	We have still not gotten our programming to work so hopefully we will sort that out until the next sprint.	We should start working on the promotional video so it does not get stressful in the end.	We had a lot of smaller tasks this week which we could have taken into account and added more tasks.	We should keep the team morale high and continue with our good work.
12	We finished of the writing part of our user manual and the packaging of our product is now finished.	We have still not gotten our programming to work so hopefully we will sort that out until the next sprint.	We should start working on the promotional video so it does not get stressful in the end.	-	We should keep the team morale high and continue with our good work.
13	We finished everything before the deadline and are now finished with our project and all of the programming is now working.	-	Focusing on delivering a good final presentation.	-	We should keep up the good team spirit until the end.

3.13 Conclusion

Project management is essential in any project made, with this chapter the team learnt that the establishment of simple principles in the team will provide an easier way of working and communicating, therefore, a nice environment of work will be created, and people will be much happier and more efficient.

There is also a very important factor, that is the prevision of possible dangers or risks the company might have, the more developed this work is, the better the company will react to the barrier that might appear. If a team of workers is already expecting that something will happen, the team will prevent and avoid the problem or, if it eventually happens, the team will be ready to face it, which is a factor that differentiates the better teams and the ones that are average or below.

To conclude, this chapter is a big pillar in the project because the core of the project is its management. A good management of it will improve the results and the well-being of all the entities involved.

4. Marketing Plan

4.1 Introduction

In the market analysis, the theory learnt during the module 'Marketing', is applied to the concept of the team's project. In this case, it is about analysing the specific target market our project is directed at, as well as the competitors of the concept. This means looking at other companies, services and products that offer added value in the same or similar field as the team's concept-a product(puzzle-game) that stimulates social interaction in public spaces. The competitors with products or services that offer the same or similar benefits as our design and could be potential substitutes, were compared in a matrix. How they promoted their products/services, the added value they were offering to customers, the price-range etc, were researched and compared.

The team then focused on researching and defining the project's hypothetical micro-environment; including the potential suppliers and buyers, who the consumers would be and which threats exist from alternative substitute products. Looking at the way other companies promote their products to reach their target market will help the team determine which communication channels will be best to bring our concept onto the market and known to the public.

The team company's macro-environment was also investigated, including the overall context in which the product will be placed. The PESTEL analysis was carried out to help identify the threats and the aspects we will need to deal with. A SWOT analysis was also carried out to clarify the company's strengths, weaknesses, opportunities and threats. Identifying these aspects will help the company know what needs to be improved, exploited and considered when describing the business plan in order to have the most chance of success.

Finally this market analysis will be used to help define the marketing plan and business strategy of the team's company.

4.2 Market Analysis

Company's micro-environment:

Identifying the target market/market segment:

'Shift it' is a company that produces and offers a product and service to events, team building workshops and municipalities of cities to help stimulate social interaction between people in public areas. With this concept, the company wants to encourage people of all ages, nationalities, cultures and capabilities to engage in a fun puzzle type of game that motivates people to collaborate or compete with others in their surroundings and in this way stimulate social interaction in public environments mainly within the city.

Potential buyers and suppliers:

When looking into the possible customers for the 'Shift it' there is two different types that has to be taken into consideration. First we have to look at who we would sell 'Shift it' to in the first place and then have a deeper dive into who would use it when it is installed.

When considering the potential buyers for our game, several options are available. One of the primary targets is urban areas, such as the city of Porto. Installing our game in one or multiple parks could enhance the city's appeal and attract more visitors. However, our customer base is not limited to cities alone. We can also market the game to major event organizers, such as large festivals, art exhibitions, and museums. Incorporating our game into these events can diversify the entertainment options available and enhance the overall experience for attendees.

The consumers of 'Shift it' in a public park would likely be the visitors to the park who are looking for recreational activities and entertainment. This could include a diverse group of people of different ages and backgrounds, such as families with children, teenagers, young adults, and seniors.

'Shift it' is installed to appeal to a broad audience or cater to specific interests, such as competition interaction and puzzle-solving. The game is also free to play which makes it even more attractive for people visiting the park. Down below is a list of possible customers.

- **List of potential customers:**

- **Families with children:** Families with young children could be a significant consumer group for the game. Parents may be looking for ways to keep their children entertained while they enjoy a relaxing day out in the park. The games could be designed to be family-friendly and inclusive, catering to a wide range of ages and abilities.
- **Teenagers and young adults:** Teenagers and young adults may also be interested in the game installed especially if they are designed to be competitive and challenging. These consumers may be looking for ways to socialise with their peers while engaging in fun activities. The game could be designed to allow for multiplayer or team-based gameplay, encouraging socialisation and teamwork.
- **Seniors:** Seniors could also be a consumer group for games installed in public parks or similar areas, especially if the games are designed to be low-impact and accessible. Games that promote physical activity and cognitive stimulation could be especially attractive to this consumer group, who may be looking for ways to stay active and engaged.
- **Tourists:** Tourists visiting a city or town may also be interested in games installed in public parks as a way to explore and engage with the local culture. The game is designed could be

designed to provide a fun activity while walking in the park and to create a memory.

- **Local residents:** Local residents may also be interested in a game installed in public parks or similar areas, especially if the game is designed to be updated regularly or have seasonal themes. This could encourage repeat visits to the park and create a sense of community around the game.

Overall, the consumers of our game could be a diverse group of people with different interests and motivations for visiting the park. The key to creating a successful game would be to design it in a way that appeals to a wide range of people while providing a unique and engaging experience. But if we really had to target one market or one specific kind of people, I think it would be people between the ages of 7-60 years old. It does not matter if they are tourist or local residents but because they way that are game is built up you still need to be a little technologically gifted to take the picture and be able to start the game. On the other hand it could also be a problem for children under 7 years old because it takes some thinking to solve the puzzle and children under 7 might become bored and or frustrated if they can't figure out how to solve it.

Looking more into the tourists that visits Porto and the north in 2022 between January and September they accumulated value of 2.251 million guests leading the ranking at the national level. They recorded 4.156 million overnight stays between in the same period and accumulated 48.5 million euros in revenue in just overnight stays.

Generally, a tourist that visits Porto spends about 92 € a day while staying in Porto this does not include accommodation which usually costs about 70-150 € a night. A tourist usually stays 2.78 days in Porto. But if you really want to save money you can get by on around 55 € a day. Most of the tourists that visit Portugal and Porto are from Spain and the UK with Germany and France following closely.

Competitor analysis:

An analysis into those who serve a target market with similar products and services as the team's company will not only help identify the threats, but also help the team determine where in relation to competitors they should position themselves on the market- what our company should offer in order to gain a strategic advantage over these other organisations. Looking at how others do things can help identify the best ways for our company to proceed. The company has to decide what added value they can offer to clients that will provide benefits that other companies do not provide to the target group.

The competitor analysis includes the following table 21:

In this table, every competitor of our company is listed and compared with respect to several characteristics.

*Competitor matrix:**

Table 21: Competitor analysis and comparison

COMPETITOR ANALYSIS	Street Furniture Australia	Parkrun	The Music Center	Happy City	Better Block Foundation	The Urban Conga	Project for Public Spaces	The Good Gym	SHIFT IT
Pricing for people	Free	Free	Free or paid	Free	Paid	Free	Free	Free	Free
Places	Parks, Public Spaces	Parks, Cities	In the company building	Urban Areas	Urban Areas	Urban Areas, Public Spaces	Urban Areas, Public Spaces	Parks, Public Spaces	Parks, Public Spaces
Promotion	Website/Social Media	Website/Social Media	Several Websites/Social Media/Posters	Website/Social Media	Website/Social Media	Website/Social Media	Website/Social Media	Website/Social Media	Website/Social Media/Posters/Leaflets
Positioning*	+++	++	++	++	++	+++	+++	+++	+++
Reputation*	+++	+++	+++	+++	++	+++	+++	+++	+++
People	Everyone	Fitness People	Everyone	Everyone	Everyone	Everyone	Everyone	Fitness People	Everyone

COMPETITOR ANALYSIS	Street Furniture Australia	Parkrun	The Music Center	Happy City	Better Block Foundation	The Urban Conga	Project for Public Spaces	The Good Gym	SHIFT IT
Partnerships	Government	1	6	Team of employees	Team of employees	City Municipalities	9	2	Municipalities, Volunteers, Parks, Events, Museums

*In these points, the team took information from the internet like comments or reviews with and reduced them to these symbols: "+++" meant that they were excellent and "++" means that they were very good but they had some things to improve.

- Emotional branding – value of a brand for a customer People have to go along with the company’s product, an emotional attachment to the product will bring people back to it and will keep people into it all the time, inviting people around them to join. The game/activity must be something that sparks something new to the person, therefore, has to be innovative, never seen before and with different things to try on, so that person can have some different experience from those the person has in the daily life.

- Perceived value – emotional and functional utility In this area, people would only pay for the product if they had something big in return. But, in the end, the product is bought by the municipality that wants to bring people together and wants to create a better community. A price of a product must be proportional to the amount of interaction brought and to the happiness of people with using the product.

- What is a good price – not too high, not too low – depends on the service A good price for these types of companies would be given their products to the public for free because if their objective is to promote public interaction they will not succeed if they ask for some money from the people, if so, the majority would not even try their product.

Threats from substitute products/services:

Threats from other companies would be if they provide similar products-the so called 'substitute' product for our own product-to the same or a similar target group as our company. Our product includes an interactive combination of a game and a puzzle for people to participate in outdoors. (Our target group is very broad.) The biggest threat to our company is if people from our target group make use of the 'substitute' products/services from these other businesses instead of our own. It is therefore important to identify these 'substitute' products, so that we can ensure that we design and create our product to be unique, offering added value and benefits to the target market that these substitute products do not. In this way we can gain more clients for our company.

Our product:

A photo shoot for people to take a picture that they cannot see, which will then be scrambled upon a screen. The users have to then solve a sliding puzzle with physical pieces in order to unscramble the on-screen puzzle in as little time as possible. They have to collaborate with others and compete against other teams to get the shortest time, fewest moves and be the highest on the ranking. Only once the puzzle is completed will the original photo be revealed. The ranking, scores and times can be seen on the website. It is more of a mental challenge than a physical one, and integrates technology with a mechanical, physical construction.

Substitute products include:

- Outdoor jungle gyms and playgrounds
- Outdoor gyms
- Interactive digital walls

- Outdoor games like giant chess or “4 in a row”
- Outdoor table tennis
- Petanque
- Outdoor cultural events like performances
- Digital gadgets like phone, gaming console, tablet
- Books
- Games like KUBB or Ring toss

Competitor matrix: Threats from substitute products/services, (Refer to Table 22)

This table compares several substitute products and services/activities that people could use or participate in instead of using our company's product. In this way they are competing against the team's product, and therefore it is useful to identify and analyse them in order to see how our company can learn and improve from what is already available on the market.

Table 22: Substitute analysis

Product	Requires interaction	Mental effort required	Action required	Accessible to all	Requires lots of space	Has loose components	competition	Physical/tech combi
Jungle gyms	No	No	Yes	No	Yes	No	No	No
Outdoor gyms	No	No	Yes	No	Yes	No	No	No
Interactive walls	Not really	Depends	depends	Yes	Depends	No	No	Yes
Giant chess	Yes	Yes	A bit	Yes	Depends	Yes	Yes	No
“4 in a row”	Yes	Yes	A bit	Yes	No	Yes	Yes	No
Table tennis	Yes	No	Yes	No	Yes	Yes	Yes	No
Petanque	Yes	No	Yes	Depends	Yes	Yes	Yes	No
Cultural events	No	No	No	Yes	Depends	Depends	No	No
Phone, tablet	No	Depends	No	Depends-mostly yes	No	No	No	No
Books	No	Yes	No	Yes	No	No	No	No
KUBB	Yes	No	Yes	Depends	Yes	Yes	Yes	No
Ring toss	Yes	No	Yes	Depends	Yes	Yes	Yes	No
Shift it	Yes	Yes	A bit	Yes	Middle	No	Yes	No

The different substitutes all score well on some and not on others. It is impossible to have the perfect solution. From the table we can see that our company's product is most similar to “4 in a row” or giant chess, but that it is unique in the way that it does not have loose components. This is good because then there is no chance for theft or lost pieces. It is also good that it does not require a big playing field like many other competitive games such as Kubb or Ring toss.

The other plus point is that it provides a mental challenge with physical actions, but the physical activity is not extreme. This makes it more inclusive for all than the more sporty alternatives. A major unique and innovative difference between “Shift it” and the substitute products is how it combines technology and mechanical, physical components. This will spark curiosity and make it interesting for all generations.

As a conclusion, one could say that the biggest threats for our company's product, are competitive

games that can be played outdoors.

Emotional branding of competitors:

This includes research into how other companies brand and promote themselves so that customers then attach value to these brands making them more likely to purchase products or services from these companies.

Benefits/added value:

A look into what the benefits are of the products and services offered by competitors. What the added value is of these products /services for the customer. This is important because people do not just buy any product or service. They buy what that product/service can uniquely offer them or benefit them in a way that competitors do not. These benefits are not just functional but also emotional, and it is the emotional benefits offered that often influences customers to purchase from a specific company rather than its competitors. This research will help our company identify and describe what we can offer and how we can offer and promote it in order to provide unique functional but more importantly emotional benefits to our customers that are different to competitors. Emotional benefits are more influential on sales because they include emotional attachment of customers to the brand, which leads to customer loyalty.

Price analysis:

The price of a product or service cannot be too high, otherwise people will not buy, but it can also not be too low otherwise people will start to question the quality of what is offered and not trust the company enough to buy from them. A lot can be learnt from how others price themselves.

Identifying the price for our company is difficult because the service of playing the game will be offered for free to people participating in the game. The institutions who will be buying our concept would be more the organisers of public events or local municipalities who want to provide their customers or citizens with a fun and socially interactive experience, and in this way attract more clients or public interest in their event or city. Attracting more people to their areas would be the benefit they would gain by investing in the company's product/service.

The willingness of business to purchase our product/services and the willingness of consumers to use it, depends on how our company portrays the product to the market and how the value proposition is promoted. That is why the branding and positioning of our company is so important, because only if our buyers and users are willing and able to buy our product/service will we sell.

Distribution/communication channels:

Based on how other company's do it, our company can decide what the best way is to reach the consumers and promote our brand to the target market in order to communicate to them what we as a company are offering. The company has to decide how they want to portray their product/service to the market and how they will promote their value proposition.

The promotion of products through technology can be achieved via various methods, such as social media marketing on platforms like Facebook, Instagram, Twitter, and LinkedIn. This can include the creation of ads, sponsored posts, or influencer collaborations to showcase the product to the intended audience. Another approach is content marketing, which involves creating content highlighting the product's features and benefits, such as blog posts, videos, or podcasts. This content can then be promoted via email marketing, social media, or other online channels.

Search engine optimisation (SEO) is a technique that involves optimising a website and product pages to rank at the top of search engine results pages (SERPs) when users search for relevant keywords. This can help to reach a wider audience and drive more traffic to the website. Pay-per-click (PPC)

advertising is also an option, which involves creating ads that appear at the top of search engine results pages or on other websites. The cost is incurred only when a user clicks on the ad, making it a potentially cost-effective way to manage marketing budgets.

Influencer marketing involves partnering with influencers or bloggers in a particular industry to promote a product to their followers. This can help to reach a highly engaged audience and build credibility for the product. Email marketing is another approach that can be used to promote a product to existing customers or subscribers. Targeted campaigns can be created to showcase the benefits of the product and encourage users to make a purchase. Finally, affiliate marketing involves partnering with other websites or influencers to promote a product and offering them a commission for every sale that they refer to the website. This can be a beneficial approach to leverage the reach of other platforms and influencers to expand the product's customer base. Video Marketing: One can utilise video marketing to showcase the features and benefits of the product. Creating product videos and promoting them on platforms like YouTube, Vimeo, or TikTok can be a highly engaging and effective way to promote a product.

Webinars: Hosting webinars can be a useful tool to educate potential customers on the product and how it can benefit them. Webinars can be promoted via email marketing, social media, or other online channels, and can provide a platform for engaging with potential customers in real-time.

Podcasts: Creating a podcast can be another effective way to promote a product. Podcasts can feature discussions about industry trends, interviews with experts, or even product demos. Promoting the podcast on social media or other online channels can help to build a loyal following and generate interest in the product.

Trade Shows and Exhibitions: Attending trade shows and exhibitions can be an effective way to showcase a product to a targeted audience. One can display the product, provide product demos, and distribute marketing materials like brochures, flyers, and business cards.

Direct Mail: Direct mail marketing involves sending printed marketing materials like postcards, flyers, or catalogs directly to potential customers via postal mail. This approach can be highly targeted and cost-effective, particularly for reaching local customers.

Outdoor Advertising: Outdoor advertising, such as billboards, bus stop ads, or street signs, can be a highly visible and effective way to promote a product to a wide audience. This approach is particularly effective in high-traffic areas like city centers, highways, or popular tourist destinations.

Product Sampling: Offering product samples to potential customers is a highly effective way to generate interest in a product. One can distribute samples at trade shows, exhibitions, or in-store promotions. This approach can help customers to experience the product first-hand, and potentially lead to future purchases.

Branded Merchandise: Branded merchandise like t-shirts, hats, or keychains can be a highly effective way to generate brand awareness and promote a product. One can distribute these items as free gifts at trade shows, exhibitions, or in-store promotions.

Company's macro environment: This includes the overall context in which the product will be placed, as well as the PESTEL and SWOT analysis.

Context:

'Shift it' is a company that provides a combination of a product and service to event organisations, businesses who want to do team building, museums, parks, municipalities etc, who want to stimulate more social interaction between visitors in public spaces. 'Shift it' provides these entities with the

service to purchase or rent their interaction-stimulating games to attract visitors, provide positive experiences and create a more social environment. It is a company that provides a type of entertainment for people outdoors, in which they can meet others, collaborating and competing with each other in a fun, interactive challenge. The context of the company is therefore in the outdoor entertainment industry for public spaces in the city. The company provides a unique experience to users and want to promote collectivism, society, awareness of others and the environment and fun. The brand must be known for creating quality, interactive outdoor games with a twist, that encourage people to go beyond the boundaries and interact with each other in a fun, comfortable way. It stands for being all-inclusive with a universal design so that every city goer no matter their language, age or culture, can participate.

Possible contexts to install the game include parks, public squares, playgrounds and other open areas like wide streets where no cars pass, where many people walk, pass through or visit during their trips through the city. The idea is to get people away from their screens, earphones and other technological gadgets while they are outdoors, so that they can enjoy their surroundings and the company of others. This can hopefully lead to a more communal atmosphere instead of one of isolation.

The Product consists of the actual puzzle game that will be installed in the public space, and it will be accompanied by an app that will provide extra information about the public space, the amount of people who have played the game and the player's time taken, score, ranking and photo if they wish to share this. The puzzle that must be solved is that of a photo the users take of themselves and the environment in which they find themselves, which then gets jumbled up. They must then solve the puzzle as fast as possible-competing against others to see what the photo looks like. The photo of the first team to complete the puzzle will appear on the screen. Collaboration and competition are incorporated in the context to encourage people to socialise and put their technical gadgets away for a while. Having to solve a puzzle to see the photo motivates participation because people are by nature curious and want to see what the photo looks like.

The present context that 'Shift it' wants to challenge is that of a more individualistic society in which people share public spaces together but because they are so often in their own digital world, or shy to approach others or simply find it strange to speak to someone they do not know, they do not notice each other or the space in which they are in. Hardly no interaction or communication takes place between people in the same space, and this is what 'Shift it' wants to change.

The PESTEL analysis below is done to provide a clear overview of the overall context in which the product/service will be placed.

PESTEL:

A PESTEL analysis, (Refer to Figure 16), studies the key external factors that influence an organisation. These factors being: Political, Economic, Sociological, Technological, Environmental and Legal.

The PESTEL Analysis Political is to analyse the policies and regulations that may affect the implementation of the game, such as restrictions on the use of resources, taxes and subsidies, and applicable laws and regulations. This helps identify potential opportunities and risks that the game may face.

The "E" of "Economic" in the PESTEL analysis for an outdoor game is to examine the external economic factors that can influence it, such as the interest rate, material price fluctuations and taxes.

The Sociological part of the PESTEL consists in analysing the social and cultural trends that can

influence the market, such as lifestyle changes, income level, consumer preferences and purchasing behaviour.

The 'Technological' part of PESTEL is to analyse current and future technologies that can have an impact on our game, such as new entertainment technologies, management systems and new methods of communication. These technologies can be used to improve the customer experience and improve operational efficiency.

The 'Environmental' part of PESTEL is to analyse the environmental factors that could have an impact on our game, such as environmental regulations, climate change, weather conditions and natural resources. In addition, it analyses the impact the game could have on the environment, particularly in terms of energy consumption and waste generation.

The "Legal" part of PESTEL consists in identifying the laws, regulations and regulations that may affect gambling. This may include laws on hours of operation, taxes on goods and services, licences and permits, and safety and health standards. In addition, it is important to understand consumer protection rules and regulations.

Pestel analysis:

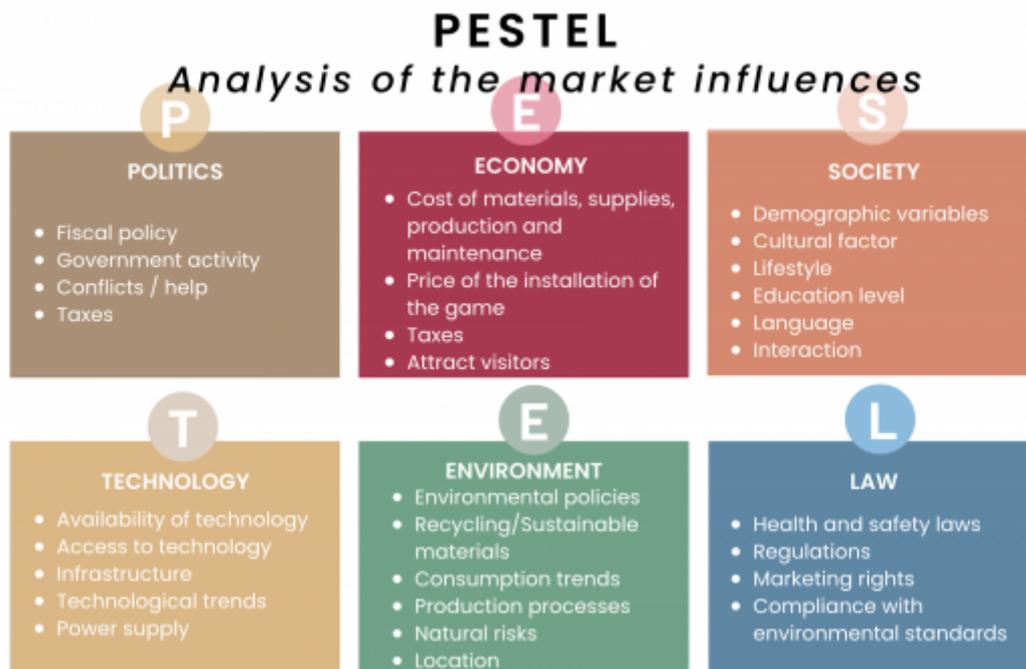


Figure 16: PESTEL Analysis

4.3 SWOT Analysis

A SWOT analysis, (Refer to Figure 17), is a strategic planning tool that helps individuals and organizations identify their strengths, weaknesses, opportunities, and threats (SWOT) related to a specific goal or situation. The purpose of a SWOT analysis is to help individuals and organizations develop strategies to leverage their strengths, address their weaknesses, capitalize on opportunities, and mitigate threats.

Swot analysis:



Figure 17: SWOT analysis

4.4 Strategy

4.4.1 Strategic Objectives

A good marketing strategy should be used to maximise the company's chances of success and lead it towards new development opportunities.

The marketing strategy of 'Shift it' must focus on the fact that the product will satisfy the needs of our customers, and on developing profitable long-term relationships with these customers.

The purpose of the marketing strategy is to identify and communicate the benefits of the 'Shift it' offerings to the target market. After creating and implementing the strategy, the company needs to monitor its effectiveness and make any necessary adjustments to ensure it continues to be successful.

Strategic Objectives

The following are some specific strategic marketing goals for 'Shift it', which seeks to provide a puzzle game that fosters social interaction in public settings like government or municipal areas:

Boost brand recognition: As a new product on the market, the main goal is to raise awareness of the sliding puzzle game. It could be accomplished by forging a strong brand identity, designing that catches the eye, and implementing digital marketing techniques like social media ads and influencer

marketing.

Increase customer base: In order for 'Shift it' to grow, it must increase the consumer base beyond the initial target market. This can be done by carrying out market research to find new target markets, creating new product features that appeal to a larger market, and utilising a combination of online and offline promotional channels.

Make the business a thought leader in the industry: 'Shift it' needs to position its business as a thought leader in the area of sociability in public spaces if it wants to earn credibility in the market. This can be done by producing educational content, such as blog posts and white papers, that demonstrates the subject-matter knowledge and competence.

Create strong customer ties: Maintaining clients and developing recurring business need the creation of strong customer relationships. This can be accomplished by providing top-notch customer service, designing loyalty programs that honour recurring purchases, and often interacting with customers via social media and email marketing.

Drive sales and income: The marketing goals should ultimately seek to increase sales and revenue. Setting sales goals, creating marketing campaigns, and monitoring our marketing data to find areas for development will help the company.

Know how to differentiate ourselves from the competition: For a company operating in a competitive environment, the aim of the marketing strategy will be to differentiate it from competitors. Indeed, 'Shift it' must know how to stand out from its competitors in order to attract the attention of customers and prospects. In this way, it can attack and expect a greater market share. This can be achieved through various marketing strategies, such as offering additional services, offering innovative services, etc.

SMART objectives

SMART is an acronym that stands for Specific, Measurable, Achievable, Relevant, and Time-bound. SMART goals are commonly used in marketing to ensure that objectives are well-defined, achievable, and trackable. Here are some SMART marketing objectives for 'Shift it':

Specific: The objective should be clear and specific. For example, it could be to increase awareness of product among government officials and municipal decision-makers.

Measurable: The objective should be measurable so it can track progress and determine success. For example, 'Shift it' could aim to increase puzzle sales by 25% within the next six months.

Achievable: The objective should be realistic and achievable. For example, if 'Shift it' has only just launched the sliding puzzle product, it may not be realistic to aim for a 100 % increase in sales in the next month.

Relevant: The objective should be relevant to the company and overall marketing strategy. For example, increasing sales of the puzzle product may not be relevant if its broader strategy is focused on developing new products.

Time-bound: The objective should have a clear time frame for achievement. For example, 'Shift it' could aim to achieve a 25 % increase in puzzle sales within the next six months.

So, a SMART marketing objective for the company could be: To increase awareness of the 'Shift it' puzzle among government officials and municipal decision-makers, and achieve a 25 % increase in

puzzle sales within the next six months, by implementing a targeted advertising and outreach campaign.

4.4.2 Segmentation and Targeting

Segmentation

The first step of the STP marketing model is the segmentation stage. The main goal here is to divide a market into smaller groups of consumers with similar needs, preferences, and characteristics.

For 'Shift it', which aims to offer a puzzle to people responsible for public spaces such as government or municipalities to increase socialisation among people in cities, it is possible to segment the market based on the following factors:

Geographic Segmentation: This involves dividing the market based on geographic location. Focus on specific regions or cities where there is a higher demand for socialisation activities, such as urban areas with high population densities. This can help the tailor of marketing efforts and distribution channels to specific areas where the product is likely to be in high demand.

Demographic Segmentation: This involves dividing the market based on demographic factors such as age, gender, income, and education level. It may find that certain age groups, such as young adults or seniors, are more interested in socialisation activities than others. This can help the tailor of our marketing messaging and product features to better meet the needs of specific groups.

Psychographic Segmentation: This involves dividing the market based on psychological factors such as lifestyle, values, and personality traits. It may find that certain types of people, such as extroverts or creative individuals, are more drawn to socialisation activities. This can help the create marketing campaigns and product features that appeal to these specific personality types.

Behavioural Segmentation: This involves dividing the market based on behaviour, such as usage frequency or loyalty to similar products. It may find that certain types of customers, such as frequent event attendees or puzzle enthusiasts, are more likely to be interested in the product. This can help the tailor of marketing efforts to reach these specific groups more effectively.

Targeting

Targeting in marketing refers to the process of identifying the specific segments of the market that are most likely to be interested in the product or service, and then tailoring our marketing efforts to reach those segments.

For 'Shift it', which aims to offer a puzzle to people responsible for public spaces such as government or municipalities to increase socialisation among people in cities, the company can target the following segments:

Public Space Managers: The primary target audience should be individuals who are responsible for managing public spaces, such as government officials or municipalities. These individuals are likely to be interested in activities that promote socialisation among people in their communities, and may be willing to invest in products or services that help them achieve this goal.

Urbanites: In addition, it's possible to target urbanites who are interested in socialisation activities

and looking for ways to connect with others in their communities. By targeting this segment, the company can create marketing campaigns that speak directly to their interests and highlight the benefits of the 'Shift it' puzzle in helping them connect with others.

Puzzle Enthusiasts: Another potential segment to target are puzzle enthusiasts who enjoy solving puzzles and are looking for new challenges. By highlighting the unique features of the 'Shift it' puzzle, such as the ability to reorganise an image of the players and reconstruct it, it can appeal to this segment's interests and showcase the puzzle as a fun and engaging activity.

Event Organizers: It is possible to target event organizers who are responsible for planning and coordinating social events in public spaces. By positioning the 'Shift it' puzzle as a unique and engaging activity for events, it can appeal to this segment and potentially secure partnerships or contracts for the product.

4.4.3 Positioning

Positioning the company in the market in relation to its competitors, (Refer to Figures 18, 19, 20, 21), can help identify where our company should best be placed to gain a competitive advantage. The way we position ourselves on the market in relation to certain characteristics like quality, price, values, will help establish the image we want people to have in their minds when thinking about or buying from our brand. This positioning is so important because it influences how our target market views our product/service. We should therefore first determine how we want people to see our brand, and then establish where we should position ourselves on the market and how, in order to achieve that image.

To position the product effectively, 'Shift it' needs to differentiate itself from other competitive or substitute products in the market. The product offers a unique value proposition that promotes sociability and community engagement in public spaces. It's possible to position the product as a fun, interactive, and engaging way to bring people together, encourage teamwork, and foster social connections.

Also, 'Shift it' has to consider emphasising the environmental benefits of its product, as it can promote sustainable and eco-friendly ways of using public spaces. Additionally, the company can position its product as a cost-effective solution that can be easily implemented in a variety of public spaces.



Figure 18: Eco-friendliness VS Complexity



Figure 19: Mental VS Physical effort



Figure 20: Fun VS Challenging



Figure 21: Inclusive VS Level of social interaction

Choosing a positioning strategy:

Identification:

Our company is looking to reach a very broad target group with respect to users-anyone visiting or using public spaces in cities, so we made graphs with characteristics on the axis, and positioned our competitors on it in relation to how they achieve these characteristics. We then placed our brand on the graph where it could potentially offer added value and gain competitive advantage over the other companies. This is then in the perfect scenario where we would want to position our brand in the market. In the end, it must be made clear to consumers what type of company we are, what we stand for, what we do and offer and with which intended universe our brand should be linked with.

Differentiation:

As a summary it should be made clear what our goal is and how we will differentiate ourselves from competitor's brands. Consumers must recognize the uniqueness of our brand.

4.4.4 Marketing-Mix

There are four main aspects, known as the « marketing mix » also called the « four P's » to which companies must pay attention:

PRODUCT: It must meet the needs of the consumers.

The product policy is used to determine all product characteristics (aesthetic and technical). To further explain the product aspect of the marketing mix, it is important to consider its features and benefits. The puzzle game comes with several features that make it attractive to potential buyers, such as:

Interactive gameplay: The puzzle game is designed to be played by multiple people simultaneously, which encourages social interaction and teamwork.

Customizable design: The puzzle game can be customized with specific images or themes that are relevant to the target audience or location where it will be used.

Portable and durable: The puzzle game is easy to implement and can withstand repeated use, making it a cost-effective investment for public spaces.

The benefits of the 'Shift it' puzzle game are numerous, including:

Increased social interaction: The puzzle game provides a fun and engaging way for people to interact with one another, fostering a sense of community and connection.

Enhanced public spaces: By bringing people together and encouraging them to engage with their surroundings, the puzzle game can help improve the overall ambiance and attractiveness of public spaces.

Cost-effective investment: The puzzle game is a cost-effective way to enhance public spaces and promote social interaction, making it an attractive investment for government entities and municipalities.

In conclusion, the product part of the 'Shift it' marketing mix is its innovative puzzle game that encourages social interaction and enhances public spaces. With its customizable design, portability, and durability, the puzzle game is a cost-effective investment that offers numerous benefits for both players and public spaces.

To finish, highlight the puzzle's quality and durability is necessary because it will be used in public areas and needs to be able to resist repeated use.

PRICE: This depends on the financial objectives as well as the kind of consumer being aimed at.

The cost of manufacture, marketing, and promotion, as well as the value that the product offers consumers, all play a role in determining the pricing of the SHIFT IT puzzle game. Here are some crucial things to remember:

Cost of Production: It is important to take into account all of the expenses related to developing, manufacturing, packaging, and shipping the puzzle game. This will assist in figuring out the lowest price at which you can sell the item and still turn a profit.

Value to Customers: Take into account the benefits the puzzle game provides to the intended

audience, such as the improved social interaction and amusement it provides. If the value is deemed to be high, it may charge a greater price.

Competition: It's critical to be informed of the pricing your market rivals are asking. Customers could find it difficult to purchase from you if the pricing is much greater than the competition.

Target Market: You must take the particular requirements and preferences of your target market, such as local or state governments, into consideration. The puzzle game might need to be priced appropriately if they have a tight budget.

These variables can be used to calculate the SHIFT IT puzzle game's ideal price.

PLACE: Where do people buy the product. This concerns both means of distribution and type of retail outlet.

The Place element of the marketing mix for SHIFT IT involves the distribution and accessibility of your product.

To effectively distribute the puzzle, it is important to consider the following factors:

Target market: Identify the specific groups or individuals who would be interested in the product. In this case, we can split the target market into 2 categories: buyers (government, municipalities who are in charge of public spaces, museums...) and users (every people who want to participate at this puzzle).

Channel selection: Determine the most effective channels to distribute the product to the target market. For example, consider partnering with a distributor who specializes in selling products to government agencies or municipal authorities.

Location: Choose strategic locations for the puzzle product to be available for purchase or play. For example, consider setting up kiosks in public spaces, or partnering with local businesses to offer the product to customers.

Accessibility: Make sure that the product is easily accessible to the target market. This might include making it available online, as well as in physical locations.

Promotion: Use marketing tactics to raise awareness of the product and generate interest among the target market. This might include social media campaigns, targeted advertising, webinars, podcasts and events or promotions designed to showcase the benefits of the product.

Concerning the installation of the puzzle, it is possible to focus on:

Public Parks: Parks are excellent places to put interactive gaming installations. By positioning the sliding puzzle in a predetermined location, it may entice people to congregate there and work on it together while conversing.

Community Centers: Community centers serves as hubs for a variety of events. It is possible to put in place the sliding puzzle in a public space where people can congregate and converse while attempting to solve it.

Outdoor plazas: A wide range of people frequently gather in plazas. Installing a sliding puzzle in a public space can encourage social contact by offering participants a fun and engaging pastime.

Shopping malls: Malls are crowded locations where people hang out and go shopping. A sliding puzzle can be used to encourage people to take a break, solve the puzzle, and engage in conversation by being placed at a gathering spot or next to seating areas.

Coffee shops: These places offer a comfortable setting for people to unwind and converse. Installing a sliding puzzle can add another activity for consumers to enjoy while encouraging interaction among customers at a café or coffee shop. (Based on this link: <https://www.familinparis.fr/restaurant-aire-de-jeux/>)

Libraries: Libraries serve as gathering places for the community to read, study, or work without interaction between people. Put the puzzle in this area can offer a pastime that motivates people to cooperate and interact with one another by setting up a sliding puzzle in a defined location.

Public Squares: In cities, public squares frequently function as gathering places or as centers of culture. People of all ages and backgrounds may congregate in a public space to solve a sliding puzzle that has been strategically placed there.

PROMOTION: There are several methods of promoting a product, including advertising, special offers, mailing and sponsorship.

The communication tactics used to market the product are referred to as “promotion.”

It’s important to take into account the following tactics to effectively sell the product:

Use advertising to reach the target market and spread the word about the puzzle. Think about using targeted billboard advertising, web advertising, or print ads in regional magazines or newspapers.

Establish connections with bloggers and journalists who write on issues including public places and participation in the community. Contact them to give interviews or product samples for review while pitching your business.

Host events or sponsor already scheduled ones to promote the sliding puzzle and generate buzz. To plan events and establish lasting relationships, it is necessary to choose to collaborate with regional community groups or organisations.

Influencer marketing: Take into account collaborating with social media influencers who are popular in the fields of public places and neighbourhood involvement. They can spread more awareness of your goods by promoting it to their followers.

Use social media networks like Facebook, Twitter, and Instagram to market the product and connect with the target market of SHIFT IT. Share user-generated content, exclusive peeks at the game, and details about future occasions or special offers.

4.4.5 Brand

Identity:

Our company's identity is represented by its name, logo and values it stands for and wants to be identified with. These three aspects will help consumers identify our company's brand from competitors.

Name:

The name 'Shift it' has to do with the sliding puzzle concept. People have to shift the pieces around on the game board so that they can unscramble the puzzle of their photo on the screen. The team wanted a short name with short syllables that was easy to say and said something about the product. The fact that the two words both have the same “it” sound when saying it has a nice sound to it. It was also investigated whether the name existed already to ensure a name was chosen that was not already being used by another company. Shift it is used for an IT company, but no company in the same field of products/services as us has this specific name.

Logo:

The aim of 'Shift it' is to bring people in public spaces together. To encourage social interaction and fun between people in public areas where many people are present but under normal circumstances never communicate with each other. This idea of connecting people and stimulating interaction is portrayed by the 3 linked human figures in the logo. The 3 pastel colours used are fun and cheerful, contrasting nicely with the black of the figures. These colours were chosen because of the fun and positive mood they radiate. Within the figures there are also geometric shapes that are slightly shifted to portray the concept of the puzzle pieces people have to shift in order to make the puzzle. The name appears under the figures in a wavy line to correlate with the shifting concept and to relate to the wavy line the linked arms of the figures make. The name appears under the logo and portrays the shifting concept of the puzzle pieces because the distance between the letters get bigger the further the word proceeds. This makes it look as if the letters are shifting away from each other.

Values:

The values of the company include: Inclusiveness Accessibility Encouraging social interaction Providing fun, positive experiences Stimulating communication and collaboration between people

The team used the Business Model Canvas, (Refer to Figure 22), to create an overview of the business strategy:

This included identifying the key resources, partners and activities, the cost structure and revenue plan, the customer segments and customer relationships, the channels and value propositions of the company.

Business Model Canvas		Designed for:	Designed by:	Date:	Version:
		Shift it			
Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments	
Local municipality/government Festivals Companies (metro, bus, banks) Suppliers Museums Restaurants Cinemas	Design and research Development Production Marketing Web design Promotion Installation Maintenance	<u>Citizens and tourists:</u> Fun experiences Social interactions <u>Partner companies:</u> Exposure/promotion Communication of information More customers <u>Festivals:</u> Attracts people Promotes positive image	To maintain a good relationship with the local customer/user we have to come up with new and fun stuff to make small changes to keep our game interesting. And with tourists we have to make it a memorable experience, so they spread the word and maybe come back some day. Channels	Big events Public parks/spaces Team building events Corporate events Schools Festivals People living/visiting the city: (Children Tourists Locals)	
	Key Resources	<u>Local government:</u> Fun use of spaces More visitors	Displaying our products in open spaces-visual representation Social media Advertising via the companies being represented Posters Leaflets Intuitive website	Business partners: Establish a personal and loyal bond by offering advert options to promote that partner via the product. Users: Establish trust and good-will by conforming to privacy policies. These relationships will probably be more temporary.	
Cost Structure		Revenue Streams			
When looking at the cost structure we start with the design and development costs to actually make our product. Then there are the material costs which in our case is wood, aluminium, and electrical components. The next cost is the installation cost, the cost of installing the game in the park, including labour, tools, and equipment. Maintenance cost is also a thing that we have to take into consideration such as cleaning the device and reparations. The last cost is marketing and promotions cost to make our product visible to as many people as possible.		Public funds to promote tourism Employed by municipalities from own budget Funds from promoting tourism Business partners Municipalities that want to work and collaborate with you Apply for funds, but go with intentional letter from municipality that say they are willing to collaborate with us on project After launch, costs less, partners can pay a fee for being involved in the project			

Figure 22: Business Model Canvas for the team's company

Value proposition:

Here we will briefly state what our product/service is and the added value it will offer, as well as who our product/service is directed at. This includes summarising the most compelling benefit the company provides, as well as how the company differentiates itself from its competition.

What is it:

A big outdoor sliding puzzle that requires people to take a picture of themselves or their environment. This picture can also be a photo provided by the company funding it. The picture appears jumbled up on the screen and the players have to slide the physical pieces to solve the puzzle in the quickest time possible in order to see what their picture looked like. They can choose an artistic filter for the photo and at the end whether they want to show it publicly or not. By scanning the QR code players can access the website to consult their ranking and download their photo.

Market pain/problem statement: How to stimulate more social interaction between people in public spaces.

Target groups

Our partnerships:

People who would volunteer to help, local governments, team building workshop (businesses that are interested), events (like festivals) or museums, businesses like restaurants surrounding the public area- attracts customers.

Our target users/customers:

- People of all ages, nationalities and cultures
- Tourists
- Local residents
- Day-visitors to the city

Our goals:

Create a fun sliding puzzle game which can help to stimulate social interaction between people and motivate people to collaborate or compete with others in public areas.

Added value:

For users

- Inclusiveness
- Encouraging social interaction
- Providing fun
- Positive experiences
- Stimulating communication
- Collaboration between people

For business partners/potential buyers:

- More visitors/clients
- A way of promotion by making the puzzles about the respective business partner or owner

Mission

- Making society less individualistic by creating interaction between individuals in public spaces
- Offer outdoor activities to get away from the digital world
- Show that it's not weird to talk to strangers
- Try to reduce people's shyness

Differentiation from competitors:

- Fun and challenging
- Accessible and appealing for a very wide audience
- Classical game with a technological twist
- Requires physical actions as well as mental thinking
- Encourages social interaction and collaboration
- Slightly competitive to increase desire to participate
- The compelling mystery of not knowing what the photo looks like is compelling to want to participate-adds excitement and curiosity
- Can have a promotional and entertainment value for partner organisations

Response:

Users:

For: People of all ages, language, background, visiting or living in the city

who: Want to socially interact and have fun with others in public spaces

the: SHIFT IT

is a: Sliding Puzzle game

that: Brings people together by encouraging collaboration and removing the barrier of interacting with others

unlike: Outdoor playgrounds or gyms

our: Company provides a unique experience that combines technology with physical actions and mental skills. It is accessible to all, and wants to promote collectivism, society, fun, and awareness of others and the environment.

Business partners:

For: local governments, team building workshop(businesses that are interested), events(like festivals) or museums, businesses like restaurants surrounding the public areas

who: Want to attract customers and promote themselves in a fun and appealing way

the: SHIFT IT

is a: Sliding Puzzle game

that: Sparks curiosity and attracts attention from users, encouraging participation and therefor visits to business partners or businesses close to public areas

unlike: normal adverts or posters or other interactive games

our: Company provides a unique experience that combines technology with physical actions and mental skills. It is accessible to all, and wants to promote collectivism, society, fun, and awareness of others and the environment. This ensures a fun, unique and unobtrusive way of promoting business partners to clients and will attract clients to the business's location.

4.5 Marketing Programmes

Actions we want to implement.

Under programmes, there is differentiation between two target groups the “Shift it” company would have to approach and promote their concept to. Firstly the people who will actually use and play the game in the public spaces, and secondly the companies and organisations who will hire or buy the company's product to install in areas they see fit. These could include festivals, the local government, museums, businesses by public spaces etc. These organisations would invest in the company's product because it can attract customers and help increase client satisfaction and enjoyment. The company wants to reach as many people of the target group as possible with its promotional programs. The company aims to be known by most of the citizens of Porto within one year of promoting itself. There is a distinction between the metropolitan area and city center. The current metro area population of Porto in 2023 is 1.325.000. [\[Macrotrends, 2023\]](#)

Oporto city proper, which is the entire municipality of Porto, is small compared to its metropolitan area, with an estimated population of just 231.800 people. The company aims to be known by the people in the city center first- which would mean that the promotional programs would have the objective of reaching around 231.000 people in the first year.

The objective is of course to also promote the company to the city's tourists, local government, cultural centers like museums and business partners in the city center. Porto welcomes 1.6 million tourists annually, the equivalent of 8 visitors per local. The company can put promotional leaflets in the airports, (mainly Porto's airport), in order to reach as many tourists as possible.

4.5.1 Programmes

Our target group playing the game, includes a very wide audience as we want to approach people walking through/visiting the city, whether they be young, old, tourist or local. This is why “Shift it” would use digital as well as physical means of promoting its concept.

Users:

Social media such as a(n) “Facebook” and “Instagram account” will be used to promote the game, particularly to the younger generations. This channel is chosen because it reaches many people at the same time and so the company could promote its product to a wide audience within a very short amount of time. It can also be used to spread the word about the company between people because people can share the stories and links about the company and its game by placing and sending posts on social media. The location of the games can be shared, and pictures of it in use can be spread quickly to the desired target audience.

The company would also have a website and Search engine optimization(SEO)or Pay-Per-click (PPC) This is so that when people search up attractions to visit in the city, the company of “Shift it” will appear among the things to do and people will then be able to visit the website and see what the company stands for and is trying to achieve, and what its products/games are about. The location, a description, instructions and photos of the game will be available on the website for people to consult. The website would describe the company's mission, values and goals and is an important channel to have because it too can be accessed by a wide range of people very easily and can be useful to display important information in a clean, professional way. The company would have to make sure however that the website appears when people search certain things to do with the city to ensure people will see it. That is why SEO will be applied. Many people search up things to do in the city when visiting and so if the website could appear then in the list, it would be a good way to approach the target group.

The physical game itself will also have a QR code through which players can gain access to the

website. This is important if users want to obtain information about the time taken to complete the puzzle, the number of moves made, the overall ranking and to download the photo taken if desired by the players. This is however not compulsory. (An app is not chosen because the team felt that people would not be so inclined to download another of the many apps just to see their score and access their photograph.)

Physical means of promotion:

Posters spread around the city hung up on bulletin boards and lamp posts is also a means of promotion the company would use. A well-made poster is very useful to attract the eye and convey the necessary information such as company identity, goal, instructions and location of the puzzle, to passersby. Specially if hung up in strategic places. The company wants to approach people in the city, so the best way to promote is then to place posters spread around the city for the people to see. Printed leaflets conveying the same information can also be dealt out and placed in tourism offices and other public buildings for people to see. A leaflet is practical because it is smaller and can be given easily to people.

Probably the most important physical promotional strategy is that of visual appearance. The game must be installed in locations where it is easily visible and frequently visited by people. The game must be visually attractive to garner attention and rouse curiosity. It must look fun. The game itself is a very powerful means to grab the attention of users and in this way promote itself by being visually appealing. The look of the game will have a big influence on motivating people to participate in it.

Potential buyers of the game(governments, partner businesses etc.)

The company's website is also used for promoting its concept to potential buyers, because it is a way to professionally showcase all the necessary information buyers would want to know about the company before purchasing or partnering up with them. The website must be intuitive, clean, informative and visually attractive-fitting in with the image the company wants to achieve.

Promotional leaflets are also good to give to potential business partners because it is a tangible, attractive and direct way of providing the necessary information. Another good way to promote the product to other businesses is to offer a trial period during which the game will be installed at the business partner such as a museum, for a certain amount of time in order to show how it attracts people. An alternative method is by keeping track of the frequency of use of the product, and making this information available on the website and other promotion channels, so that partner organisations can see in numbers how often the game is played-proving how it attracts customers.

Finally a sort of advertising can be implemented in the game itself for the business partners for which they either pay for or install in a bought game from the company. This advertising would include instead of the users taking a photograph of themselves, they get a picture that has to do with the business partner itself. For example a restaurant near the public space where the game is located could advertise their name and food, because the game would have a jumbled up puzzle of a picture of the restaurant that the players need to solve. Another example is a museum that can advertise itself by providing a picture of what it showcases from the puzzle that the players have to solve. (These business either pay for this advertising, or they own the puzzle-game on which these adverts are showcased.)

The contact details such as email and telephone number are also important for the company to make available to the potential buyers. This information must be present on the promotion channels used.

4.5.2 Budget

The budget would be allocated firstly to producing the puzzle-game. So buying all the necessary components and materials needed to make the game, as well as the machinery needed and equipment required in the production process.

Part of the budget will be used to install the games in the public spaces, as well as to maintain it. (If a business partner buys the game, then they will have to pay for the installment and maintenance.)

Finally another part of the budget will go to advertising and promoting the company and its product. The printing of the leaflets and posters have to be paid for, as well as the services of the graphic designer or web designer. The company has to pay to get their website on top of the list too.

The average pay for a Web Designer is €37,468 a year and €18 an hour in Portugal. The average salary range for a Web Designer is between €26,340 and €45,486.

The average pay for a Graphic Designer is between €17,909-€30,488 a year and between €8-€15 an hour in Portugal.

[Economic Research Institute, 2023], [Payscale, 2023]

The price for the paper and printing the posters and flyers depends entirely on the quality and size of the paper as well as whether the prints are black and white or colour. The amount of prints will of course also affect the price. The larger the format, the more ink used and the more expensive the print. Colour prints are more expensive than grey scale. The quality and finish of the paper or cardboard influences the price a lot too. The thicker the paper in mm, the more expensive. The paper quality is measured in GSM. GSM stands for 'Grams per Square Meter'. Quite simply, it allows print buyers and print suppliers to know exactly about the quality of paper that is being ordered. The higher the GSM number, the heavier the paper and the more expensive. The average weight of regular office paper or copy paper. 130 - 250 GSM paper: The weight most commonly used for promotional posters. 260 - 300 GSM paper: Thicker but still bendable card weight which works well for high-end brochures or magazines.

120 - 170gsm: Ideal for booklets, flyers and brochures (the heavier the weight of the stock - the more upmarket the feel). 150gsm - 170gsm is also a great stock for posters. 200 - 250gsm: Perfect for magazine and booklet covers.

One also has to choose the finishing of the paper. So whether the company wants a matte or glossy print. Glossy paper is cheaper than matte mainly because they absorb less ink than its matte counterparts. Premium Look: Glossy pictures have a premium look that is perfect for capturing photos with high-resolution graphics. The sheen also helps to highlight details in the images, making them more realistic and vibrant. Glossy paper is often seen as having a more professional look. Which option to choose for printing posters depends. One should take into consideration the purpose and how one wants to display the posters. If the posters will be used for a long time, then a matte finish would be the better option. If the posters are displayed for a short time, a glossy finish would be better.

Funding:

- The company can obtain public funds from the city to promote tourism in order to help finance their concept.
- "Shift It" can also be employed by municipalities to liven up the city and attract visitors.
- Funding from municipalities who are willing to collaborate with "Shift it".
- Business partners around the public areas or museums can pay to advertise themselves on puzzles that the players have to solve. They could also pay to have the puzzle

installed near them in order to attract clients to their business near to the game.

- The company can also earn money by selling the puzzle game to other organisations such as museums or festivals.

After the initial launch, costs will be less and more focused on the maintenance of the puzzles installed in the public areas.

4.5.3 Control

How our company would monitor and control the programs once implemented. This is important to see if the programs chosen by the company to promote itself and its product are working effectively to reach the target audience and objectives set out at the start of the year.

- The company can keep track of how many likes it gets on social media and on how far it is spread on the social media platforms. It can also keep track of how many people

visit the website and how often it is visited in a certain amount of time.

- The company can observe whether people stop to look at the posters, and can ask the tourism offices and other public building services to observe how many people ask

about them or take a leaflet.

- The company can monitor how many business contact (and buy from) them via their website.
- Keeping track of the frequency of use of the game itself is in general also an effective way to see if they are promoting themselves well enough to attract many

customers.

The best way of monitoring which promotional programs are working the best, is to ask players to fill in a survey. This can be sometimes a physical paper handed out by employees, but it would mainly be an online survey that players can access by scanning the QR code on the location of the game to access the company's website. On this survey, they would have to answer the question of how they came to know about the company or its product. The program with the most answers would be the most effective promotional method.

Maybe this survey can be shown on the screen to be completed by the players after the puzzle is made.

4.6 Conclusion

Based on this market/economic analysis, the team decided to create the company "Shift it", which offers and installs a socially interactive game in public spaces intended for people living in or visiting the city, because it was observed that people making use of outdoor public areas do not socialize and are very focused on their technologies, which leads to them not interacting with their beautiful environment or others surrounding them. Consequently, the team decided to create an outdoor sliding puzzle game that incorporates technology with physical moving components which encourages interaction and social collaboration with a touch of competition.

This chapter helped the team define the marketing strategy for the company “Shift it”. The research and competitor analysis done in this chapter were used to establish the company's targeted market segment and its position in the market. Creating a unique identity and investigating how the company could stand out from its competitors lead to the creation of Unique value propositions for the two target groups. Defining a well-grounded marketing strategy will help company maximize its success.

Now that the marketing strategy has been defined, the next chapter will be focusing on the necessary sustainability measures that are applicable to the team's concept and that need to be considered when further developing the product/service. This is to ensure that the final result will be as eco-friendly and sustainable as possible. This is of great importance because the impact of the production process, the material choice, the use and the end-of-life of the product on the earth must be kept as minimal as possible.

5. Eco-efficiency Measures for Sustainability

5.1 Introduction

The underlying idea of sustainability has drawn more attention in recent years as a result of the urgent need to address the environmental and social problems that the world is currently facing. Sustainability is the capacity to satisfy existing needs without compromising the capacity of future generations to satisfy their own needs. In the past, georesources like oil, gas, and coal have been major factors in promoting economic expansion and development. Yet, the usage of these resources has also had a considerable negative impact on human health and the environment. Thus, the use of sustainable engineering techniques is necessary to minimize negative environmental effects and advance sustainable development.

Sustainable development aims to handle social, economic, and environmental issues in ways that encourage long-term viability. The United Nations' Sustainable Development Goals (SDGs), address issues like poverty, health, education, gender equality, clean water and sanitation, affordable and clean energy, sustainable cities and communities, responsible consumption and production, climate action, life below the waterline, and life on land, provide a framework for addressing these challenges.

Figure 23 presents all the mentioned goals:



Figure 23: The United Nations' Sustainable Development Goals (SDGs)

Indicators of sustainability, like the Happy Planet Index, quantify how well nations can ensure that their population lives long and fulfilling lives without consuming excessive amounts of resources or harming the environment. Two other ideas that are crucial to achieving sustainability are eco-efficiency and life-cycle analysis. Eco-efficiency is the process of producing goods and services with a lower impact on the environment while still providing financial benefits. A life-cycle analysis is a methodical procedure for assessing a product's, service's, or process's environmental impact throughout the course of its entire life cycle, from the extraction of raw materials to disposal or recycling. **The framework of the method is presented in figure 24:**

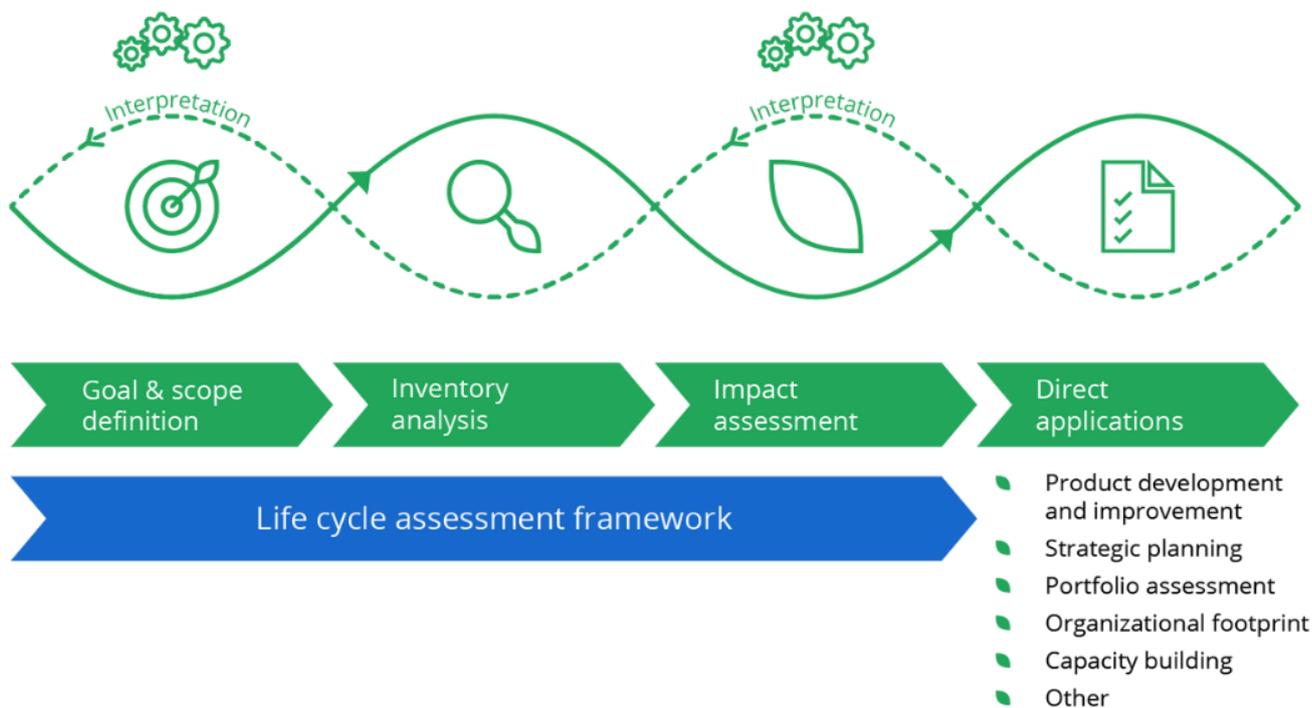


Figure 24: Life-cycle assessment framework.

Energy policy plays a crucial role in sustainability because it affects the types of energy that are used to drive economic development and progress. For instance, the energy policy of the European Union prioritizes the reduction of greenhouse gas emissions, the promotion of renewable energy sources, and the improvement of energy efficiency.

5.2 Environmental

Environmental sustainability is founded on the ideas of limiting environmental harm, decreasing waste and pollution, and conserving resources. This involves encouraging environmentally friendly behaviors including responsible waste management, the use of renewable energy, and sustainable agriculture.

Environmental sustainability aims to ensure that natural resources are utilized in a way that minimizes the adverse effects on the environment while maintaining their availability for future generations.

The project's environmental sustainability is significantly influenced by the materials chosen. Aluminum is a better material to employ than iron or galvanized steel since it is lightweight, resistant to corrosion, and has a longer lifespan. Moreover, aluminum has a high recycling rate and is one of the most recycled materials on earth, which allows for many uses and reduces the environmental impact of production.

Due to its strength, longevity, and resistance to decay, white oak, a hardwood, is regarded as a strong option for outdoor applications. Nonetheless, it is crucial to make sure that the production method is environmentally benign and that the wood is sourced responsibly. Due to their rapid growth rates and inherent resistance to pests and degradation, teak and bamboo are additional environmentally viable wood options.

The advantages of plexiglass are its light weight, resistance to breakage, and durability. Also, it is

totally recyclable and is accepted by recycling facilities, which lessens its impact on the environment. It is crucial to take the manufacturing process and the energy efficiency of the devices into account when designing electronic components. Making use of energy-efficient machinery and procuring resources ethically helps lessen the industrial process's impact on the environment. Also, it is essential to dispose of electronic waste properly to prevent landfill contamination and environmental harm.

The electronic outdoor game's ability to be repaired and upgraded can have a big impact on how environmentally sustainable it is. The demand for replacements is decreased by extending the game's lifespan, which also minimizes the quantity of waste produced. This is due to the fact that resources, such as the materials and energy required for production and transport, are conserved while creating a new game. Also, the game's upgradeability might lessen waste since it makes it possible to incorporate new features and technological advancements without having to throw away the entire game. This also implies that the game can be modified to meet altering requirements and tastes, enhancing its adaptability and making it appropriate for various occasions and events.

5.3 Economical

When something is economically sustainable, it means it can continue to be financially viable over an extended period of time. It entails striking a balance between resource management, economic development, and environmental effect reduction.

Economic sustainability in the context of a project or product refers to taking into account all expenses associated with the project or product, from its conception to its eventual disposal or recycling. This entails developing goods that are strong, long-lasting, and able to be repaired or recycled, as well as choosing materials and components that are reasonably priced and have no negative environmental impact.

Materials

The project's materials were chosen with the goal of achieving economic sustainability in mind. This was accomplished, in part, by choosing aluminum, which has a low weight-to-strength ratio and uses less energy during production and shipment. This results in decreased manufacturing expenses that can be passed on to the customer, increasing the game's accessibility and affordability. Also, the game's components' usage of aluminum ensures their durability, lowering the need for frequent repairs or replacements and adding to their economic sustainability.

In order to maintain economic sustainability, white oak, wood from sustainably managed forests, was selected. The project team was able to make sure that the production process would not contribute to deforestation or other adverse environmental impacts by using wood that is supplied from ethically managed forests. White oak's excellent resilience and extended lifespan also meant that the game's components constructed from wood would need little upkeep or repair, which would result in lower expenses for players.

Because of its low cost and high durability, Plexiglass was chosen to shield screens, which again helps to preserve the economy. Plexiglass is a more affordable option for screen protection than glass due to its lower cost, and it will also last longer due to its resilience, further lowering expenditures.

While not always the most obvious economic option, neoprene foam was chosen for its cushioning capabilities and minimal environmental impact. Neoprene foam protects the game's parts and ensures their durability, lowering the frequency of repairs and replacements.

Transportation methods

An area of economic sustainability that is frequently disregarded is the transportation of supplies and components. In addition to being a huge expense for businesses, the transportation process can significantly contribute to environmental damage. The project's transportation effect was reduced by using materials that required little packaging and were lightweight. As was already established, the use of lightweight materials like aluminum and plexiglass made the game's components easier to handle during production and also lightened the game's total weight. As a result, it took less gasoline to transport the commodities, which in turn resulted in lower transportation costs.

Also, whenever possible, local suppliers were selected to further cut down on shipping expenses and environmental effects. Locally sourced materials and components not only cut down on transportation costs but also helped local economies, which supports long-term economic viability. The project team reduced the transportation-related carbon footprint by using local suppliers, which is a crucial factor in achieving economic sustainability.

End-of-life options

In order to achieve economic sustainability, end-of-life choices for materials and components must be carefully taken into account. The materials used in this project were chosen because of their potential for recycling or other uses. By using this strategy, waste is minimized and the resources' economic worth is increased.

Aluminum, for instance, is one of the materials that can be recycled the most times without losing any of its original qualities. The aluminum components in the game can be recycled when they have served their purpose, cutting down on waste and the need for new raw materials.

Similar to other sturdy woods, white oak can be used for a range of projects. When the wood in the game reaches the end of its usable life, it can be recycled into furniture, flooring, or other wood-based items to prolong its economic life and minimize waste.

Plexiglass can still be recycled through some specialized recycling schemes, despite not being as easily recyclable as aluminum or repurposable as white oak. This lessens the requirement for virgin materials by allowing the material to be saved from landfill and repurposed in new products.

Neoprene foam is a material that has a low environmental impact but is not generally recyclable. Because of its toughness and insulating qualities, it can be used in a wide range of items, extending their useful lives.

The project team was able to guarantee that the materials had maximum economic value and the least environmental impact by taking into account the end-of-life choices for the materials and components used in the project. This strategy is consistent with the circular economy's guiding principles, which emphasize recycling and reuse as ways to minimize waste and increase the economic worth of resources. Additionally, it serves as an example of how companies can pursue sustainability objectives while maintaining their financial viability.

5.4 Social

The component of sustainability known as social sustainability is concerned with building and maintaining inclusive, varied, and egalitarian communities that can meet the requirements of both the present and the future. Social equality, human rights, social justice, community involvement, access to basic services, education, healthcare, and cultural diversity are only a few of the topics that are included under the term "social sustainability." It entails fostering sustainable attitudes, routines,

and laws that enhance the quality of life and well-being of both individuals and society as a whole. Our product can have both positive and negative impacts on society.

Positive impacts include:

- Collaboration and social connection are encouraged by the game, which promotes group gatherings, conversation, and cooperative puzzle-solving. When people of various ages and backgrounds play the same game together, it can foster a sense of camaraderie and social cohesiveness.
- The project can encourage people to be more active, engaging in physical activity in a group setting can foster social interactions and aid in the dismantling of barriers across various racial and ethnic groups.
- To put the puzzle pieces together, players must use their creative and problem-solving abilities. This may be an enjoyable and stimulating way to develop these abilities and may encourage people to partake in other creative endeavors.

On the other hand, the game can also has its negativities:

- Even while the game could encourage interpersonal communication and participation in the community, it's crucial to make sure that everyone can use it. However, the game will be made in a way that will support diversity and tolerance while preventing social isolation.
- Pictures of players are taken and shared as part of the game. Making sure that participants are aware of how their images will be used and that their privacy is respected is crucial. Processes for consent and communication that are clear can help allay privacy worries and guarantee that everyone will enjoy the game.

5.5 Life Cycle Analysis

This LCA's objective is to evaluate the environmental effects of producing, using, and discarding an electronic outdoor game that uses both physical and digital sliding puzzles.

The scope of this LCA includes every stage of the game's life cycle, from the gathering of raw materials to the disposal at the conclusion of its useful life. The term "functional unit" refers to a single game unit that consists of the actual puzzle pieces, electronics, an aluminium frame, and a plexiglass cover.

Inventory: Raw materials: aluminium, wood, plexiglass, and electronic parts

Manufacturing procedures: Raw materials extraction and processing, game component assembly, transportation of materials, and final product

Phase of use: Energy usage while playing the game

End of life: Electronic garbage and gaming parts disposal

Impact evaluation: In order to examine the game's effects on the environment, impact categories such as climate change, resource depletion, human health, and ecosystem quality were considered.

The impact assessment's findings are displayed below:

Climate change may be exacerbated by greenhouse gas emissions from the energy used in the game's creation, use, and disposal. Energy use during gameplay and the production of aluminum and plexiglass both utilize a lot of energy and emit greenhouse gases. Additionally to having other negative effects on the environment, the disposal of electronic trash (or "e-waste") can increase greenhouse gas emissions.

Natural resource depletion - the extraction and processing of natural resources is necessary for the manufacturing of the game's raw materials, such as aluminium and wood, and this can result in depletion. The manufacturing process may also demand water, which contributes to water depletion.

Human health - Hazardous compounds that may be damaging to human health may be used in the production and disposal of electronic components, such as the reflecting optical sensor. Hazardous elements can leak into soil and water during the disposal of e-waste, endangering human health.

Ecosystem quality - If unsustainable logging practises are adopted, the manufacture of wood items for the game may have an adverse effect on forests and wildlife habitats. Ecosystems and biodiversity can be harmed by the disposal of e-waste because hazardous compounds can poison the environment by leaching into soil and water.

Interpretation: According to the LCA data, the game's biggest impact on the environment is climate change, with greenhouse gas emissions from production and energy use also having an impact. The extraction and processing of aluminium account for the majority of the influence on the depletion of natural resources, which is relatively minimal. The influence on ecosystem quality and human health is also negligible, proving that the game has no effect in these areas.

5.6 Conclusion

To ensure that the project stays financially feasible over a significant amount of time, the materials for the project were chosen with economic sustainability in mind. The shipping techniques were improved to minimise costs and environmental harm, and the materials utilised were lightweight and robust. It was also thought about how to dispose of materials and parts at the end of their useful lives, with a focus on recycling and minimising waste. An important aspect of ensuring environmental sustainability was highlighted as the project's capacity for repair and improvement. Overall, preventing environmental impact, reducing waste and pollution, conserving resources, and guaranteeing economic viability are all included in the project's approach to sustainability.

6. Ethical and Deontological Concerns

6.1 Introduction

In a society, ethical and deontological issues are crucial, first by suggesting regulations that go above and beyond the law. Businesses stand to lose a lot from ethical scandals, particularly those that depend on their brand's reputation. Certainly, we have observed a number of businesses fail due to ethical issues, either by losing customers, markets, or both. With the rise of social media in our society in recent years, this influence might be much more significant.

Making sure that our project is morally flawless is important to us. To do this, we concentrated on several perspectives, creating the pieces that follow. The engineering ethic comes first, where we concentrate on the responsibilities of the engineer. Finally, we go on to sales and marketing ethics, where we attempt to set boundaries for when these activities can be carried out. Moreover, there is environmental ethics, which is connected to the section on sustainability, and liability.

In conclusion Deontology and ethics research is crucial because it offers a framework for comprehending and assessing human behavior and decision-making. People can more successfully negotiate difficult ethical conundrums and come to decisions that are in line with their particular values and views by considering moral principles and ethical values.

6.2 Engineering Ethics

It is the obligation of engineers to design and produce systems and products that are trustworthy, safe, and suit societal needs. They must also take into account how their actions may affect the environment and society at large.

The duty to emphasize safety is one of the cornerstones of engineering ethics. Engineers must create systems and products that don't endanger people's lives. Before products are put on the market, this entails creating fail-safe devices and undertaking thorough safety testing. They must also take precautions to reduce any hazards connected to their employment and be open about any such dangers.

The need to act with honesty is another essential element of engineering ethics. Engineers are expected to conduct themselves with the utmost professionalism, integrity, and openness at all times. People need to be responsible for their activities and accept blame for any errors or failures.

Engineers must think about the social and environmental effect of their work in addition to safety and integrity. They must make an effort to create systems and products that support sustainability and safeguard the environment. This could be developing products that use less energy, utilizing renewable resources, or cutting down on waste and pollution.

A commitment to professional development and ongoing learning is another aspect of engineering ethics. Engineers must stay current on the most recent advancements in their industry and constantly strive to advance their abilities. They must also be prepared to stand up and voice their concerns whenever they notice potential ethical problems in their own or their colleagues' work.

Engineering ethics ultimately revolves around applying technical expertise and knowledge for the benefit of society. It entails a strong commitment to moral standards and a readiness to accept accountability for the effects of one's activity. By adhering to these principles, engineers may contribute to the creation of a better world and improve people's lives all across the world [[Brock E Barry, Joseph R Herkert, 2015](#)].

In our team we intend to take these ethical considerations into account to make a safe and environmentally friendly product that we would be happy taking responsibility for.

6.3 Sales and Marketing Ethics

The moral ideas and ideals that direct the behavior of sales and marketing professionals in their interactions with clients and stakeholders are referred to as sales and marketing ethics. In the corporate sector, adhering to these principles is crucial for preserving credibility, trust, and reputation.

Honesty is one of the cornerstones of sales and marketing ethics. Sales and marketing professionals should never make false or misleading statements about their goods or services. They shouldn't make promises they can't keep or overstate the advantages or characteristics of their products. Instead, they should give customers accurate and comprehensive information so they may make informed choices [[Pankaj M. Madhani, 2020](#)].

Respect for the customer's autonomy and privacy is a key tenet of sales and marketing ethics.

Professionals in sales and marketing are forbidden from obtaining personal data about customers or influencing their behavior by using unethical methods like spamming, phishing, or hacking. Companies should only utilize data that has been collected with the customer's consent and respect their right to privacy and choice.

Sales and marketing professionals should conduct themselves honestly, with respect, and without indulging in any discriminatory or exploitative behavior. This includes using unethical or dishonest sales tactics to prey on vulnerable groups, such as the elderly or the underprivileged. It also entails abstaining from any prejudice based on racial, gender, age, or religious grounds.

Professionals in sales and marketing should be mindful of the possible social and environmental effects of their activity. Instead of marketing goods that are bad for people or the environment, they ought to work to promote sustainable and socially conscious products and services.

Professionals in sales and marketing should also be dedicated to ongoing development. They should seek out opportunities to advance their knowledge and abilities and keep up with the most recent industry standards and best practices. Also, they must be receptive to criticism and ready to alter their methods when required.

In conclusion, sales and marketing ethics are crucial for preserving the marketability and credibility of companies. Sales and marketing professionals can forge close bonds with their clients and stakeholders and contribute to the long-term success of their companies by upholding values like honesty, respect, non-discrimination, social responsibility, and continual improvement.

In our project we have to take the sales and marketing ethics into real consideration. Since we have two different customers we have to think about this makes the sales and marketing ethics that we have to think about a bit broader. We also market our product to a broad amount of people meaning with everything from children to seniors we have to be careful with our marketing strategy. One last thing to take into consideration when marketing our product is that we have to make it really clear that our game is free for the people playing it in public spaces.

6.4 Environmental Ethics

A subfield of philosophy called "environmental ethics" is concerned with the moral and ethical problems that the environment and our interaction with it present. It entails taking into account the effects of human activity on the environment as well as our need to save and maintain it for future generations [Joseph R Des Jardins, 2012].

The appreciation of nature's inherent value is one of the cornerstones of environmental ethics. This implies that nature has value independent of whether it serves human needs. Instead of only seeing the natural world as a resource to be used for our own gain, we should respect and value it for what it is.

The responsibility to minimize environmental harm is another crucial aspect of environmental ethics. This entails lowering our carbon footprint, preserving resources, and eliminating waste and pollution. We should be aware of how our actions affect the environment and work to reduce any unfavorable impacts.

Environmental ethics entails not only reducing harm but also fostering environmental sustainability. Using resources in a way that ensures their availability for future generations is what is meant by this.

Wherever possible, we should employ renewable resources, reduce our use of non-renewable resources, and work to build a just and sustainable society.

Seeing how linked all living things are is another aspect of environmental ethics. Thus, people and nature are interdependent and a part of a bigger ecosystem. We must take into account how our actions will affect other species and try to safeguard biodiversity and natural environments.

The obligation to care for the environment is a last aspect of environmental ethics. This entails accepting accountability for the effects of our behavior on the environment and trying to repair ecosystems that have been harmed. Also, we should encourage laws and procedures that safeguard the environment and the natural world.

In conclusion, environmental ethics is a significant area of study that pushes us to consider our relationship to nature and our duty to maintain it. We may build a more just and sustainable society for future generations by appreciating the intrinsic value of nature, reducing harm, encouraging sustainability, respecting interconnection, and taking care of the environment.

With our project we have taken the environmental ethics into consideration by looking into how we can make our innovation as sustainable as possible with as small as possible impact on the environment. This can be seen with everything from the components we are using to the materials used in the project

6.5 Liability

A legal notion known as “liability for an innovation” relates to the inventor's obligation to take responsibility for the effects of their creation. If a novel product or process is properly conceived, produced, and labeled with the necessary instructions and warnings, the inventor is generally not responsible for any harm that may result from its use or misuse.

Yet, if an injury results from a risky or flawed invention, the creator may be held accountable for the victim's losses. Depending on the specifics of the case, liability may emerge under a variety of legal theories, including strict liability, carelessness, or breach of contract.

In conclusion, a variety of factors, including an innovation's nature, intended application, and the level of care the inventor exercised in developing, testing, and marketing the invention, affect its liability. In order to protect ourselves from unwanted legal risks and liabilities and to ensure that their discoveries are both reliable and safe, we as inventors should take the required precautions.

In our case we must follow the guidelines below to protect ourselves:

- Electromagnetic Compatibility (EMC) Directive (2004/108/EC 2004-12-15): intends to regulate side effects between electronic components that are connected/interface together, like electromagnetic radiation, fields in the vicinity of electronic components, etc [\[European Commission, 2014\]](#).
- Low Voltage Directive (LVD) (2014/35/EU): concerning health and safety challenges of electrical equipment with defined limits of voltage [\[European Commission, 2014\]](#).
- Radio Equipment Directive (RED) (2014/32/EU): a regulatory framework for placing radio equipment on the market, ensuring no interference and data security regulation in radio communication with other devices [\[European Commission, 2014\]](#).

6.6 Conclusion

During this chapter about ethics, it was important for us to identify and be aware about when doing a project like this. It has been a good thing to hear from all the group members what all of us think are important and different points of view. During this chapter we identified things that we should absolutely avoid at any costs (false advertisement, liability, etc.) The different fields of ethics also gave a broad and good overview about everything that we must think about when producing an innovation/product.

Both the user and the maintenance worker who will work on the product should be considered when designing the product. The product must be safe to use and maintain for the duration of its useful life.

To prevent any unethical business practices, a responsible and supervised sales strategy should be used. The sale of the goods will be more likely to be ethical and responsible, without deceiving or taking advantage of clients, thanks to this.

The environmental impact of the materials used in the product's manufacture, use, and recycling should be as little as possible. This entails considering elements like the materials carbon impact and making sure they can be recycled or disposed of in an eco-friendly manner.

Reusable and repairable parts should be included in the product. As a result, the product's lifespan will be increased, and less trash will be produced. Repairable parts can also assist in lowering the long-term cost of maintenance and repairs.

Finally, it's critical to accept responsibility when issues arise. This entails being open about any product-related difficulties and taking action to address them as soon as possible. By accepting responsibility, the business can win over customers and preserve its good name.

The choices we took about our product were influenced and driven by all these ethical restraints and rules that we discovered. In the next chapter Project development a lot of things are included. The Project development part describes how our project was developed and what is included in it. Everything from the ideation, concept, measurements and drawings can be found in this part of the report among lots of other things .

7. Project Development

7.1 Introduction

The following chapter contains all the steps taken towards developing a concept to solve the chosen problem of how to stimulate social interaction in public spaces. It starts with the ideation phase in which different ideas were explored as to what could be created to encourage social interaction in public areas. The team had ideas about different types of classical games that could be given a creative twist and installed in public spaces for people to enjoy. These different ideas are explained. Eventually one was chosen and this idea was then further developed into a more tangible concept by exploring the different ways in which it could be achieved. The defining process of the overall requirements, technology, mechanisms, components and necessary shape could then lead to the designing of the concept and the choosing of the materials and suppliers for the different

components. Different options of materials and possible technical components were researched and compared on important characteristics such as durability, price, sustainability, UV resistance, etc, in order to converge and conclude with the final chosen list of components and materials. Two lists of components and materials were made, one for the actual prototype that will be made, and one for the concept if it were to be produced in big scale and installed to be used by the public. This chapter includes the rough concept sketches as well as the later more advanced technical drawings, flow chart and system schematics of the concept. It should include everything necessary to build the final prototype and know what is needed should the concept be produced in “real life”.

7.2 Ideation

The mind map (In Figure 25) presents an overview of how the team came to the final topic and different ideas relating to this topic, namely competitive and collaborative games or puzzles to stimulate social interaction.

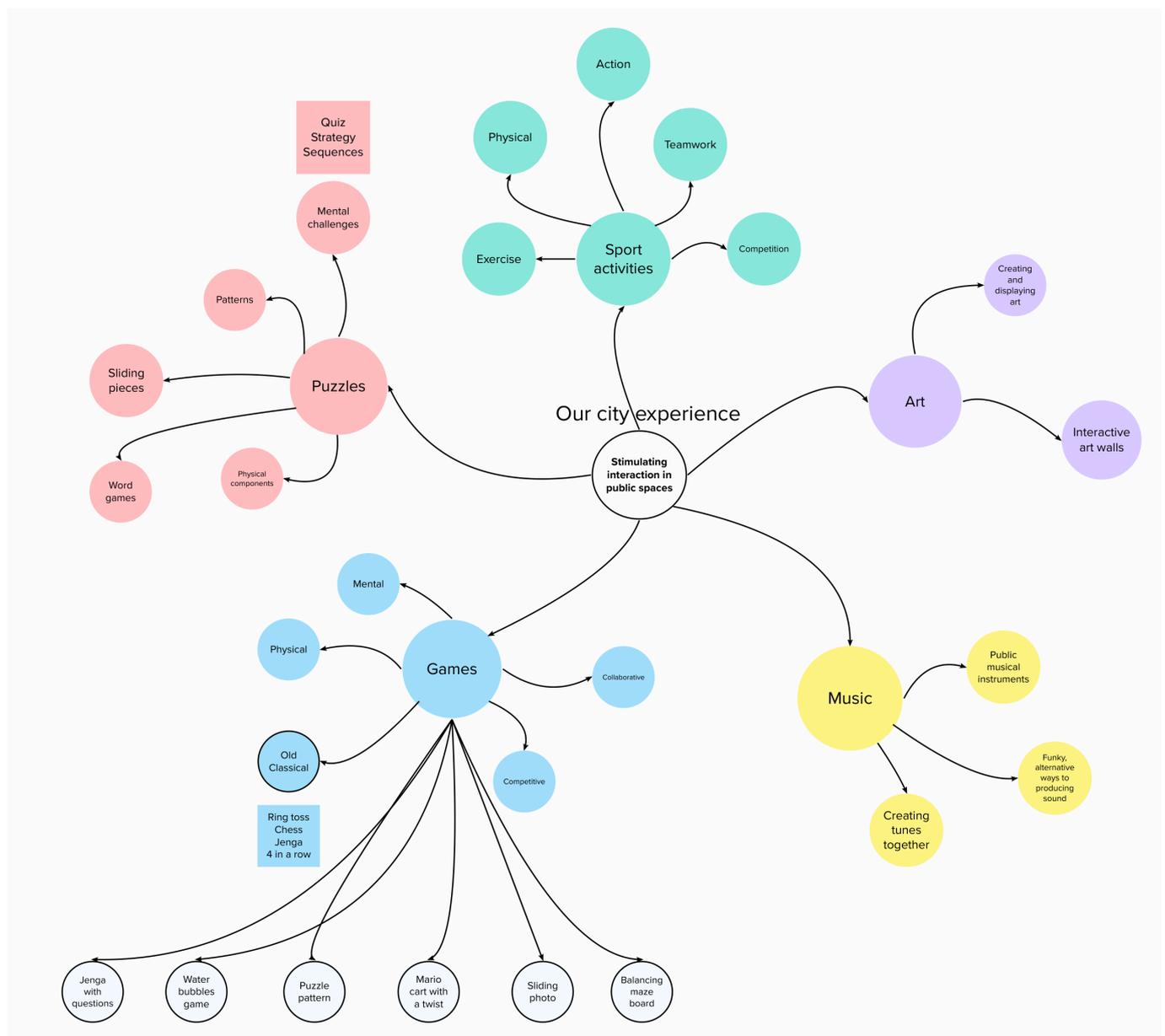


Figure 25: Ideation mindmap

The idea generation page (In Figures 26 and 27) summarize the different ideas and inspiration behind these ideas of game concepts that the group came up with. Then there are quick sketches and system designs of the chosen idea, namely the sliding photo puzzle as described in the idea generation page.

Ideation sketches shows the sketches that were made of different classical games and the game how we generated our idea:

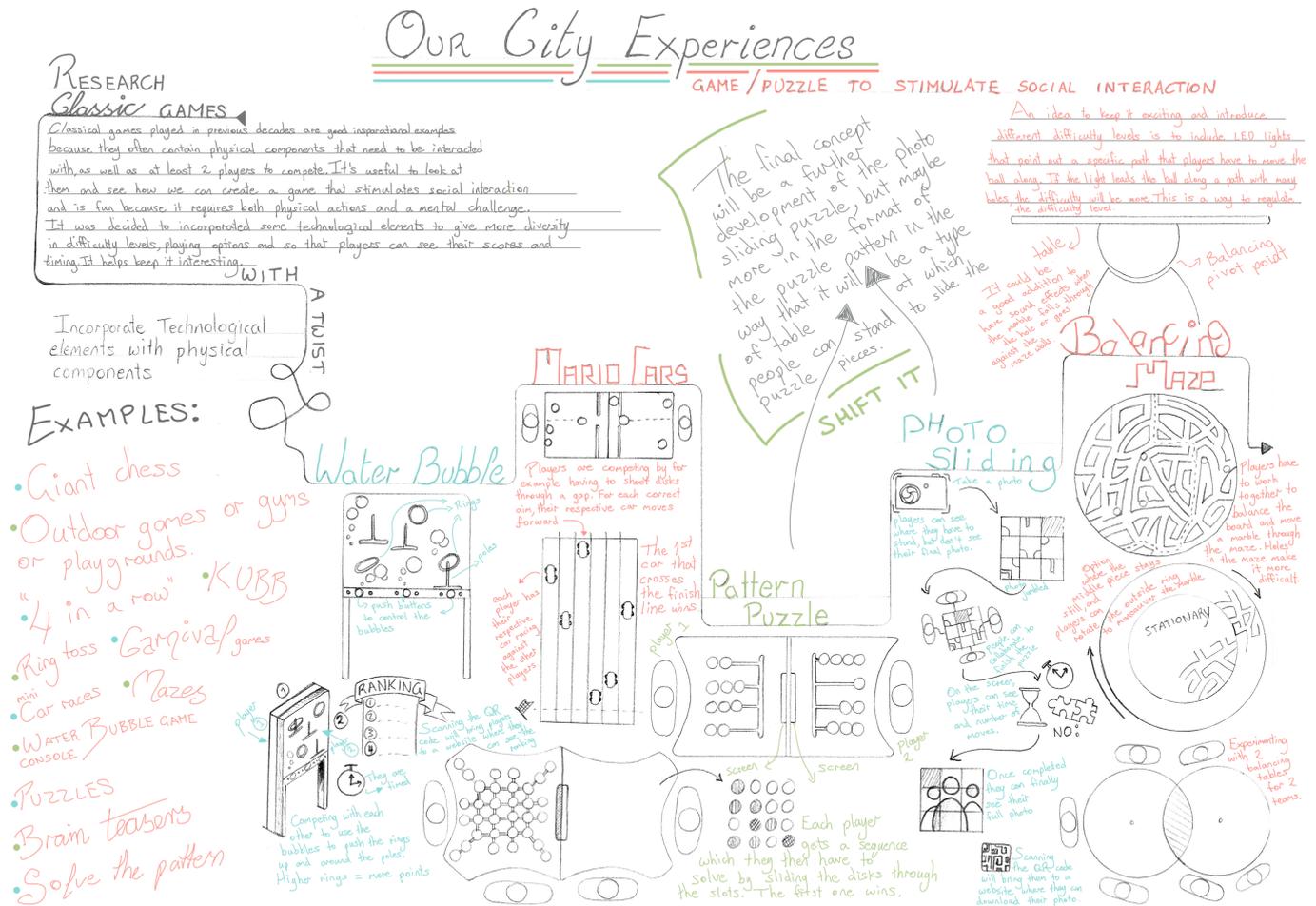


Figure 26: Idea generation

Ideation sketches with descriptions:

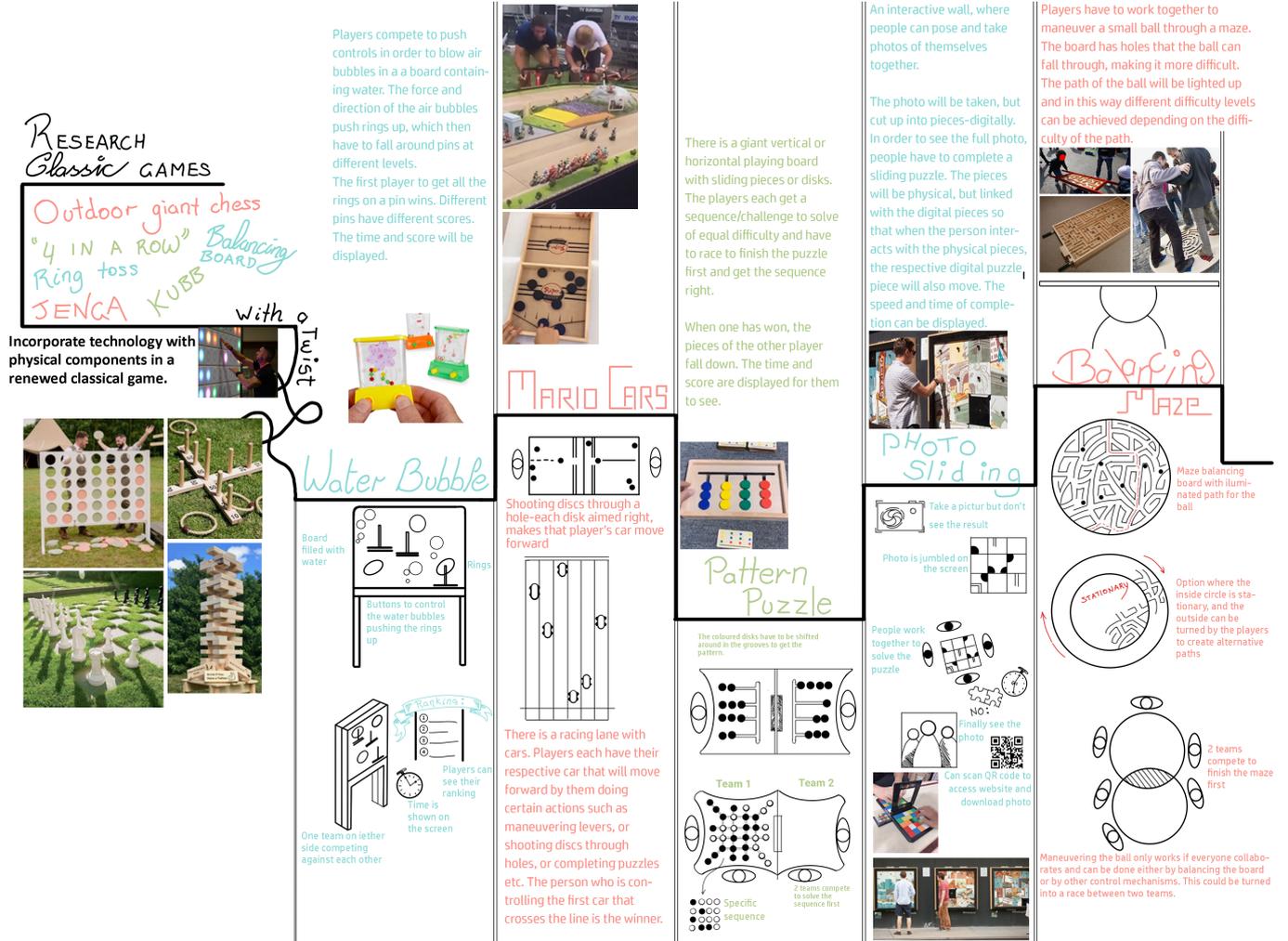


Figure 27: Sketches with descriptions

Puzzle sliding mechanism ideas:

These sketches show experiments on different ways to make the individual puzzle pieces slide vertically and horizontally on the playing board, without being able to remove the puzzle pieces from the playing board (Refer to Figure 28)

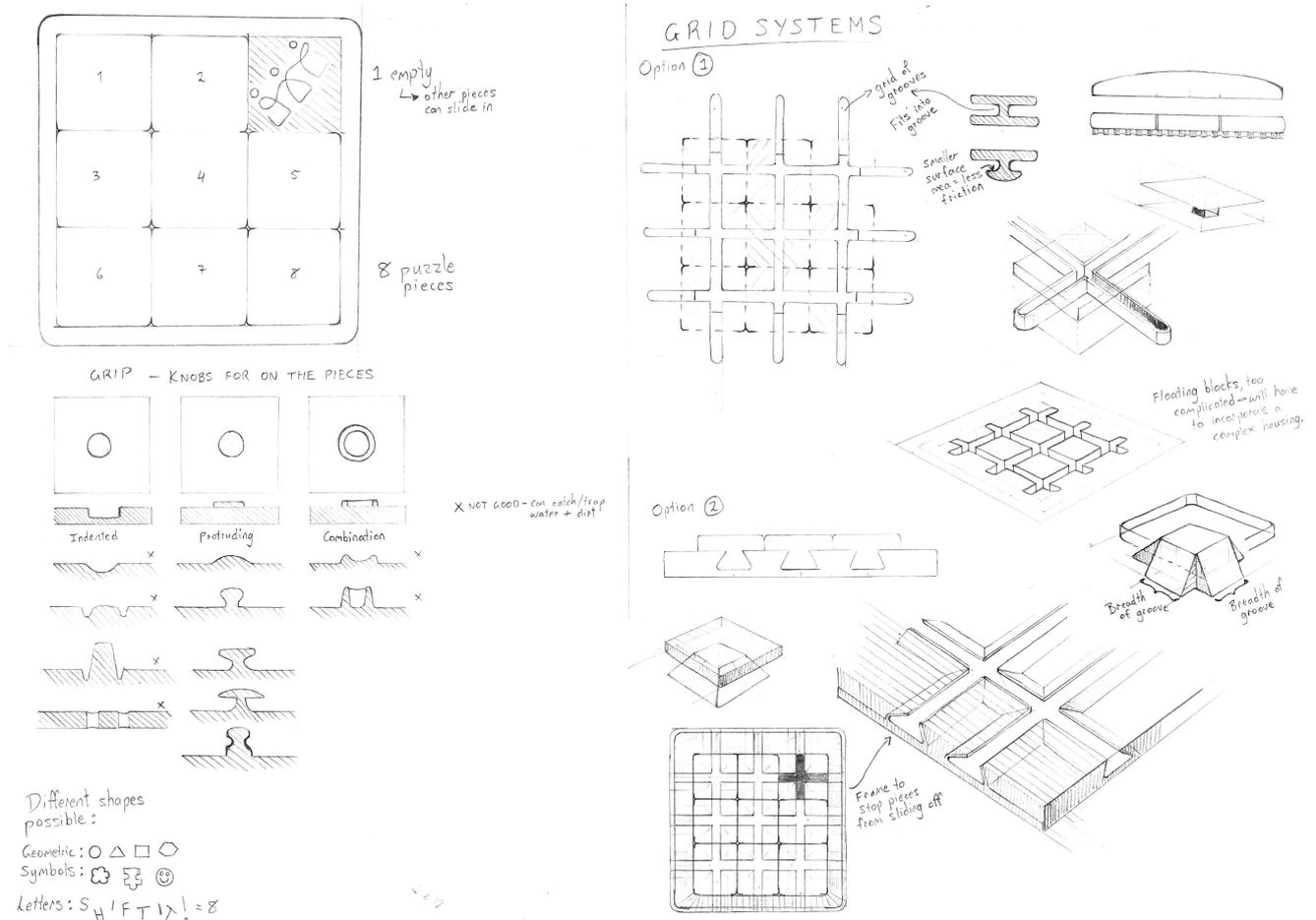


Figure 28: Sliding puzzle mechanism

Adjustable height ideas:

The game has to be playable by young children as well as adults, and therefore the playing board surface must be adjustable in height. Various mechanical, manual systems of adjusting height were researched and experimented (Refer to Figure 29). The lip and groove system of the puzzle pieces is also described on this figure. This lip and groove system allow the puzzle pieces to slide along each other without being able to remove the pieces from the playing board.

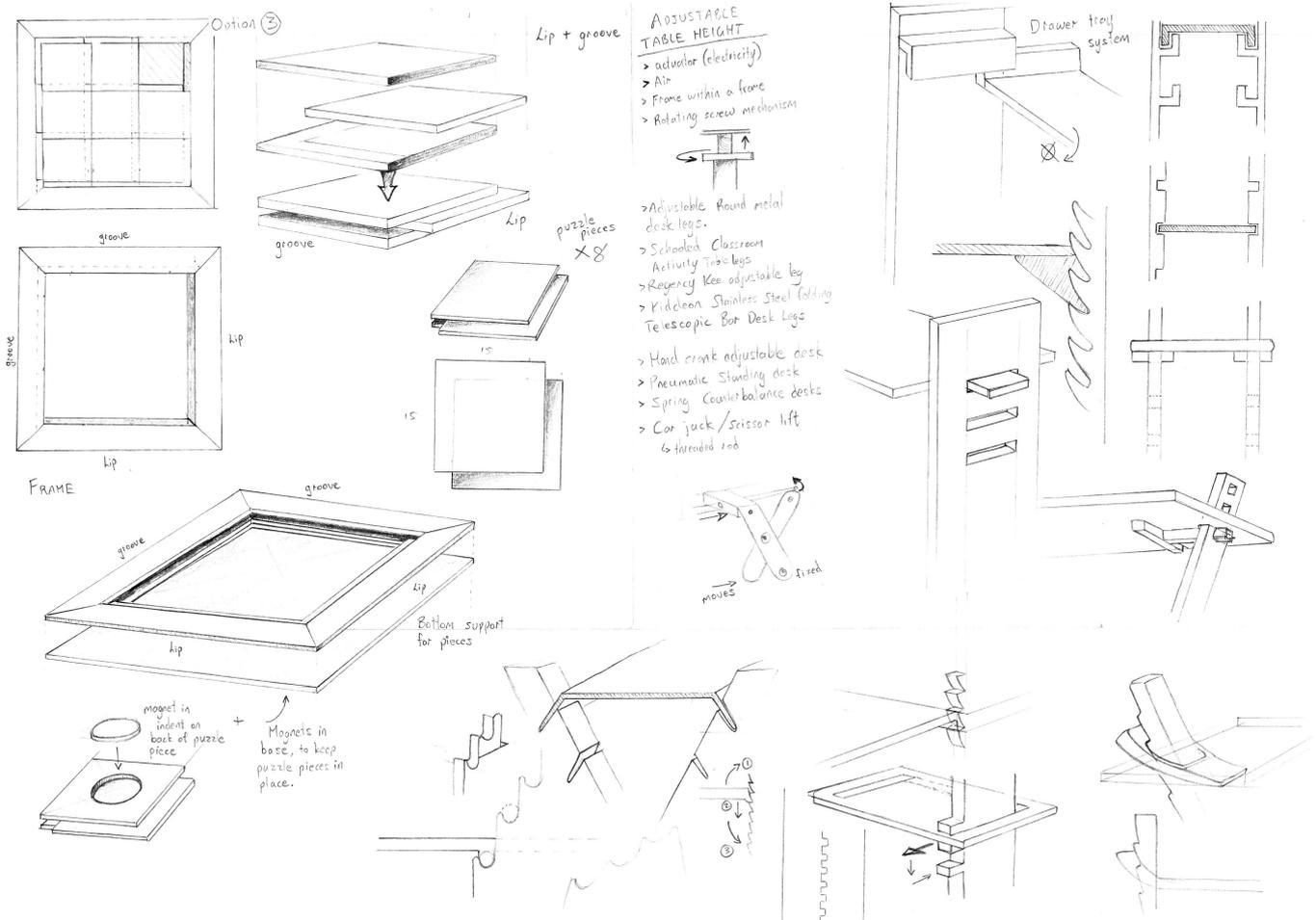


Figure 29: Adjustable height and puzzle piece sketches

- **Height Adjustable Ideas** Various more technical systems of adjusting height were also researched and experimented with as seen in (Refer to Figures 30, 31, 32, 33).

Support Technical Drawing explains how the part that attaches the height adjustment system would be attached to the upper part of the invention (Refer to Figures 30)

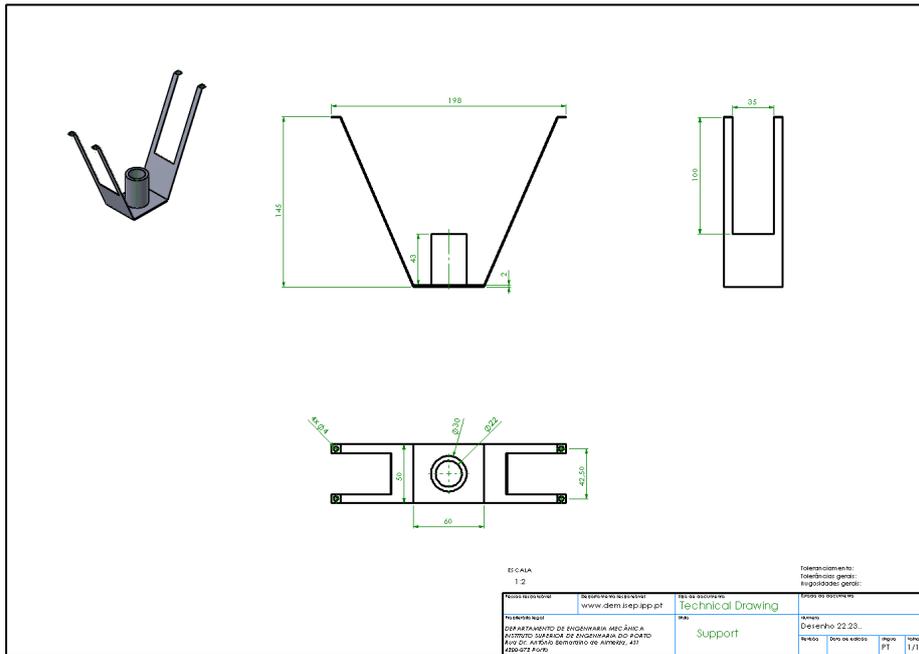


Figure 30: Adjustable height drawings

The support will fix the height adjustable system to the table. This way the movement of the cylinder will be transferred to the top part of the device making it adjustable.

Actuator Technical Drawing is explaining the idea how the actuator would look like (Refer to Figure 31)

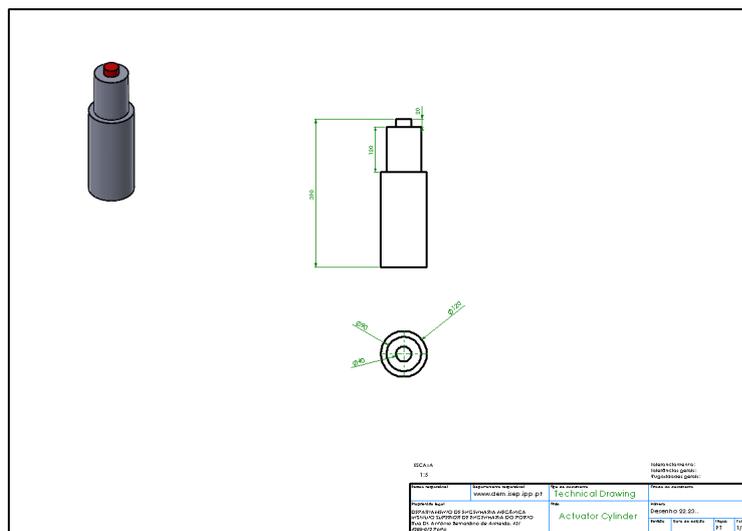


Figure 31: Actuator technical drawing

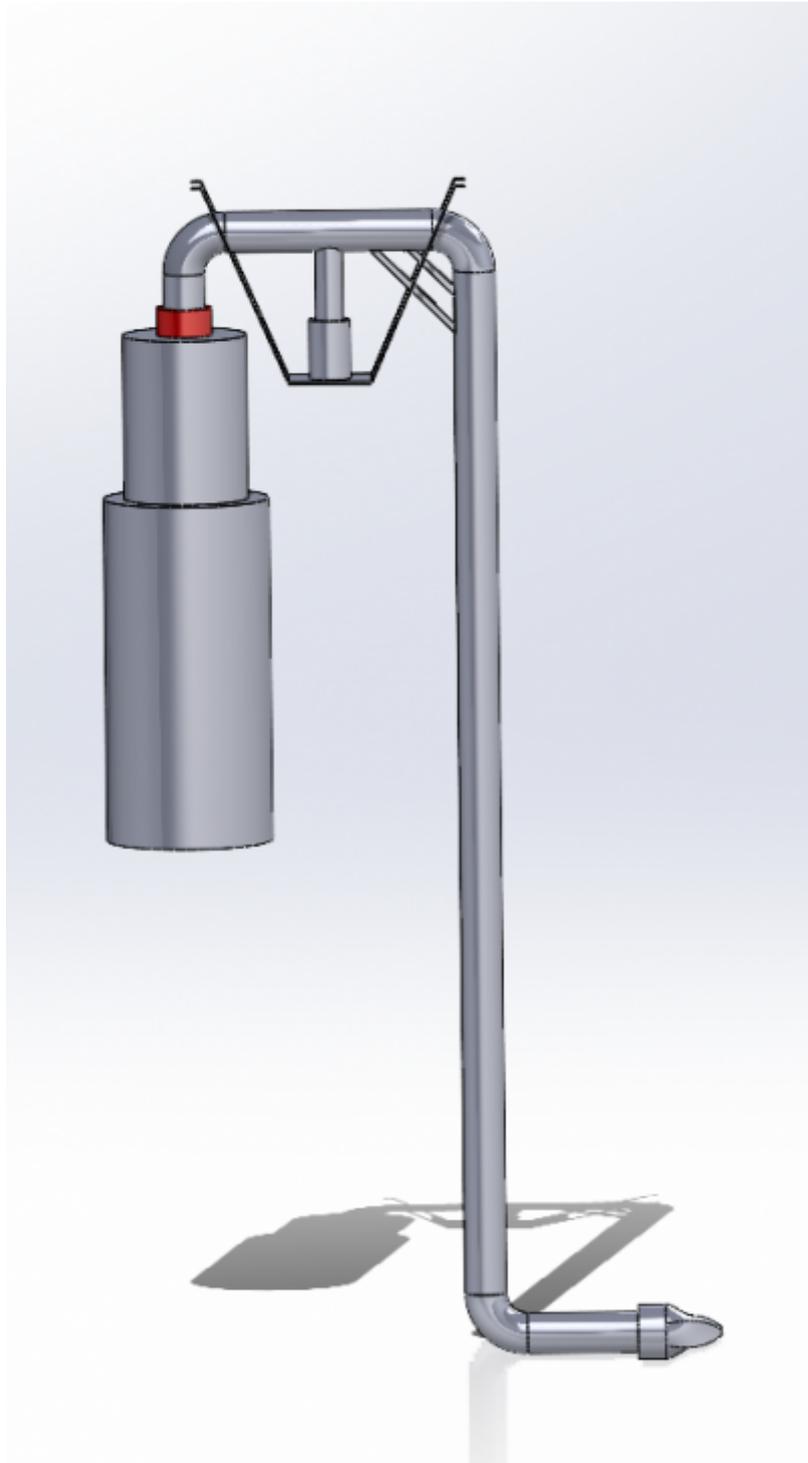


Figure 33: Adjustable height concept assembly

This is a system sketch that replicates what this would look like in reality.

A real life idea that can be well implemented to the equipment is the gas lift mechanism that operates, for instance, in office chairs. It's very practical and easy to activate with a pedal that presses the button to allow the movement of gas inside the mechanism to lift or lower the puzzle table.

This is what a gas lift looks like in reality, (Refer to Figure 34).



Figure 34: Gas Lift Mechanism

Now, a section view of the gas lift mechanism (colors were added to have a easier visual understanding of the components), (Refer to Figure 35).

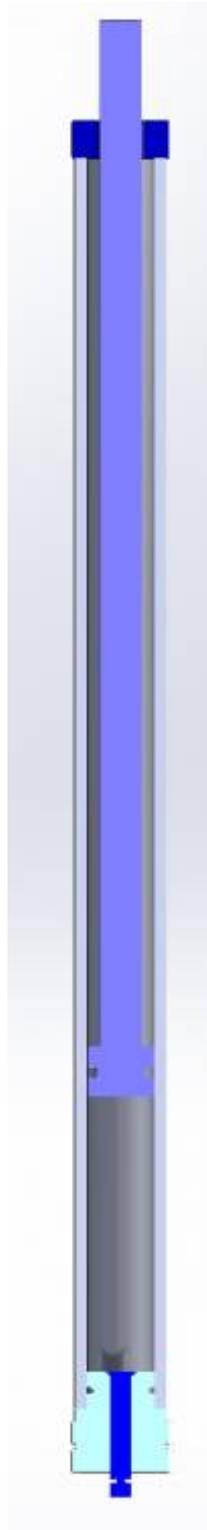


Figure 35: Section View of the Gas Lift Mechanism

And this is how the pedal would activate the gas lift to move the equipment up and down, (Refer to Figure 36).

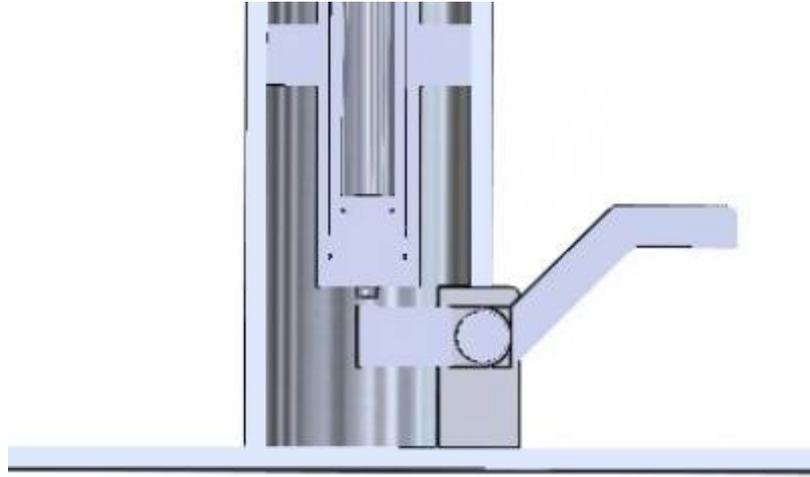


Figure 36: Gas Lift Pedal

Rough design sketches of the product:

These following sketches are rough ideas of how the game as it would stand in the public space could look like. There are many different designs and ways it could be built (Refer to Figures 37, 38)

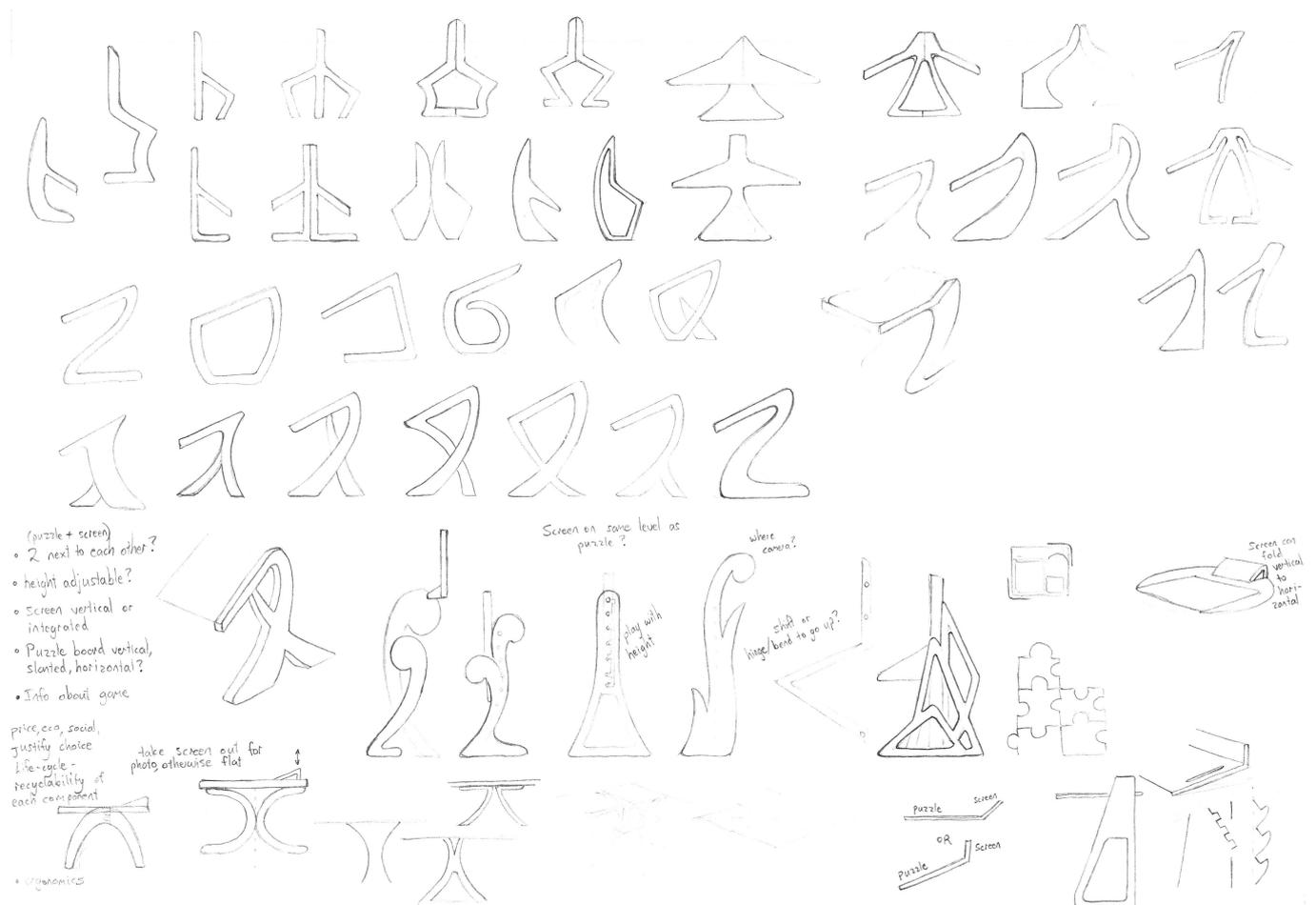


Figure 37: Rough design sketches 1

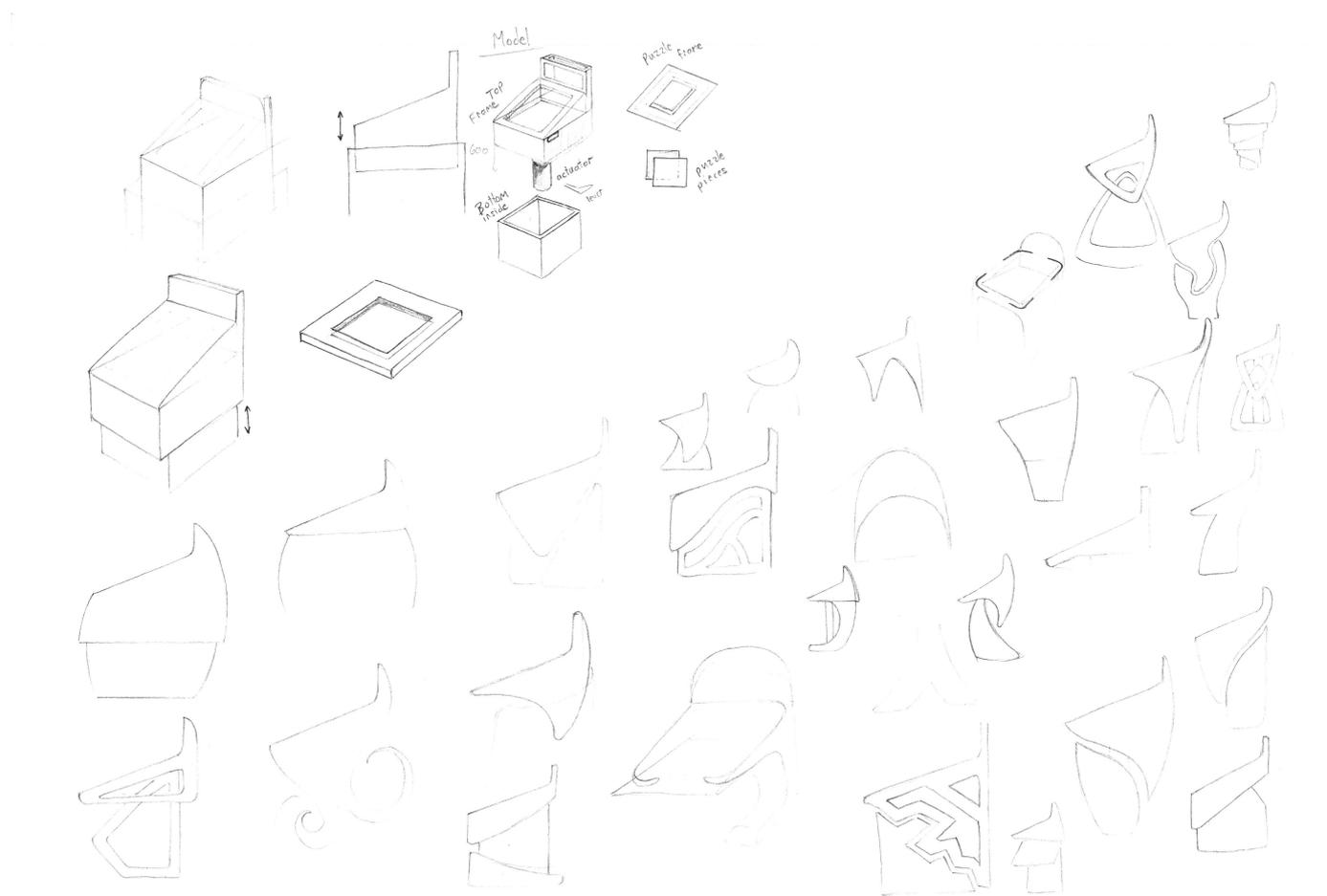


Figure 38: Rough design sketches 2

7.3 Concept

The final concept is an interactive puzzle game that stimulates interaction. It is meant to be installed in public spaces like parks or open squares for passers by to interact with and interact with others in their environment by collaborating or competing to solve the puzzle. The first step is to press the button-this will start a countdown for the users' picture to be taken. The users will see on the screen/user interface whether they are standing in a good position within the frame, but they cannot see what their photograph looks like. They then have the option to choose an artistic filter for their mystery photo, which appears on the screen as digital pieces that are all jumbled up. The level of difficulty can also be selected. By collaborating with each other they must try to solve the puzzle by sliding physical puzzle blocks horizontally and vertically on the game board to solve the puzzle on the screen, which will reveal their mystery photograph. They must complete it as fast as possible- competing with other teams for the best score. They will see their time and number of moves throughout the process on the screen. The team with the lowest time and number of moves, wins. Users can then choose whether they are willing to share their photograph on the screen for others to see or not, and if they consent to making their score public.

By scanning the QR code, people are brought to the website of the company where they can find their photo back and see all the scores, times and ranking of the teams. In this way they can see how they can improve their score the next time they participate. The website also provides information about the company, it's goals, values and instructions about the puzzle game. People can also see all the locations in the city where the puzzle-game is installed.

Competition motivates people to participate, and the fact that the photograph is a mystery, makes people want to complete the puzzle because they are curious to see what they look like.

Flow chart of the whole concept process:

(Figure 39) shows the step process a user would go through when interacting with the product. It gives an overview of the decisions that have to be made and the actions required in order to participate in the game. This makes it clear for people exactly what they need to do, as well as what they can expect from the game itself.

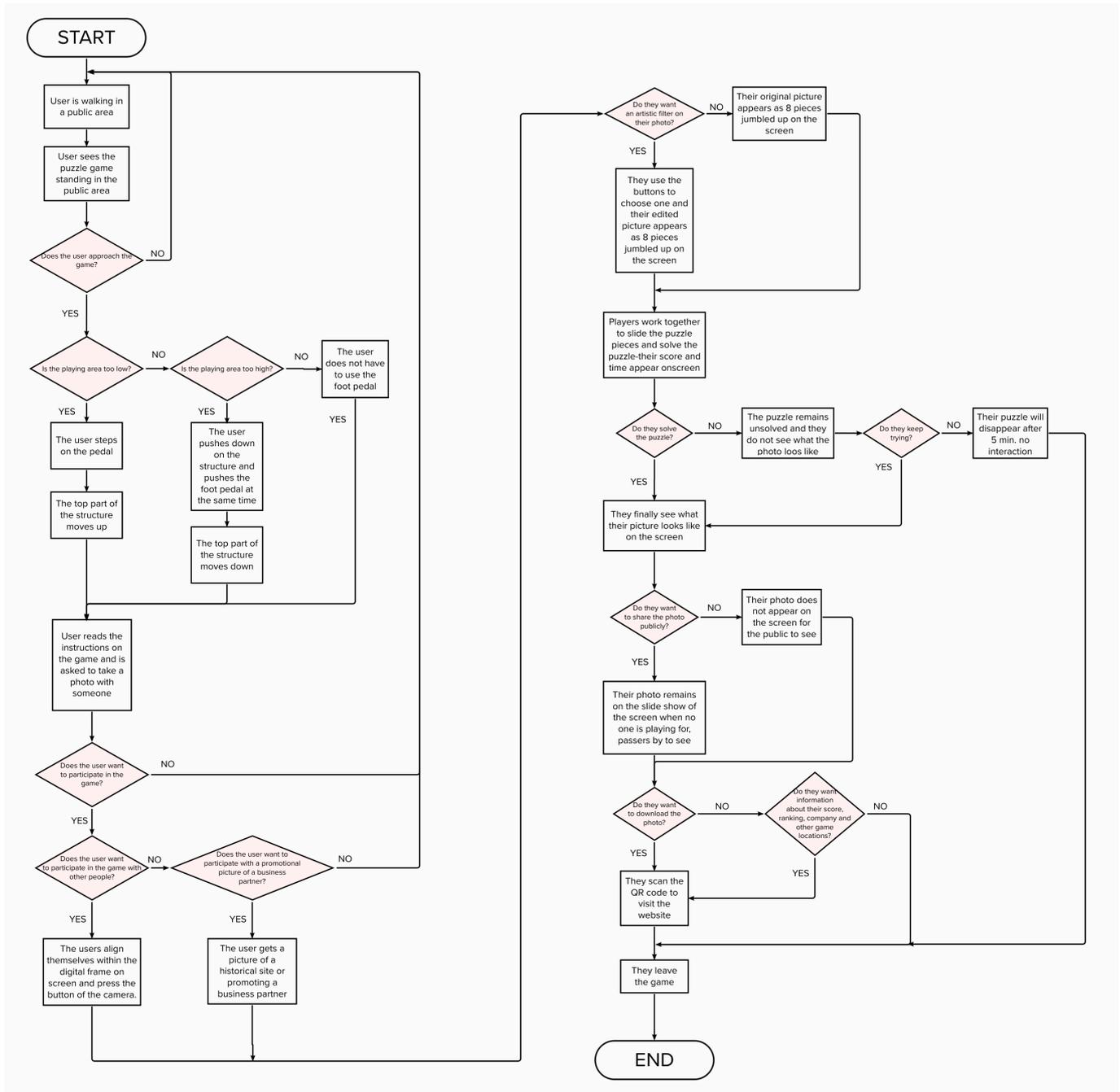


Figure 39: Game Flow Chart

7.4 Design

7.4.1 Structure

The concept includes a physical, mechanically working part that is closely integrated with an electronic aspect and software. Physical and digital components must work together to lead to a successful outcome of the concept. The physical components include the actual puzzle that users must solve. The puzzle is made of 8 pieces that can slide horizontally or vertically within a grid. These pieces would need to be contained within a frame and mounted at an ergonomic height. The puzzle pieces are then linked by electronic components to the digital screen on which the the photo of the users taken by the incorporated camera is jumbled up in 8 digital puzzle pieces.

The puzzle game will be installed in public areas for everyone to use and enjoy. Everyone includes children, teens, adults, the elderly and people with disabilities. In order to ensure ergonomic use of the product by as much of the population as possible, anthropometric measurements (Refer to Table 23) for certain population groups were researched and used as the basis for the measurements of the design [Toon Huysmans, Johan Molenbroek, 1980], [Autonomous, 2021], [Mazibur Rahman, 2015].

Anthropometric dimensions:

Table 23: Applicable Anthropometric measurements

Measurement description	Measurement purpose	Mean (mm)	sd (mm)	5th (%)	95th (%)
Standing elbow height children m+f (7 years)	Min. height of the puzzle board surface from the ground	756	44	684	828
m		753	42	684	822
f		758	46	682	834
Standing elbow height students m+f (17-27)	Max. height of the puzzle board surface from the ground	1095	60	996	1194
m		1131	51	1047	1215
f		1058	46	982	1134
Standing elbow height adults m+f (31-60)	Max. height of the puzzle board surface from the ground	1056	65	949	1163
m		1099	57	1005	1193
f		1018	43	947	1089
Standing elbow height adults m+f (60+)	Max. height of the puzzle board surface from the ground	1025	64	920	1130
m		1067	52	981	1153
f		985	47	908	1062
Eye height children m+f (7 years)	Min. height of the puzzle digital screen from the ground	1140.06	135.73	980.25	1329.7
Eye height students m+f (17-27)	Max. height of the puzzle digital screen from the ground	1649	91	1499	1799
m		1711	71	1594	1828

Measurement description	Measurement purpose	Mean (mm)	sd (mm)	5th (%)	95th (%)
f		1586	60	1487	1685
Eye height adults m+f (31-60)	Max. height of the puzzle digital screen from the ground	1602	85	1462	1742
m		1659	79	1534	1784
f		1551	55	1461	1641
Eye height adults m+f (60+)	Max. height of the puzzle digital screen from the ground	1561	86	1420	1702
m		1620	65	1513	1727
f		1506	63	1402	1610
Children's weight (kg) m+f (7 years)	x 10=max. force needed to push pedal down of gas lift	26 kg	4 kg	19 kg	33 kg
m		26 kg	3 kg	21 kg	31 kg
f		26 kg	4 kg	19 kg	33 kg
Adults' weight (kg) m (31-60)	Max. Downwards force of people pushing/leaning on game	82 kg	12 kg	62 kg	102 kg
Children's arm length m+f (7 years)	Max. depth/width of the puzzle board to reach all pieces	521	33	467	575
m		520	31	469	571
f		522	34	466	578
Children's grip circumference m+f (7 years)	Max. Circumference of puzzle piece handles/knobs	92	8	79	105
m		91	8	78	104
f		92	8	79	105
Forefinger breadth students m+f (17-27)	Min. diameter of the push buttons	15	1	13	17
m		16	1	14	18
f		14	1	12	16
Forefinger breadth adults m+f (31-60)	Min. diameter of the push buttons	18	2	15	21
m		19	1	17	18
f		16	1	14	18
Forefinger breadth adults m+f (60+)	Min. diameter of the push buttons	18	2	15	21
m		18	2	15	21
f		17	2	14	20

First round of technical drawings:

Box dimensions. The final concept will be designed within the following dimensions:

Based on the applicable anthropometric measurements from the chosen percentiles, the box dimensions could be determined. These are the most important dimensions according to which the

product must be designed (Refer to Figures 40, 41, 42)

A link to the pdf of these figures is also given to access a better quality image.

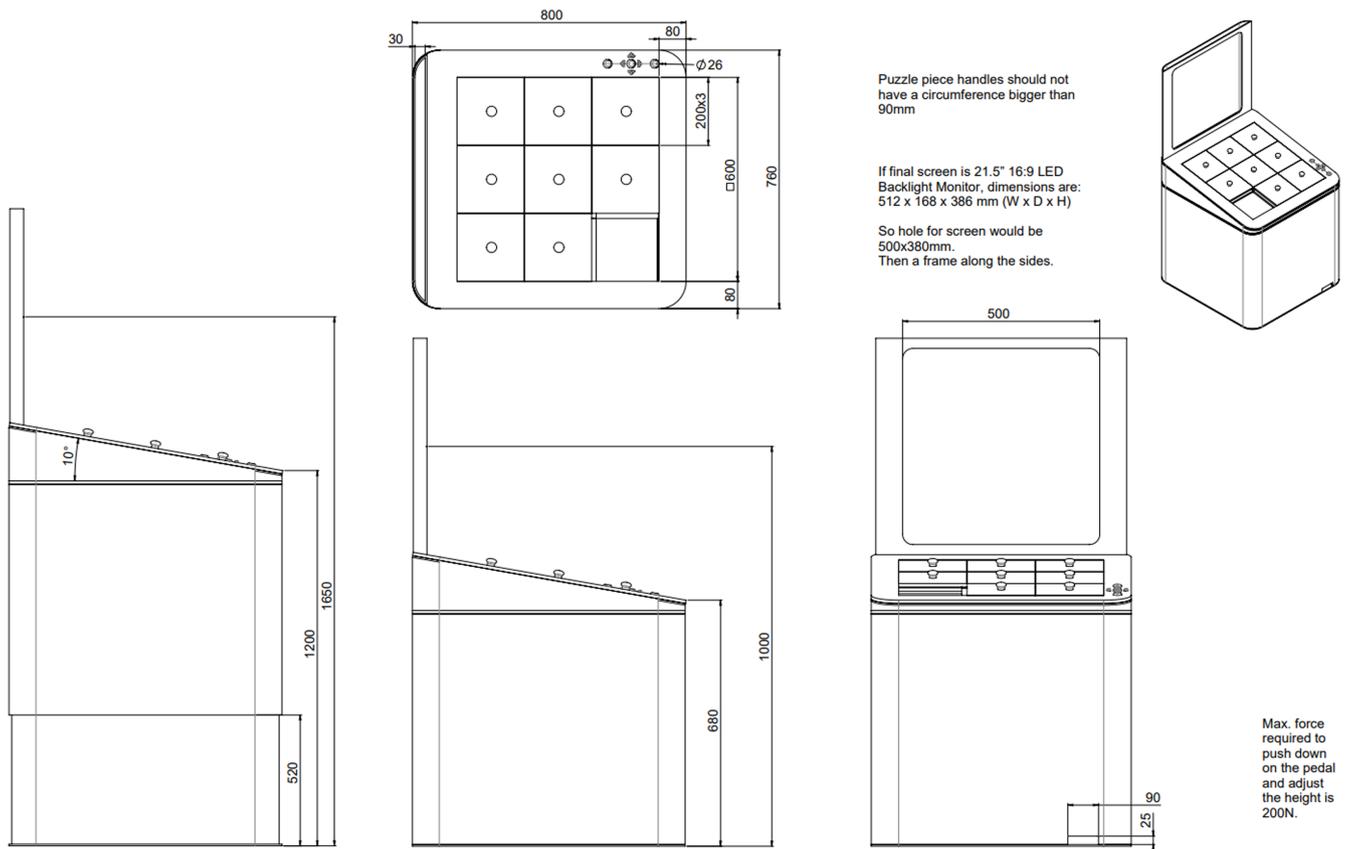


Figure 40: Assembled product view

Direct link to pdf of main assembly with measurements:

[main_assembly.pdf](#)

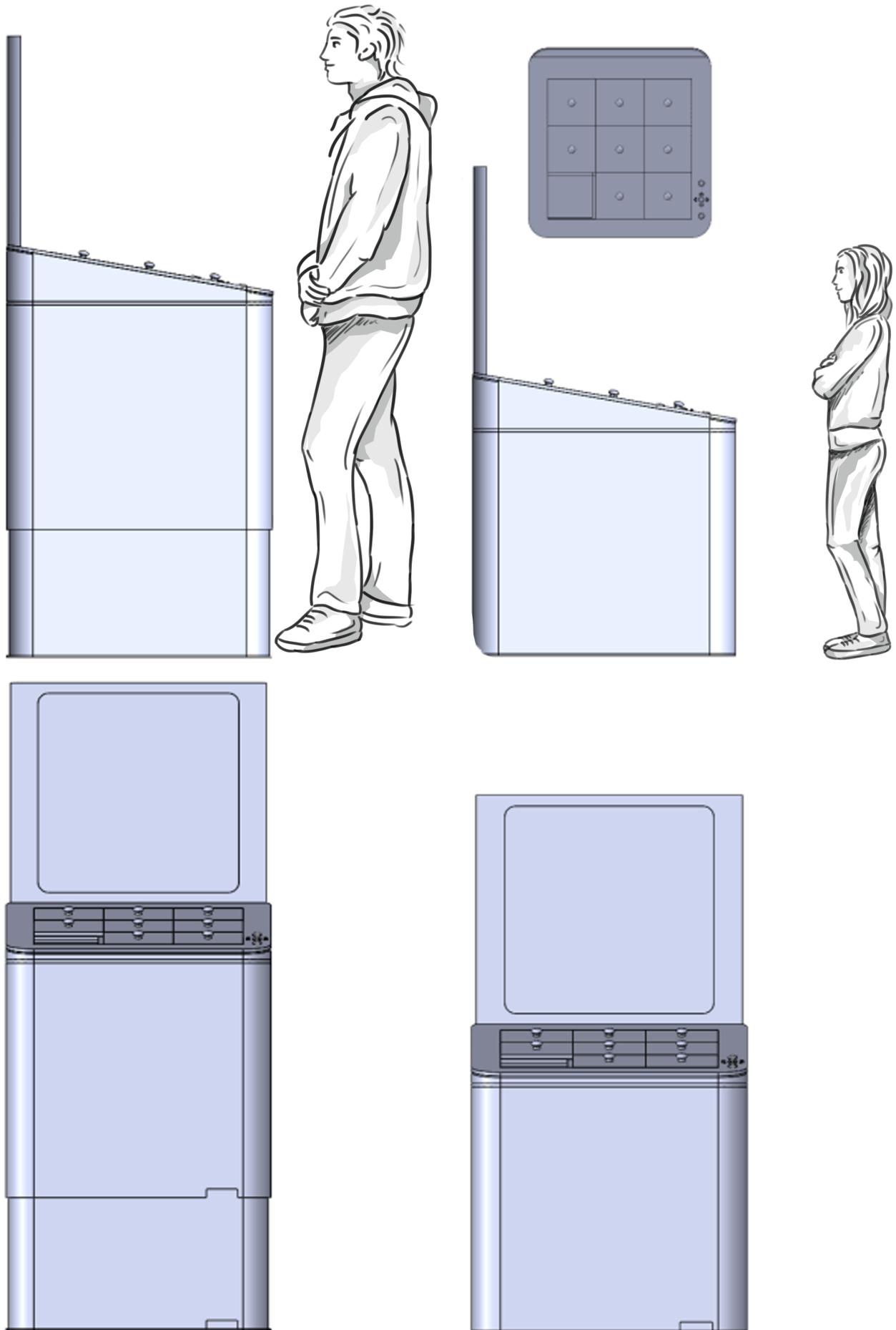
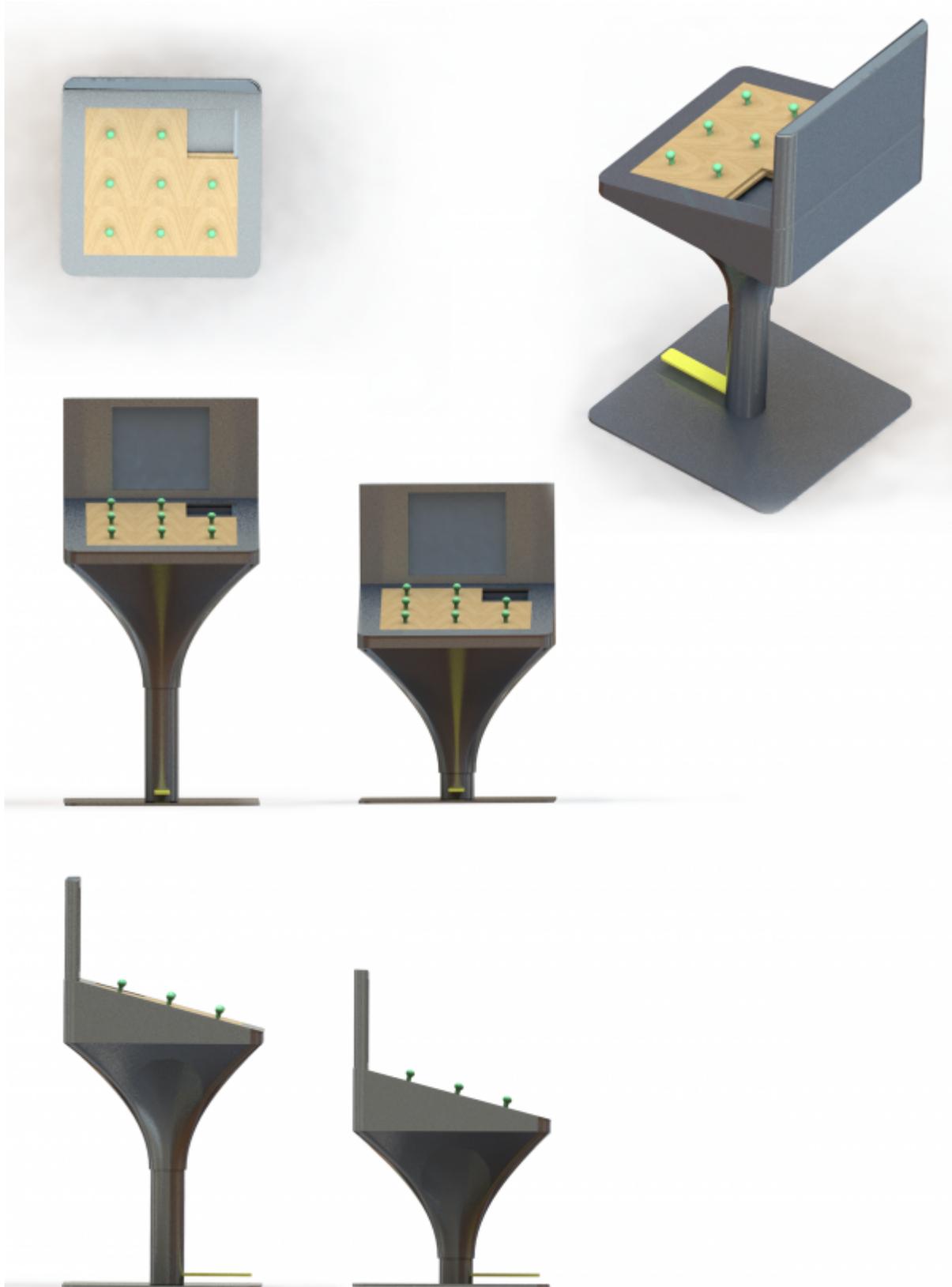


Figure 42: Shown in proportion

Further design and developments of the product shape and configuration with the materials applied. Refer to Figure 43





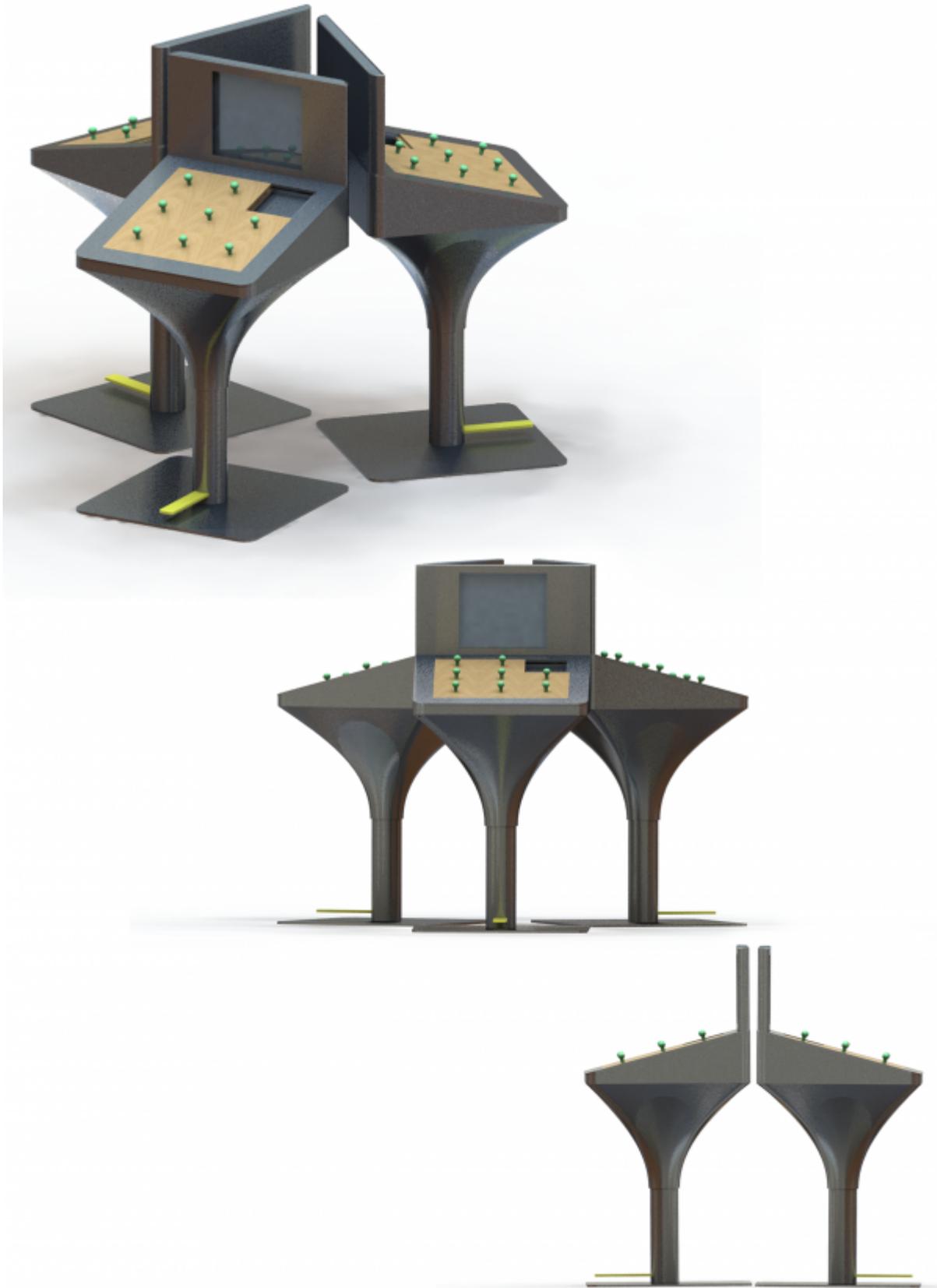


Figure 43: Rendered views of the product concept

After these initial designs, the product design was further optimised. This included adding handle indents in the side of the puzzle game to enable easier handling and transport of the product. The pneumatic lift and its contact with the foot pedal was re-designed, as well as the foot pedal itself. Refer to Figure 44

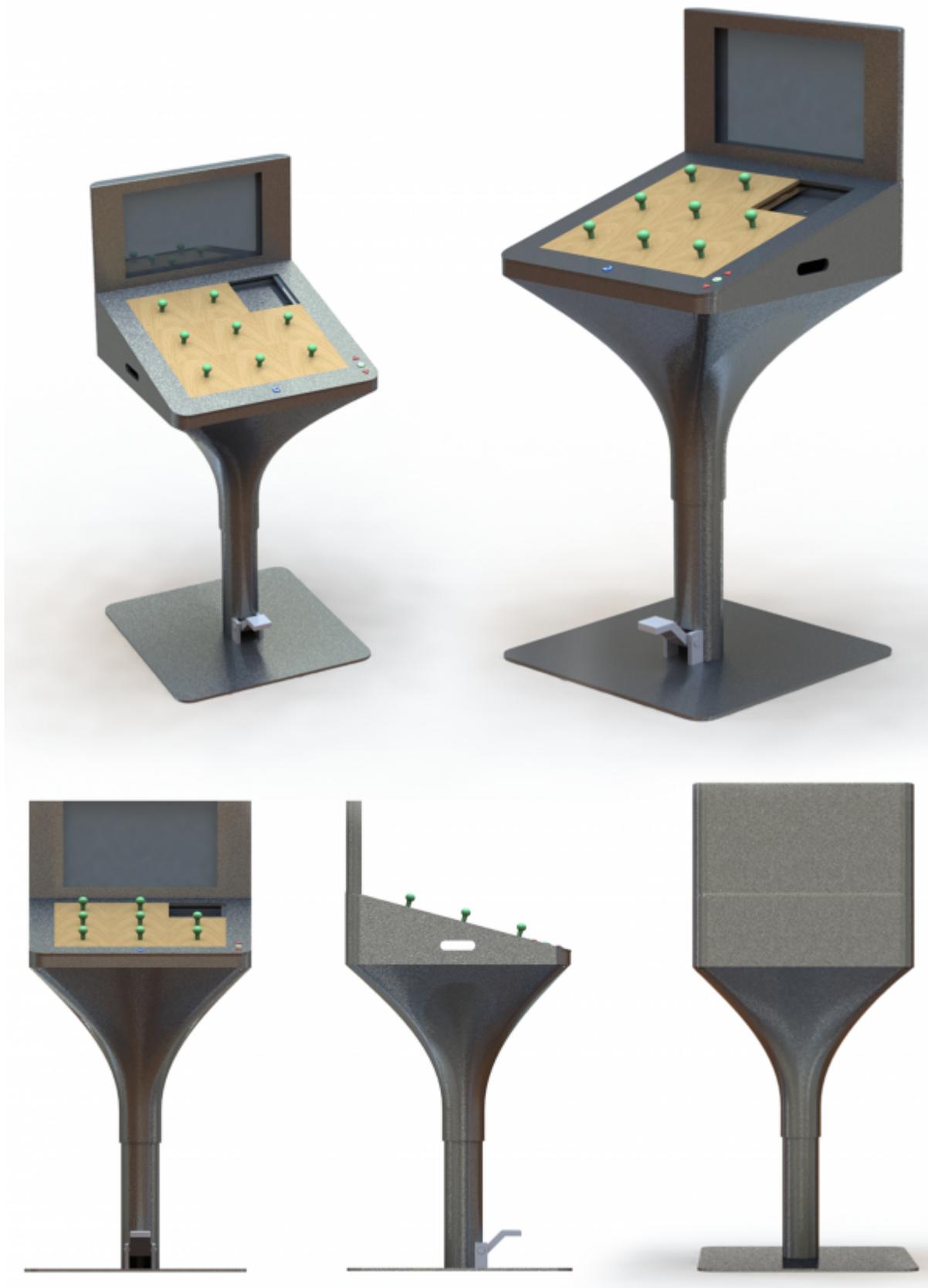




Figure 44: Rendered views of the final product concept

The final dimensions of the product can be seen in figure 45. One can see how the height of the puzzle table can vary by means of the foot pedal and pneumatic lift, depending on the height of the player. The difference in height can be seen in the figure below.

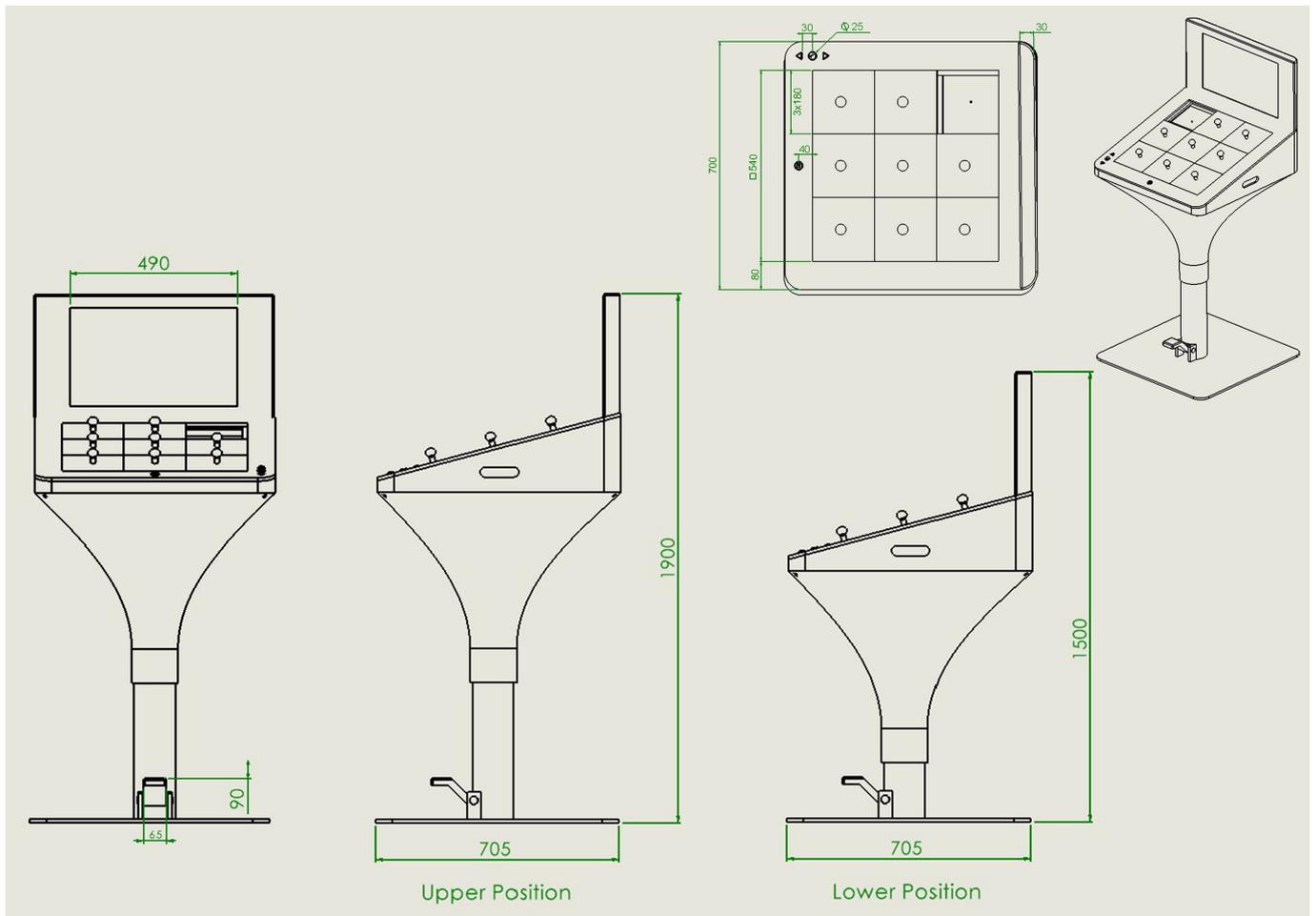


Figure 45: Final product basic dimensions

Now that the main construction and requirements of the game are known, the list of components can be determined to result in a working product. A distinction is made between what is needed/possible to obtain for building the prototype, and what would be used if it were to be actually built and installed in public spaces to be used by people in the city.

The list of components includes the following:

Physical:

- Puzzle pieces
- Frame
- Construction
- Cover for screen
- Interactive buttons or controls
- Solar panel and battery

Electronic and digital:

- Screen-user interface
- Sensors or tracking camera
- Camera
- Timer
- Speaker(s)

The following table 24 shows the list of components needed to build the prototype.

Table 24: List of possible components for the prototype

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
9 + 3 as backup	Sensores de luz ambiente Ceramic Photocell	-	-	1	0.40 €/0.67 (per 10) €	0.4 g	Botnroll, Mouser	Botnroll Mouser
40	Cabos ponte Premium Silicone Covered Male-Male Cabos ponte - 200mm x 40	-	-	2	9.35 €	-	Available on campus	ISEP
9	1kΩ resistor	-	-	3	0.193 € (per 10)	-	Mouser	Mouser
1	Arduino Mega	-	-	4	32.81 €	-	Available on campus	ISEP
1	Laptop Camera	-	-	5	-	-	Available on campus	Property of Team 4
5	Push Button TS02-66-55-BK-160-LCR-D	-	-	6	0.094 €	-	Mouser	Mouser
1	Laptop Screen	-	-	7	-	-	Available on campus	Property of Team 4
1	Height adjustment system - office chair gas lift OR Amortecedores Gás para Cadeiras Altas / Estirador (hidráulico)	-	Metal and plastic (office chair component)	8	31,33 €	-	ISEP OR Riva Office supplies	Riva Office supplies
1	Foot pedal	-	PLA, volume: 16494 mm ³	9	?	-	Technical drawings-Team 4/ 3D printed at ISEP	
2	Pedal brackets	-	Steel plate, volume: 9401 mm ³	10	?	-	Technical drawings-Team 4/ Supplied by and made at ISEP	
1	Pedal pin	-	Zinc plated steel bolt, M8 x 57 mm	11	?	-	Supplied and altered by ISEP	
2	Washer	-	Steel, hole diameter: 8 mm, outer diameter: 15 mm	12	?	-	Supplied by ISEP	
2	Base platform	-	Steel plate, 247 x 250 x 5 mm	13	?	-	Supplied and altered by ISEP	
1	Base cylinder holder	-	Steel tube, outer diameter: 40 OR 48 mm, inner diameter: 36 OR 42 mm, (wall thickness: 2 OR 3 mm	14	?	-	Supplied and cut by ISEP	
1	Top cylinder holder and guide	-	Steel tube, outer diameter: 60 mm, inner diameter: 53 mm	15	?	-	Supplied and cut by ISEP	
4	Base support legs	-	Hollow steel profile, 20 x 20 x 160(length) mm, wall thickness: 1.5 mm	16	?	-	Supplied and cut by ISEP	
4	Plastic inserts	-	PLA 3D printed, 20 x 20 x 15 mm, thickness: 3 mm	17	?	-	Technical drawings-Team 4/ 3D printed at ISEP	

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
1	Self locking nut	-	Metal, 8 nuts self-locking standers D8	18	5,49 €	-	Leroy Merlin	
2	Tightening bolts	-	Metal, M6 x 40 mm bolt	19	?	-	Supplied by ISEP	
2	Nuts for extra thread grip	-	Metal, hole diameter: 6 mm	20	?	-	Supplied by ISEP	
4	Fastening screws	-	Zinc plated, 20 screws Standers philips M4 x 20 mm	21	3,49 €	-	Leroy Merlin	
1	Puzzle Pieces (Lip/Groove)	-	Painel Contraplacado(Plywood board) 1200 x 600 x 5 mm	22	8,99 €	-	Leroy Merlin	Leroy Merlin
1	Puzzle frames (Lip/Groove)	-	Painel Contraplacado(Plywood board) 600 x 300 x 5 mm	23	3,49 €	-	Leroy Merlin	Leroy Merlin
2	Puzzle base support and casing	-	Painel Contraplacado(Plywood) 800 x 400 x 10 mm	24	6,99 €	-	Leroy Merlin	Leroy Merlin
1	Part of laptop support	-	Ripa Casquinha BR Aplainada (Planed wooden batten CASQUINHA WHITE) 18 x 18 x 900 mm	25	1,99 €	-	Leroy Merlin	Leroy Merlin
8	Handles for gripping puzzle pieces	-	Wood - Pux Mad Faia 30 mm ENV 259	26	0,99 €/unit	-	Leroy Merlin	Leroy Merlin
1	Universal glue for assembling the prototype	-	Cola UHU Contacto Gel 50 ml Super-forte	27	6,94 €	-	Ponto das Artes	Ponto das Artes
1	Transparent tape	-	Fita Cola Transparente Tesa 19 mm x 33 m	28	1,24 €	-	Ponto das Artes	Ponto das Artes
1	Adhesive for assembly	-	Cola Branca Mad Axton 225 g	29	3,19 € (14,18 €/kg)	225 g	Leroy Merlin	Leroy Merlin
1	Keeping wires in place	-	Patafix UHU white fixing pads (Pastilhas Fixacao Patafix UHU branco)	30	3,29 €	-	Leroy Merlin	Leroy Merlin

Table 25: Final list of materials and components for prototype

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
9 + 3 as backup	Sensores de luz ambiente Ceramic Photocell	-	-	1	0.40 € / 0.67 (per 10) €	0.4 g	Botnroll, Mouser	Botnroll Mouser
40	Cabos ponte Premium Silicone Covered Male-Male Cabos ponte - 200mm x 40	-	-	2	9.35 €	-	Available on campus	ISEP
9	1kΩ resistor	-	-	3	0.193 € (per 10)	-	Mouser	Mouser
1	Arduino Mega	-	-	4	32.81 €	-	Available on campus	ISEP

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
1	Laptop Camera	-	-	5	-	-	Available on campus	Property of Team 4
5	Push Button TS02-66-55-BK-160-LCR-D	-	-	6	0,094 €	-	Mouser	Mouser
1	Laptop Screen	-	-	7	-	-	Available on campus	Property of Team 4
1	Height adjustment system - office chair gas lift	-	Metal and plastic (office chair component)	8	31,33 €	-	Supplied by ISEP	
1	Foot pedal	-	Re-used plastic component of office chair hand lever	9	-	-	Office chair supplied by ISEP	
2	Base platform	-	Steel plate, 247 x 250 x 5 mm	10	?	-	Supplied and altered by ISEP	
1	Base cylinder holder	-	Re-used base part of office chair	11	-	-	Office chair supplied and altered by ISEP	
1	Top cylinder holder and guide	-	Solid steel tube, diameter: 25 mm, inner drilled hole diameter: 10 mm x 50 mm deep	12	?	-	Supplied, cut and drilled by ISEP	
4	Base support legs	-	Hollow steel profile, 20 x 20 x 160(length) mm, wall thickness: 1.5 mm	13	?	-	Supplied and cut by ISEP	
4	Plastic inserts	-	PLA 3D printed, 20 x 20 x 15 mm, thickness: 3 mm	14	?	-	Technical drawings-Team 4/ 3D printed at ISEP	
2	Tightening bolts	-	12 Steel screws STANDERS SCREW ZINC PLATED, M5 x 20 mm bolt	15	3,69 €	-	Supplied by ISEP	Leroy Merlin
8	Nuts welded for thread	-	Metal: zinc-plated, M8, 8 Nuts SELF-LOCKING STANDERS D8	16	5,49 €	-	Supplied by ISEP	Leroy Merlin
4	Bolts for fastening supports onto base	-	4 screws STANDERS SCREW ZINC PLATED M8 x 30 mm	17	3,49 €	-	Supplied by ISEP	Leroy Merlin
4	Feet for uneven ground	-	Metal and plastic, 4 levelers for feet M8 4 UNITS	18	2,99 €	-	Leroy Merlin	Leroy Merlin
4	Fastening screws	-	10 ROUND Screws 5 x 20 mm	19	2,79 €	-	Supplied by ISEP	Leroy Merlin
1	Puzzle Pieces (Lip/Groove)	-	Painel Contraplacado(Plywood board) 1200 x 600 x 5 mm	20	8,99 €	-	Leroy Merlin	Leroy Merlin
1	Puzzle frames (Lip/Groove)	-	Painel Contraplacado(Plywood board) 600 x 300 x 5 mm	21	3,49 €	-	Leroy Merlin	Leroy Merlin
2	Puzzle base support and casing	-	Painel Contraplacado(Plywood) 800 x 400 x 10 mm	22	6,99 €	-	Leroy Merlin	Leroy Merlin
1	Part of laptop support	-	Ripa Casquinha BR Aplainada (Planed wooden batten CASQUINHA WHITE) 18 x 18 x 900 mm	23	1,99 €	-	Leroy Merlin	Leroy Merlin

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
8	Handles for gripping puzzle pieces	-	Wood - Pux Mad Faia 30 mm ENV 259	24	0,99 €/unit	-	Leroy Merlin	Leroy Merlin
1	Universal glue for assembling the prototype	-	Cola UHU Contacto Gel 50 ml Super-forte	25	6,94 €	-	Ponto das Artes	Ponto das Artes
1	Transparent tape	-	Fita Cola Transparente Tesa 19 mm x 33 m	26	1,24 €	-	Ponto das Artes	Ponto das Artes
1	Adhesive for assembly	-	Cola Branca Mad Axton 225 g	27	3,19 € (14,18 €/kg)	225 g	Leroy Merlin	Leroy Merlin
1	Keeping wires in place	-	Patafix UHU white fixing pads (Pastilhas Fixacao Patafix UHU branco)	28	3,29 €	-	Leroy Merlin	Leroy Merlin

The following table 26 shows the list of components that can be used to produce the actual product.

Table 26: List of possible components for the final product

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
9	Sensores de luz ambiente Ceramic Photocell (in case those don't work we will try these TCRT5000)	-	-	1	0.40 €/0.67 (per 10) €	0.4 g	Botnroll, Mouser	Botnroll Mouser
40	Cables	-	-	2	9.35 €	-	Mouser	Mouser
9	1k ohm resistor	-	-	3	0.193 € (per 10)	-	Mouser	Mouser
1	RASPBERRY PI 3 MODEL B BCM2837	-	-	4	40.27 €	42 g	Digikey	Digikey
1	Câmara Web	-	-	5	34.99 €	-	Continente	Continente
5	Push Buttons	-	-	6	0.091 € (per 10)	-	Mouser	Mouser
1	AOC e2270Swn 21.5" Full HD Preto monitor de ecrã plano	-	-	7	82.88 €	4.5 kg	Fnac	Fnac
1	Screen Protection	-	Plexi	8	-	-	-	
1	Pneumatic Actuator	-	-	9	*	*	*	
1	Foot Lever 1	-	-	10	-	-	-	
1	Foot Lever 2	-	-	11	-	-	-	
1	Pin EN ISO 8734	-	Steel	12	-	-	-	

Quantity	Designation	Norm	Material	Rf. Number	Price	Weight	Supplier	Link to page
8	Puzzle Pieces (Lip/Groove)	-	White Oak	13	1200-2000 €/m ³	-	-	
1	Frame (Lip/Groove)	-	Aluminium	14	2.30 €/kg	-	-	
1	Frame Base	-	Aluminium	15	2.30 €/kg	-	-	
1	Big diameter Cylinder	-	Aluminium	16	2.30 €/kg	-	-	
1	Funnel	-	Aluminium	17	2.30 €/kg	-	-	
2	Retainer 50x100mm	-	Aluminium	18	2.30 €/kg	-	-	
1	Screen Frame	-	Aluminium	19	2.30 €/kg	-	-	
1	Rubber Insert	-	Rubber	20	-	-	-	
1	Cylinder-Sliding Pieces Connector	-	Aluminium	21	2.30 €/kg	-	-	
1	Piston Rod Guide	-	Aluminium	22	2.30 €/kg	-	-	
16	Screw ISO 4017	-	Steel	23	-	-	-	
8	Handles	-	White Oak	24	1200-2000 €/m ³	-	-	
2	Brackets	-	Aluminium	25	2.30 €/kg	-	-	
1	Base	-	Aluminium	26	2.30 €/kg	-	-	

*These factors will be available after the determination of the total weight of the device because it is very important to know how much weight the gas lift has to support.

7.4.2 Materials

Various materials that could potentially be used to make the various parts of the game were researched and compared in order to be able to select the best, most sustainable option (Refer to Tables 27, 28, 29, 30)

- Possible materials for sliding pieces:

The sliding puzzle pieces are around 200 mm x 200 mm, and slide with a lip and groove system in and along each other. They therefore need to be constructed in a material or have a specific finishing applied that gives them a low frictional coefficient. They are also the parts that will be man-handled and so need to be made from a robust material that can withstand wear and tear and the outdoor conditions. The game will be installed in public spaces mainly outdoors. Below are tables comparing various different materials that could potentially be used for constructing the puzzle pieces as well as the other parts of the game's structure such as housing and frames.

Table 27: Plastic options 1

	PTFE	PUR	UHMWPE	Silicone	Nylon
--	-------------	------------	---------------	-----------------	--------------

	PTFE	PUR	UHMWPE	Silicone	Nylon
Low coefficient of friction	Yes	Yes	Yes	Yes	Yes
Resistance to corrosion	Yes	Yes	Yes	Yes	Yes
Chemically Inert	Yes	Yes	Yes	Yes	Yes
Heat resistance (°C)	200	93	90	230	220
Durable (years)	85	25-50	15-20	20+	10
Recyclable	Yes	No	Yes	Yes	Yes
Price (€/kg)	15.00	4.00	3.16	9.00	2.71

Additional information: PUR has different kinds of coefficient of friction for each one of its formulas, different formulas will get a different coefficient of friction. It can't be recycled too because it is made of a network of different components and the recyclability of the material is hard because each component has different characteristics and that affects the way the material is recycled so PUR can only be downcycled to a material that is less effective with lower quality. If PTFE is made without perfluorooctanoic acid, or PFOA, makes it much safer and easier to recycle.

- Possible plastics:

Table 28: Plastic options 2

	PP	PE	PS	PLA	PHA	PVC	HDPE
Chemically Inert	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flexibility	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Durable (years)	20	50-100	500	15	1.5-3.5	25-40	50
Recyclable	Depends	Yes	Depends	Yes	Yes	Yes	Yes
Biodegradable	No	No	No	Yes	Yes	No	No
Price (€/kg)	0.80	1.00	1.02	15.00	3.00	1.15	1.07

Additional information: PP is recyclable if not too many additives are added. A bad side of this plastic is that it is UV-sensitive, so for sunlight exposure might be a problem. A good thing with PE is that it is commonly used in toys manufacturing, and it is UV-resistant, as well as cheap. PHA has a good property that allows the user to configure which type of characteristics he wants the material to have because different configurations of the chain lead to different types of properties, for instance, the shorter they are, the more rigid, brittle and crystalline and the longer they are, the more flexible and stretchier they are.

- Choice of the plastic: By analysing the table, two types of plastics were chosen to make part of our device: PVC was chosen because it is a good material for frames and we will need the construction of a frame for our sliding pieces, the frame will be to protect the pieces and to make them slide properly too, with this we will be sure that no one takes the pieces from its place and that the game will be functional. One more important feature about PVC is that it can protect and insulate electric wiring and components. The other type of plastic for the device will be PE because it can serve as a protection layer because of its impact resistance properties. It is a light-weight material and can cheap too, highly recyclable and durable too.

- Possible metals:

Table 29: Metal options

	304 Stainless Steel	Aluminium	Iron	Galvanized Steel
Low coefficient of friction	Yes	Yes	Yes	Yes
Resistance to corrosion	Yes	Yes	Yes	Yes
Chemically Inert	Yes	Yes	Yes	No
Heat resistance (°C)	871	655	648	200
Ductility (MPa)	515-625	90	540	250
Durable (years)	20	40-80	50-100	72
Recyclable	Yes	Yes	Yes	Yes
Price (€/kg)	1.30	2.30	0.13	0.65

Additional information: Within the stainless steel there is 2 types: 304 and 316 stainless steel and for the aim of the project the 316 is not an option because it is more used in high corrosive environments like the sea. Stainless steel is not completely chemically inert, it is dependent on the chromium it has, the higher the percentage of chromium, the higher the surface protection against corrosion or chemicals. The coefficient of friction of aluminium can vary depending on the type of alloy, surface finish or the environmental conditions. Iron can be treated to improve its properties and make it more resistant to environmental conditions. For instance, the addition of nickel or chromium creates a stainless steel alloy. Another treatment is to apply a protective coating, such as paint or a corrosion-resistant primer. Additionally, the maintenance and cleaning can always help to prolong the life of iron components and prevent corrosion. For the galvanized steel, the coefficient of friction depends on the specific type of galvanized steel and the surface finish, but usually, it is moderate to high. It is also not very chemically inert because it has a zinc coating, and the zinc can react with certain elements of the environment.

-Choice of the metals: After analysing the metal table, the conclusion came out to the use of 304 Stainless Steel for its price, durability and recyclability, the source of it can even be second hand materials that are no longer being used or excess from manufacturing processes. It will serve as the outside part of the device to protect the components inside and to keep the device working no matter the outside conditions. A easy and affordable way of maintain the outside part in good conditions it's cleaning and taking care of it. Aluminum it is also very usable in the housing of our device because it is a light material and has the right properties to handle outside conditions, although the price is a bit higher it is highly recyclable and the source of the material can be very sustainable.

- Possible wood types:

Table 30: Wood options

	Teak	Bamboo	Sweet Chestnut	White Oak	Eucalyptus	Maritime Oak
Durability (years)	50-70	4-7	15-25	40-80	15-30	40
Insect resistance	Yes	No	Yes	Yes	Yes	Yes
Weather resistance	Yes	No	Yes	Yes	Yes	Yes

	Teak	Bamboo	Sweet Chestnut	White Oak	Eucalyptus	Maritime Oak
Workability	Good	Very Good	Good	Good	Yes	Yes
Hardness	High	Very High	Low	High	Yes	Yes
CIFES Appendices	No	No	No	No	No	No
IUCN List of Threatened Species	Least concern	Least concern	Least concern	Least concern	Least concern	Least concern
Availability	Low	High	High	High	High nationally	High nationally
Pricing (€/m ³)	1000-2500	300-700	600-1200	1200-2000	11.90	74.60

Teak is highly durable and resistant to rot, insects, and weathering, making it a popular choice for outdoor furniture and boats. However, it is a hard wood that can be difficult to work with, and it is also one of the most expensive woods available due to limited availability and mixed sustainability practices. However, bamboo used in exterior conditions is perishable and will deteriorate in a matter of years. This is also paralleled in the short natural life cycle of bamboo, where many species quickly reach full maturity after only two or three years, and are subsequently attacked by decay mold and fungi, typically collapsing only a few years later. Bamboo is also susceptible to insect attacks such as powder-post beetles, termites, and marine-borers. Bamboo, on the other hand, is a highly sustainable and affordable wood that is durable and easy to work with. It grows quickly and is widely available, making it a popular choice for flooring, furniture, and other household items. Chestnut is a moderately durable wood that can be difficult to work with due to its irregular grain and hardness. It is moderately priced and a renewable resource, but less widely available than bamboo or white oak. White Oak is highly durable and easy to work with, making it a popular choice for furniture and flooring. It is moderately priced, renewable, and widely available in many regions of the world. Uses Maritime Pine - Paper (pulpwood), flooring, boxes/crates, and construction lumber. Uses of Eucalyptus - Utility lumber, pallets, paper (pulpwood), fenceposts, flooring. Veneer, and turned objects

Besides real wood species, synthetic wood types were also looked into as a potentially more sustainable choice compared to wood.

- **Composite wood:** Composite furniture is a term that is often used synonymously with poly lumber, however they are not the same thing. While poly lumber is made 100 % from plastics, composite lumber is made from a blend of wood pulp and plastic. Composites are used mainly in the building industry for decking and fencing, and are not widely used for building furniture.

- **Resin:** Real resin is a plant-based material, and, unlike plastic, is not made from hydrocarbons. Regardless, “plastic resin” is often made of high-density polyethylene (HDPE), and is typically woven into a wicker to look like natural wicker furniture. It is also commonly called synthetic wicker or resin wicker. Resin wicker is a strong material that is resistant to fading and cracking. It also comes at a lower price point than natural wicker because its base components are widely available and relatively inexpensive to produce.

- **Plastic furniture:** Plastic furniture typically refers to injection molded plastic, in which melted plastic is forced into a mold and rapidly cooled so that it retains the shape of the mold. A lot of plastic furniture is molded into a single piece, which means that no assembly or hardware is necessary. For that reason, injection molded plastic has the lowest price point of all plastic furniture because it can

be mass produced quickly and cheaply. However, there are manufacturers that mold plastic chair pieces (like seats and backs) and use a heavier frame material like aluminium or steel for additional strength and durability. Plastic furniture is popular as an economic option that will usually last a couple of years and then needs replaced due to its tendency to bend and crack, particularly in cold weather. There are higher end plastic furniture manufacturers that make furniture with thicker walls and higher weight limits, however.

- Poly / Poly Lumber Furniture: Poly lumber is made from high-density polyethylene (HDPE), a plastic that is used for a wide variety of products like furniture, toys, food containers, and more. In fact, most poly lumber is made from recycled HDPE that comes from discarded water bottles and milk jugs. The plastic is melted down into a liquid and extruded into different board sizes. The poly lumber is then used just like wood to build each piece of furniture. Poly lumber is solid, and coloured throughout, so it is a heavy material that is scratch-resistant and weathers well. One of the side benefits of poly lumber that is made from recycled materials is that it keeps plastic out of the landfill, giving them new life as a piece of furniture or other consumer good. It is more expensive than injection molded plastic furniture, both because it is more durable and not made using mass production [\[ECCB Outdoor, 2018\]](#).

Another name for poly lumber is plastic timber. Eco Green Recycled Plastic Timber Planks, Poles and Bollards are made from 100 % Recycled Plastics from post consumer plastic waste.

Used for: Plastic jungle gyms for schools' playgrounds, park furniture for an urban development or improving facilities for a specific environment.

Advantages:

- Maintenance free
- Insect proof
- Will not rot
- Has a slip-free surface
- Has a long life-span
- Weatherproof
- Safe
- Designed to deal with the most demanding environment
- Maintenance free
- Strong & durable
- Easy to clean
- Cost effective
- Environmentally friendly
- Can be recycled again
- Visually attractive - looks like timber
- 100 % Plastic-from post consumer waste
- Superior to wood composite decking which can sometimes absorb moisture
- Our Plastic timber product has a wood-like texture which is not slippery wet or dry. Recycled plastic decking has been tested to be less slippery when wet than wood and concrete, which actually encourage the growth of molds and mildews that can be very slick [\[British Recycled Plastic, 2023\]](#).

Disadvantages: The timber will expand or contract slightly depending upon variations in the temperature. To accommodate potential movement, adequate spacing should be provided between adjacent and abutting boards [\[Green Furniture, 2023\]](#).

Alternatives to our recycled poly lumber solution don't offer the same sustainability, either. Metal rusts. Wood splinters. Webbing tears. Aluminium frames bend. Any outdoor space can be met with harsh elements that would damage lower quality materials. In the end, this damaged furniture is trashed and sent off to the landfill.

Process:

Using post-consumer waste begins with proper sorting. The material is then thoroughly washed and decontaminated. The base plastic material is processed in a plant and converted into sturdy poly lumber. The plastic is decontaminated to a high purity level, thus ensuring it is safe for use. The purified recycled plastic is formulated with colour pigments, creating colourful, Eco-friendly, maintenance-free products.

It will never leach or contaminate the soil or the ground water, since it is non-porous and contains none of the toxic chemicals found in pressure treated timber. Also the use of plastic timber saves our trees since no wood is used in our products.

Working with it:

Plastic timber is just as easy to work with as wood; in some cases the plastic planks are even easier than wood. It can be cut, drilled, routed and nailed using standard woodworking tools. Carbide blades are recommended for best performance. Virtually all deck fasteners can be used with the plastic timber planks. We use stainless steel / zinc plated screws in the manufacture of our outdoor furniture. Plastic timber planks also hold nails and screws 40 % - 50 % better than wood. Pre-drilling is not necessary, but depending on the application might be preferred.

- **Foam:** The team researched different foams that could be potentially used, in case it was decided to create a soft layer on the puzzle pieces to make them safe and attractive for young children.

First, different playground ground covers were researched, because some of these materials would work to put on the puzzle pieces as they are quite big.

Unitary Materials:

Unitary materials are chemically bound elements that are formed into solid or semi-solid surfaces, such as tiles or rolled products like turf. Unitary materials also include solid surfaces that are poured as a liquid and are allowed to solidify as a soft, spongy surface like rubber. Artificial turf is a common unitary playground ground cover. Unitary ground covers typically are more expensive than loose materials. Their composition is more complex and often requires experienced installation skill. They also need a better-prepared subsurface, but once they're in place, their maintenance is lower due to high durability and strong ability to withstand kick-outs. When choosing a loose or unitary cover for your playground, it's important to consider some general pros and cons to each before looking at the specific advantages and disadvantages of the common ground cover types.

These are the advantages for unitary ground covers:

- Long durability in all conditions
- Easier to accommodate ADA requirements
- Attractive appearance
- Sure-footed grip for safety

Disadvantages of unitary ground covers are:

- Higher purchase and installation cost
- Specialised knowledge required for installation

- May become less resilient over time
- Availability may be an issue

Synthetic Turf:

Synthetic turf is a popular choice for a unitary ground cover. It's more suitable for structured applications like child care centers where a flat surface exists. Turf is also very low in maintenance and easy to spot articles that could be hazardous to children. Many colors are available when choosing turf, and it can work nicely into an eye-pleasing design.

Advantages to using synthetic turf can be:

- Clean and low maintenance
- Excellent in both indoor and outdoor play areas
- Safe from hidden objects

Disadvantages to using synthetic turf:

- Higher cost per area
- Requires professional installation
- Less heat resistant

Synthetic Tiles:

Synthetic tiles are often used for playground ground covers. They're harder than synthetic turf but smaller and easier to handle during installation. Most synthetic tiles are a rubber-based compound, and some are composed of recycled materials like automotive tires. Synthetic tiles are popular for installing over existing surfaces like concrete slabs or asphalt lots. They require a flat and smooth substrate but give a cushion effect when in place.

Advantages to synthetic tiles are:

- Highly durable and impact resistant
- Excellent for renovations where a solid base is already in place
- Highly suitable for ADA approval

Disadvantages to synthetic tiles include:

- Expensive when compared to other ground covers
- Requires professional installation
- Dirt and debris can accumulate in the joint cracks

Poured-In-Place Rubber:

Rubber is not a common playground ground cover. Rubber ground for playground is used in projects where specialized conditions and high budgets exist. From an architectural standpoint, there are many colours available that can produce creative surface patterns. Poured in place rubber is more popular for high-end resorts and amusement parks than in civic playgrounds.

Here are the advantages of poured-in-place rubber ground cover for playgrounds:

- Long life and durable wear
- Very skid and abrasion resistant
- Excellent compliance for disabled persons

There are a few disadvantages to using poured-in-place rubber:

- Expensive playground surface
- High skill required to install
- Can become harder over time due to UV rays. Impact testing recommended.

Products Not Recommended

It's worth mentioning a few products that experts don't recommend for playground ground covers as well:

- Grass is a hard surface and requires heavy maintenance.
- Concrete is far too hard and very dangerous.
- Wooden boards and decks at ground level are slippery when wet.
- Bare earth is dirty and prone to invasive insects.
- Loose-fill rubber can't be made to accommodate ADA standards.

EPDM foam:

Properties of EPDM foam:

EPDM is a very weather-resistant raw material, making this foam rubber highly resistant to UV radiation and ozone. These properties ensure a long life span when the material is used outdoors. In addition to UV radiation and ozone, it is also resistant to water and other fluids. When touched, the material will not stain easily or age faster, as most hardnesses of EPDM foam have a closed-cell structure. A few very soft types have semi-closed cells. This soft, compressible material also has very good mechanical properties, which means that the material will return to its original shape following compression. EPDM is not flame retardant, so if you are looking for a material with flame retardant properties, we recommend neoprene foam instead. Despite it lacking flame-retardant properties, this material is well suited to use within a wide range of temperatures (from around -40 °C to 120 °C). EPDM foam is available in many different hardnesses and thicknesses, ranging from extremely soft to 50 Shore A. The very soft version is fully compressible, while the harder types are up to around 25 % compressible. EKI provides EPDM foam in both self-adhesive and non-adhesive forms in the colours black, grey and white. Self-adhesive foam rubber is easy to install.

EPDM rubber is safe and non-toxic, which makes it a great option for children's playgrounds. An EPDM rubber flooring is not only durable but has a couple of more benefits. Ethylene Propylene Diene Monomer (EPDM) membranes are incredibly environmentally friendly and offer a range of benefits for flat roofing, which contributes to sustainability and energy efficiency. EPDM roof membranes have several environmentally friendly benefits, including being 100 % recyclable [\[The Rubber Company, 2023\]](#).

Neoprene foam:

Neoprene foam is the sponge-like version of neoprene, and it is available in two types: open-cell neoprene foam and closed-cell neoprene foam. Neoprene foam is soft, shock-absorbent, insulating, and pliable, making for a neoprene material that is incredibly effective in a multitude of scenarios. A neoprene foam rubber sheet is often used in applications such as a neoprene floor-mount vibration-isolator, a closed-cell neoprene sill-sealer, and a neoprene wrap for PVC pipe.

Neoprene is a type of synthetic rubber, and it can be made in either solid or foam versions. Thus, neoprene is always a type of rubber, first and foremost. But it may or may not be foam neoprene. Foam neoprene maintains many of the resistances and tolerances exhibited by other rubber-sheet products. It is resilient against the corrosive effects of ozone and oxidation, maintains a tolerance to a

wide range of temperatures, and offers moderate chemical- and oil-resistance, making it ideal for a variety of general-purpose applications. (This degree of versatility is the main reason for why neoprene is known as the general-purpose rubber.) However, not every foam neoprene material is structurally similar. There are two distinguishing categories of neoprene foam rubber: open-cell neoprene sponge and closed-cell neoprene sponge rubber.

When offered in a foam form, neoprene is available in either an open-cell variant or a closed-cell variant. Thus, neoprene foam does not come in just one type. These two forms of foam neoprene are produced differently and, consequently, have differing structures. Each one's structure determines the applications for which it is best suited.

Open-cell Neoprene foam:

Open-cell foam neoprene is especially permeable, allowing energy and matter to diffuse throughout the structure of the material. Remarkably, foam neoprene, even when permeated, still maintains its structural integrity. To some, open-cell foam neoprene's permeability may seem like a downside. After all, an open-cell structure defeats the point of many sealing applications. And its permeability likely reduces its effectiveness in aquatic settings. Yet, there is still good reason for why open-cell neoprene foam is such a highly-coveted commodity. Vibration absorption and—consequently—sound insulation is one type of application that benefits greatly from the use of open-cell foam neoprene. The ability to absorb sound is a hallmark of open-cell neoprene sponge sheets because of their expanded capacity for intaking sonic waves. When sonic waves come into contact with open-cell neoprene foam, this material's open pores readily absorb these vibrations. Whereas, in the case of a non-permeable rubber mat, a larger proportion of a sonic wave's force is rebounded off the mat—rather than absorbed.

Its proficiency at vibration absorption, coupled with its comparatively low density, allows the open-cell variant of foam neoprene to enjoy a spectrum of uses.

Closed-cell Neoprene:

Closed-cell neoprene foam is typically used for applications requiring heat insulation or shock absorption. This form of neoprene sponge is defined by the closedness of the gaseous pockets within the foam neoprene material. Unlike open-cell neoprene foam, closed-cell neoprene foam's internal chambers are completely segregated—there are no openings connecting these pockets of gas. This structural difference may seem inconsequential, but it changes many of the circumstances to which the material can be applied. Closed-cell neoprene sponge tends to be harder and less flexible than open-cell neoprene sponge because its closed-cell structure does not permit air to escape when the mat is pressed or flexed. However, closed-cell neoprene rubber is water- and air-tight, and it resists compression better than its open-cell counterpart. Furthermore, its closed structure better prevents heat from escaping the material, making closed-cell foam neoprene better at insulating heat. These traits give the closed-cell neoprene sheet-material a stronger and more resilient structure when compared to an open-cell neoprene sheet. Thus, closed-cell foam neoprene is excellent for applications requiring both heat insulation and sealing capabilities—such as applications in aquatic settings. In short, closed-cell neoprene is better than open-cell neoprene in terms of structural stability and water- and air-tightness [\[Rubber-Cal, 2023\]](#).

When purchasing foam neoprene, always know identify what is the material must accomplish and apply that consideration toward the selection process when purchasing neoprene.

By researching and comparing all of the above mentioned materials on various characteristics in

relation to the different parts of the game, the following materials were chosen for the actual final product that would be produced to install in public spaces (Refer to Table 31).

Table 31: Final list of materials.

Type of material	Final material	Purpose	Reason
Metal	Aluminium	Frame of the game	Aluminium is a lightweight and corrosion-resistant material that offers a high strength-to-weight ratio, which makes it a suitable choice for products that need to be lightweight yet strong. It is also highly durable and can withstand harsh environmental conditions, which makes it a reliable material for long-term use.
Plastic	Plexiglass	Screen cover	Plexiglass is a clear and transparent material that offers high optical clarity, making it a good choice for screen covers where visibility is important. It's highly durable and impact-resistant, suitable for high-traffic areas and outdoor use. Plexiglass doesn't yellow over time and is weather-resistant.
Wood	White Oak	Puzzle pieces; frame of the puzzle	Compared to other possible wood we could use, white oak has great durability and weather resistance, which is important for us since our puzzle game will be placed outdoors.
Rubber	Neoprene foam	Puzzle coating	Neoprene foam is soft, flexible, and waterproof, offering excellent thermal insulation for outdoor products. It's resistant to UV rays, ozone, and oxidation, making it suitable for long-term outdoor use. Neoprene foam is also durable and abrasion-resistant, ideal for high-traffic areas or environments with a risk of impact or wear.

Local suppliers of Portugal for the final chosen materials were then found and listed (Refer to Table 32).

Table 32: Material suppliers

Material	Supplier	Cost
Aluminium	CALDEIRA CLEMENTE	-
Neoprene foam	EUROFOAM	-
Plexiglass	Pixartprinting	€ 63.84
White Oak		

In the following link it can be seen all the simulation results for the prototype model made in solidworks:

[simulation_files.pdf](#)

7.4.3 Smart System

Hardware

The black box diagram (Refer to Figure 46), gives a schematic overview of the inputs and outputs of the hardware and software system that will be used in the construction of the product.

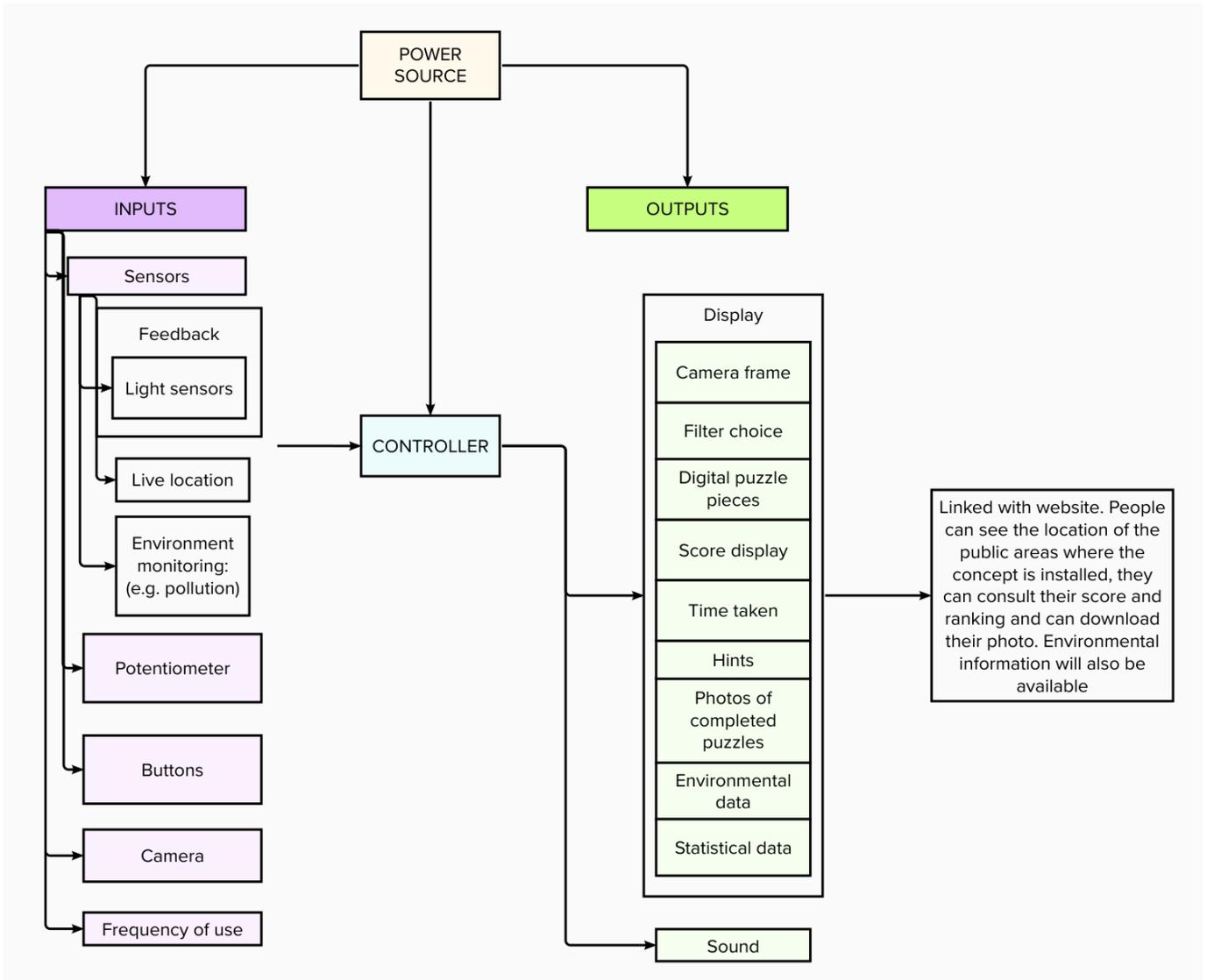


Figure 46: Black box Diagram

The following figure displays the detailed schematics of the product's system.

Refer to Figure 47

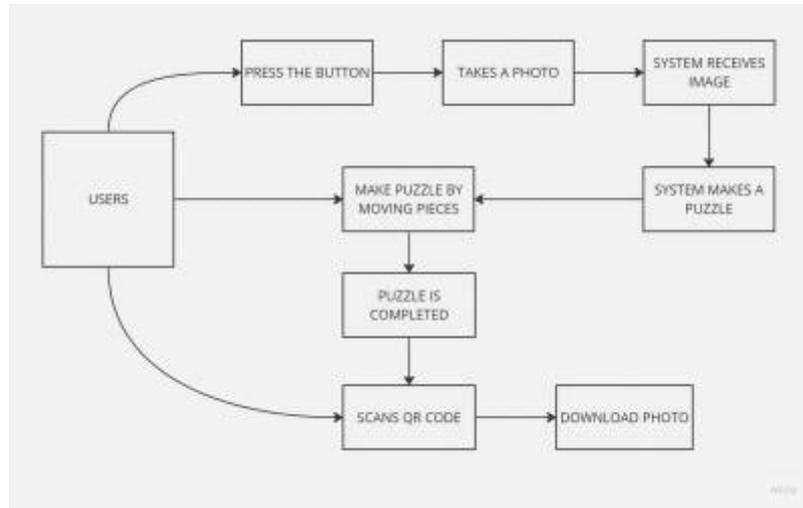


Figure 47: General system diagram

The following figure displays the detailed schematics of the electronics for the final product. The Raspberry Pi 3 with all its connections are clearly shown.

Refer to Figure 48

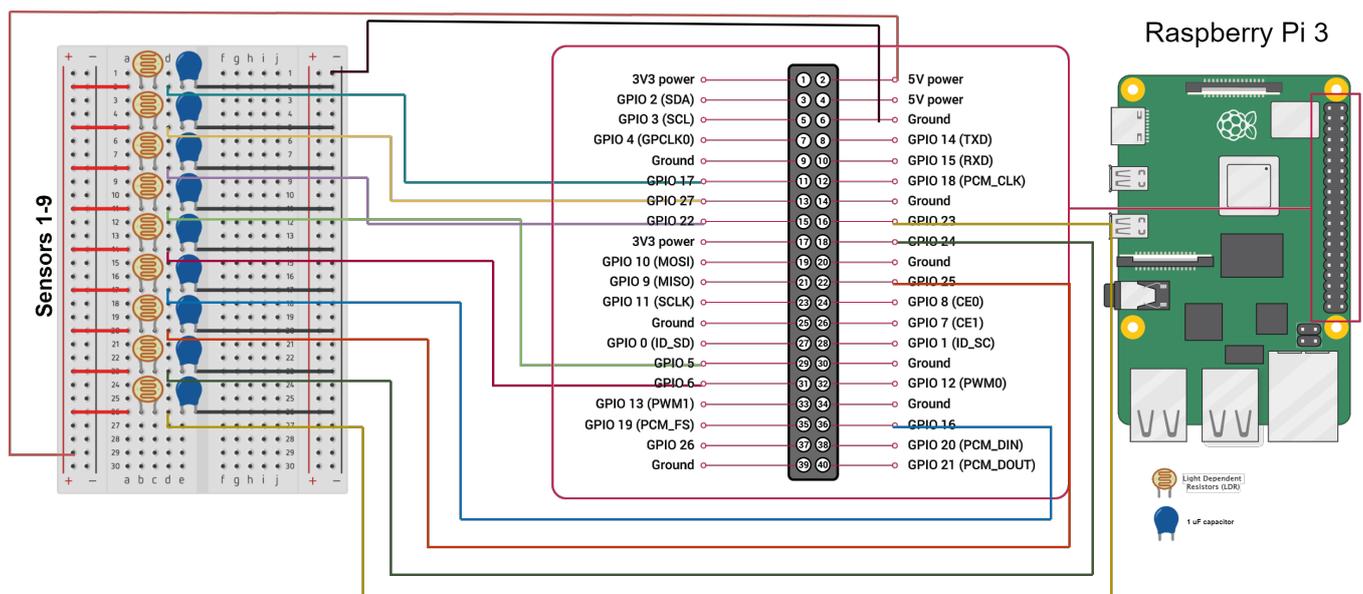


Figure 48: Electronics diagram

Software

7.4.4 Detecting the movement of the puzzle pieces

The 8 puzzle pieces sliding vertically or horizontally on a 9-piece grid. This means there is always one space open in order to be able to slide the pieces around. The image that needs to be solved will appear on the screen, and the players have to solve it by sliding the physical pieces. Therefore the

movement of the physical pieces need to be detected in order for it to be reflected on the screen so that the players can see if their actions are contributing to solving the puzzle. This means that sensors will have to be used in order to detect the movement of the puzzle pieces and transfer that information to the screen. Listed below are different options of sensors that could be used in order to achieve what is mentioned above.

Hall Effect Sensors: These are contactless sensors that can detect the presence or absence of a magnetic field. You can attach a small magnet to the bottom of each puzzle piece and install Hall effect sensors under the board. As the puzzle pieces move on the board, the sensors can detect the changes in the magnetic field and determine the position of each piece.

Optical Sensors: These sensors use light to detect the position of objects. You can place an LED and a phototransistor on opposite sides of each puzzle piece and install the same sensors under the board. When the puzzle pieces move, they interrupt the light beam, and the phototransistor detects the changes in light intensity, enabling you to determine the position of each piece.

Pressure Sensors: These sensors can detect the force or pressure applied to them. You can install pressure sensors under each puzzle piece, and as the pieces move, the sensors can detect the changes in pressure, allowing you to determine the position of each piece.

Resistive Sensors: These are touch-sensitive sensors that can detect the position of touch on their surface. You can place a thin resistive film on top of the puzzle board and attach conductive strips to the bottom of each puzzle piece. As the pieces move, they contact the resistive film, and the sensors can detect the changes in resistance, enabling you to determine the position of each piece. Each type of sensor has its own advantages and disadvantages, and the choice of sensor will depend on factors such as accuracy, cost, and complexity. Whatever the sensor type chosen, the data collected from the sensors can be processed by a microcontroller or single board computer, and communicated to the screen for display.

using computer vision techniques: Take a picture of the puzzle with the pieces in their initial positions. This will serve as the reference image. Use an image processing library, such as OpenCV, to detect the positions of the puzzle pieces in the reference image. You can do this by applying object detection or template matching algorithms. As the user moves the puzzle pieces, use a camera or webcam to capture the current state of the puzzle. Use the same image processing library to detect the positions of the puzzle pieces in the current image. Compare the current positions of the puzzle pieces with their positions in the reference image to determine which pieces have been moved and where they have been moved to. Communicate this information to the software controlling the sliding puzzle. This could be done via a wireless connection between the physical puzzle pieces and the software, or by using sensors on the puzzle pieces that can detect their positions and report this information to the software. Overall, this approach would involve a combination of image processing, computer vision, and hardware integration techniques to create a fun and interactive sliding puzzle game.

- A chart comparing all the different options:

Table 33 compare the researched sensors on various important characteristics and come to decide the best option for the concept.

Table 33: Sensor comparison

	Price	Accuracy	Complexity	Ease of use	Teams knowledge
Hall Effect Sensors	Average	High	Complex	Hard	No knowledge
Optical Sensors	Average	High	Average	Medium	Some knowledge

	Price	Accuracy	Complexity	Ease of use	Teams knowledge
Pressure Sensors	Expensive	Medium	Average	Hard	Some knowledge
Resistive Sensors	Cheap	Medium	Complex	Hard	No knowledge
Computer Vision	Expensive	High	Complex	Hard	Some knowledge

Conclusion:

The easiest and most accurate way to track the movement of the sliding puzzle pieces will depend on various factors such as the size of the puzzle, the required accuracy, and the budget. If accuracy is the primary concern, using a camera-based computer vision system can be the most accurate way to track the movement of the puzzle pieces. With a high-resolution camera and an image processing algorithm, you can track the position of each puzzle piece with high accuracy. Additionally, camera-based systems can be relatively easy to set up, and you can use an off-the-shelf computer vision library such as OpenCV to simplify the image processing task. However, camera-based systems can be relatively expensive, and they require a significant amount of computational power, which can make them less than ideal for some applications. If cost is a concern, using resistive sensors or pressure sensors can be a relatively inexpensive option. Both types of sensors can be used to detect the position of the puzzle pieces with reasonable accuracy, and they can be relatively easy to set up. Resistive sensors are relatively inexpensive and require minimal hardware, while pressure sensors can be slightly more expensive but offer better accuracy. Overall, the choice of the easiest and most accurate way to track the movement of the sliding puzzle pieces will depend on the specific requirements of our project. We may want to consider factors such as accuracy, cost, ease of setup, and complexity before making a final decision.

7.4.5 Digital Display

When deciding on the screen suitable for the project there were a few factors that we had to consider. The first and the most important one is that the screen had all the features that we wanted for the best price. So, to get the best overview of this a matrix Table 34) was created with different types of screens that are available on the market.

- Matrix comparing all the different Screens and monitors available on the market:

Table 34: Screen/monitor comparison

	Price	Accuracy	Complexity	Ease of use	Size	Sound
Computer monitor	Expensive	High	Complex	Hard	Medium	Bad
Television screen	Average	High	Complex	Hard	Hard	Okay
Smartphone/tablet	Average	Medium	Complex	Hard	Easy	Okay
Projector	Expensive	Low	Average	Medium	Hard	Bad
Virtual headset	Cheap	High	Easy	Hard	Easy	Bad

After analysing the above matrix, the conclusion was that the most suitable screen for the project is the computer monitor. This is because the screen must be big enough to enable multiple people to see the screen. A computer monitor is not too hard to work with either which is a big plus. A computer monitor is also affordable and will not be affected by the lighting outside as much as for example a projector.

After deciding on the computer monitor, the next challenge is to determine which kind of display the television screen should have. This display should have a good resolution but not be too expensive. Different types of displays are compared in the Table 35.

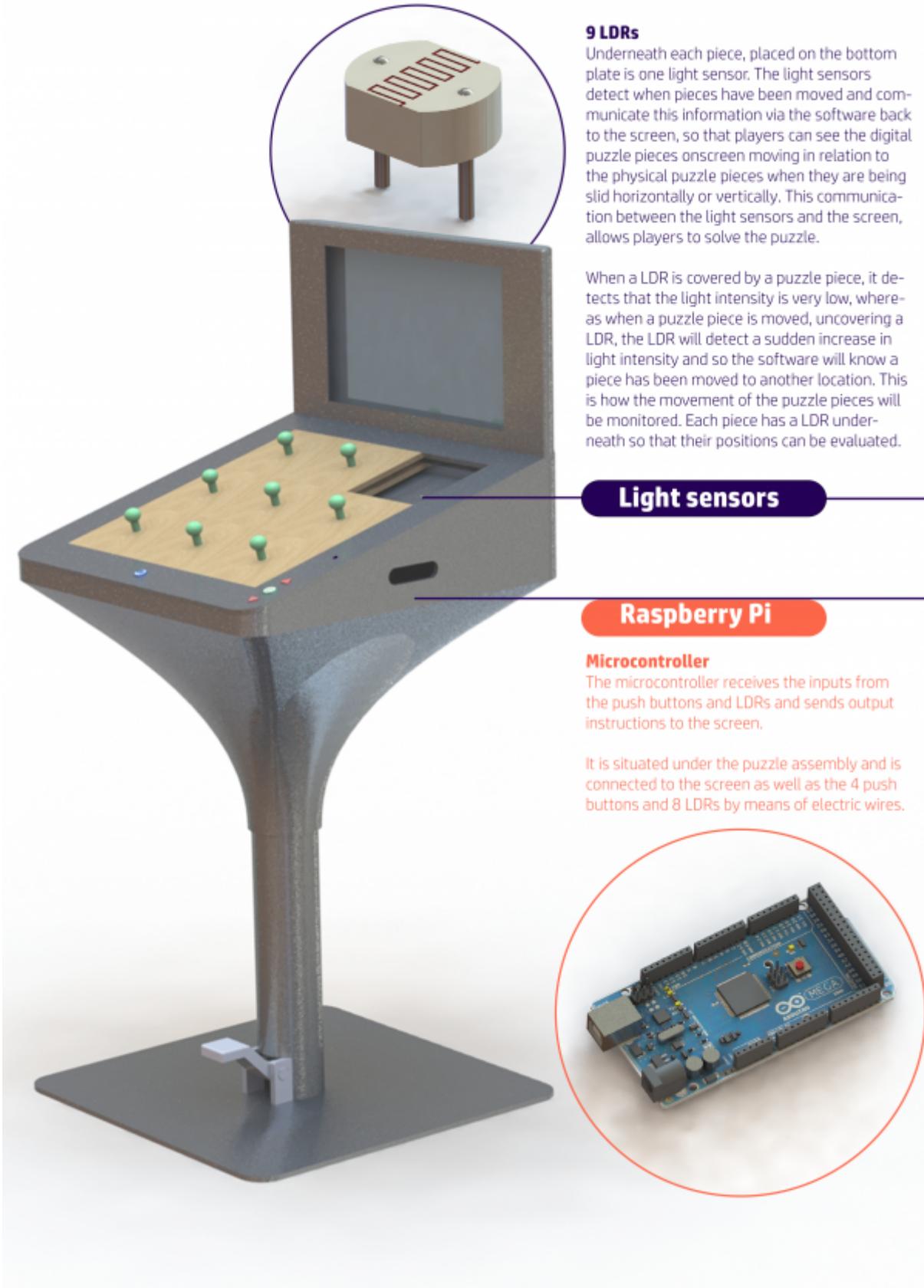
- Matrix comparing all the different displays available on the market:

Table 35: Display comparison

	Price	Accuracy	Complexity	Ease of use
LCD	Expensive	High	Complex	Hard
LED	Average	High	Complex	Hard
OLED	Average	High	Average	Hard
CRT	Expensive	Medium	Complex	Easy

Conclusion: As a conclusion for both matrices above the screen we are going for with our project is a computer monitor with an LCD display. The motivation for this is that the screen is as big as we want it to be, the display has high enough resolution and is able to work outside on a sunny bright day.

The final design in combination with the selection of the materials, the electronic components and the programming of the software lead to the final concept with all its functions and features. Diagrams and explanations of these features, where they are on the puzzle table and what they are for, can be consulted in figures 49, 50 and 51.



9 LDRs
Underneath each piece, placed on the bottom plate is one light sensor. The light sensors detect when pieces have been moved and communicate this information via the software back to the screen, so that players can see the digital puzzle pieces onscreen moving in relation to the physical puzzle pieces when they are being slid horizontally or vertically. This communication between the light sensors and the screen, allows players to solve the puzzle.

When a LDR is covered by a puzzle piece, it detects that the light intensity is very low, whereas when a puzzle piece is moved, uncovering a LDR, the LDR will detect a sudden increase in light intensity and so the software will know a piece has been moved to another location. This is how the movement of the puzzle pieces will be monitored. Each piece has a LDR underneath so that their positions can be evaluated.

Light sensors

Raspberry Pi

Microcontroller
The microcontroller receives the inputs from the push buttons and LDRs and sends output instructions to the screen.

It is situated under the puzzle assembly and is connected to the screen as well as the 4 push buttons and 8 LDRs by means of electric wires.

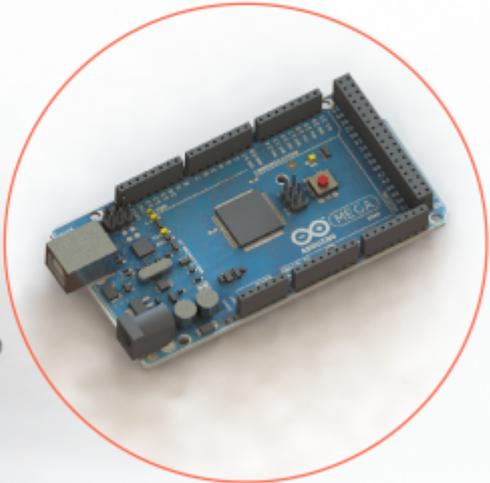


Figure 49: Electronic features

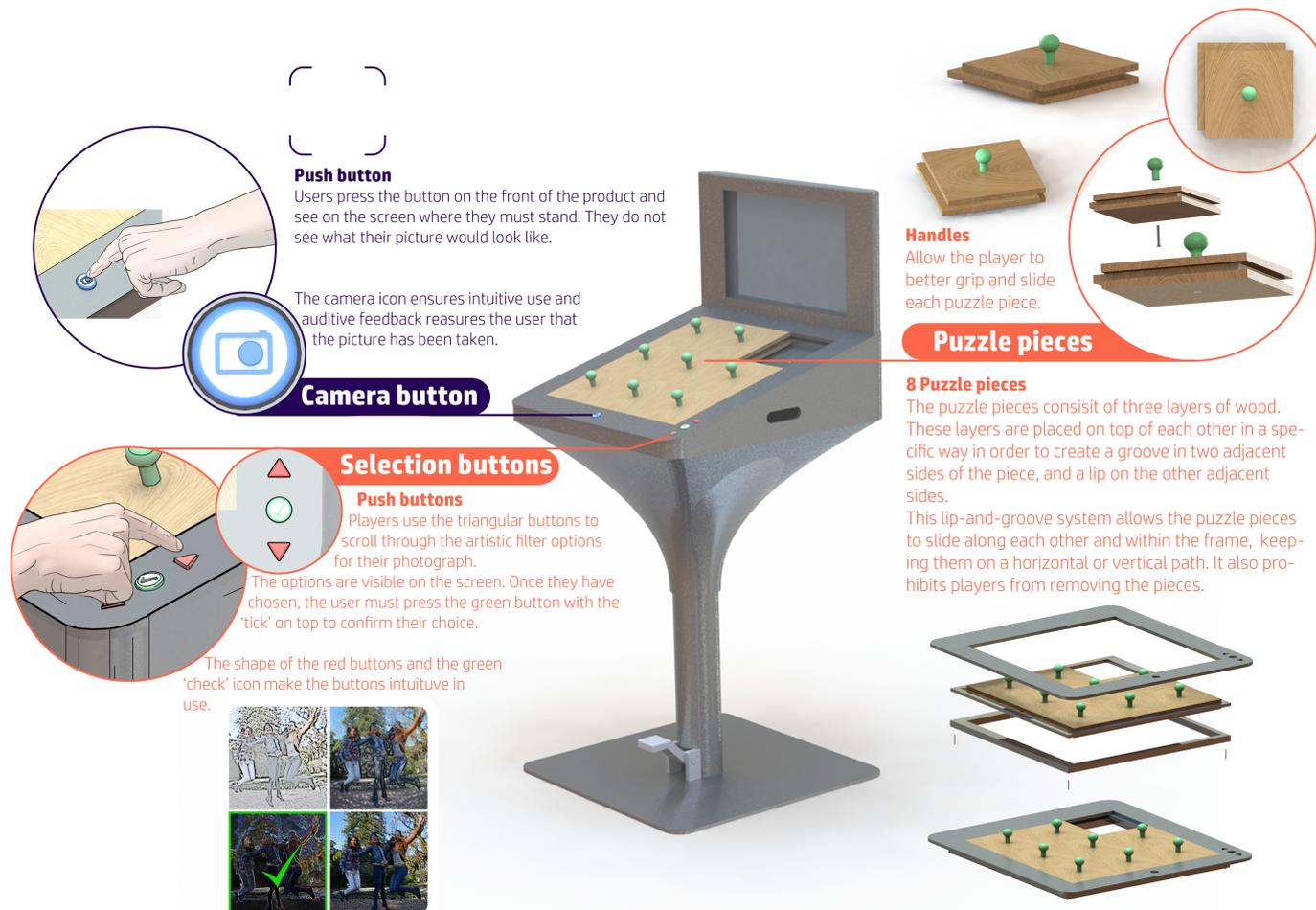


Figure 50: Puzzle pieces and buttons

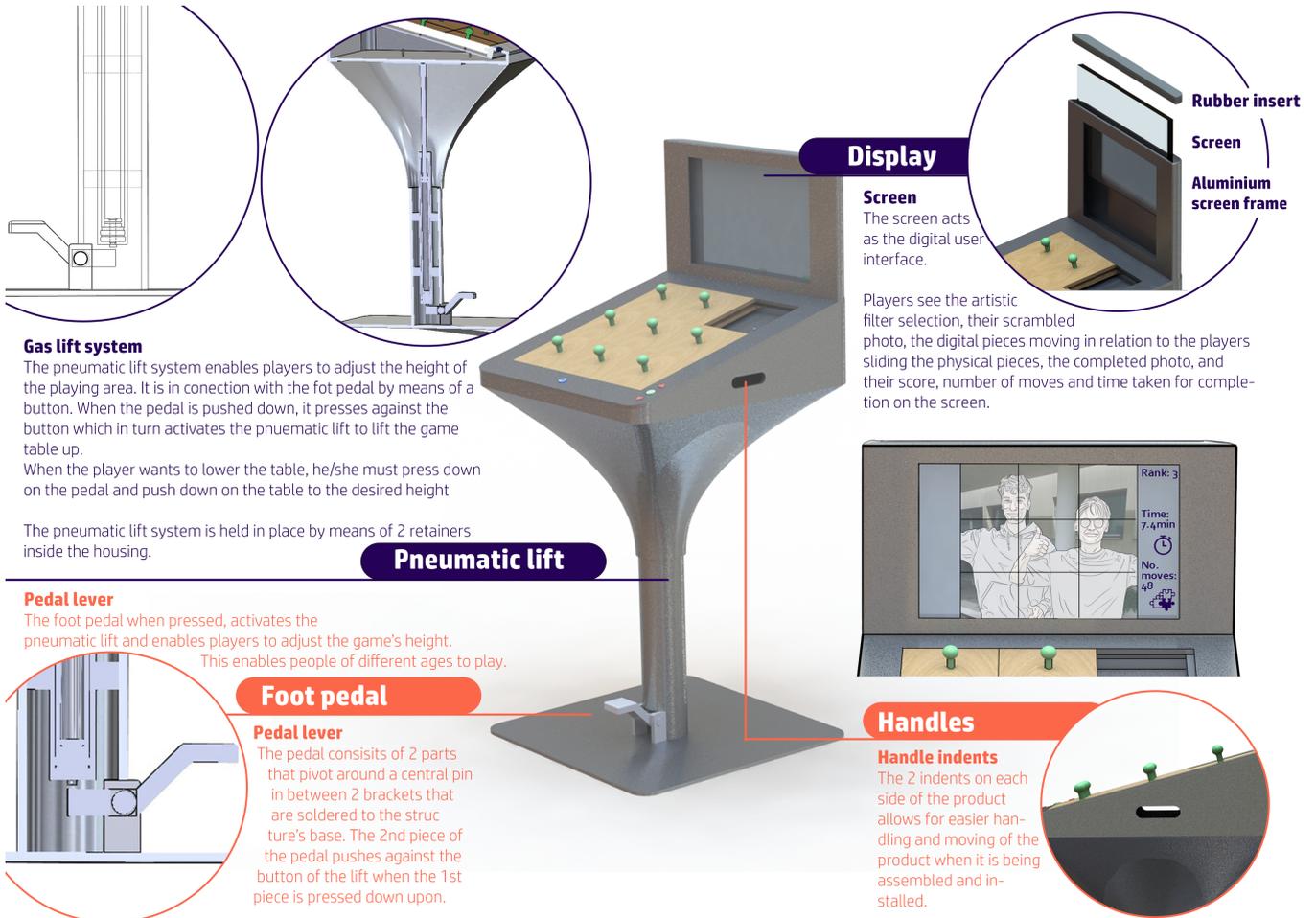


Figure 51: Screen, foot pedal and pneumatic lift

The colors of the product are quite basic. The housing is made of aluminium and will therefore have a silver coloring. Some of the Puzzle pieces, the handles and the foot pedal can however be painted in the colors identifying *Shift it's* brand. These colors including pastel green, a type of red and dark purple, refer to figure 52 can be used for details on the product to liven it up, give it a fresh, playful appearance and represent the company. They should however not be over-used so that the puzzle table does not become too much for the eye.

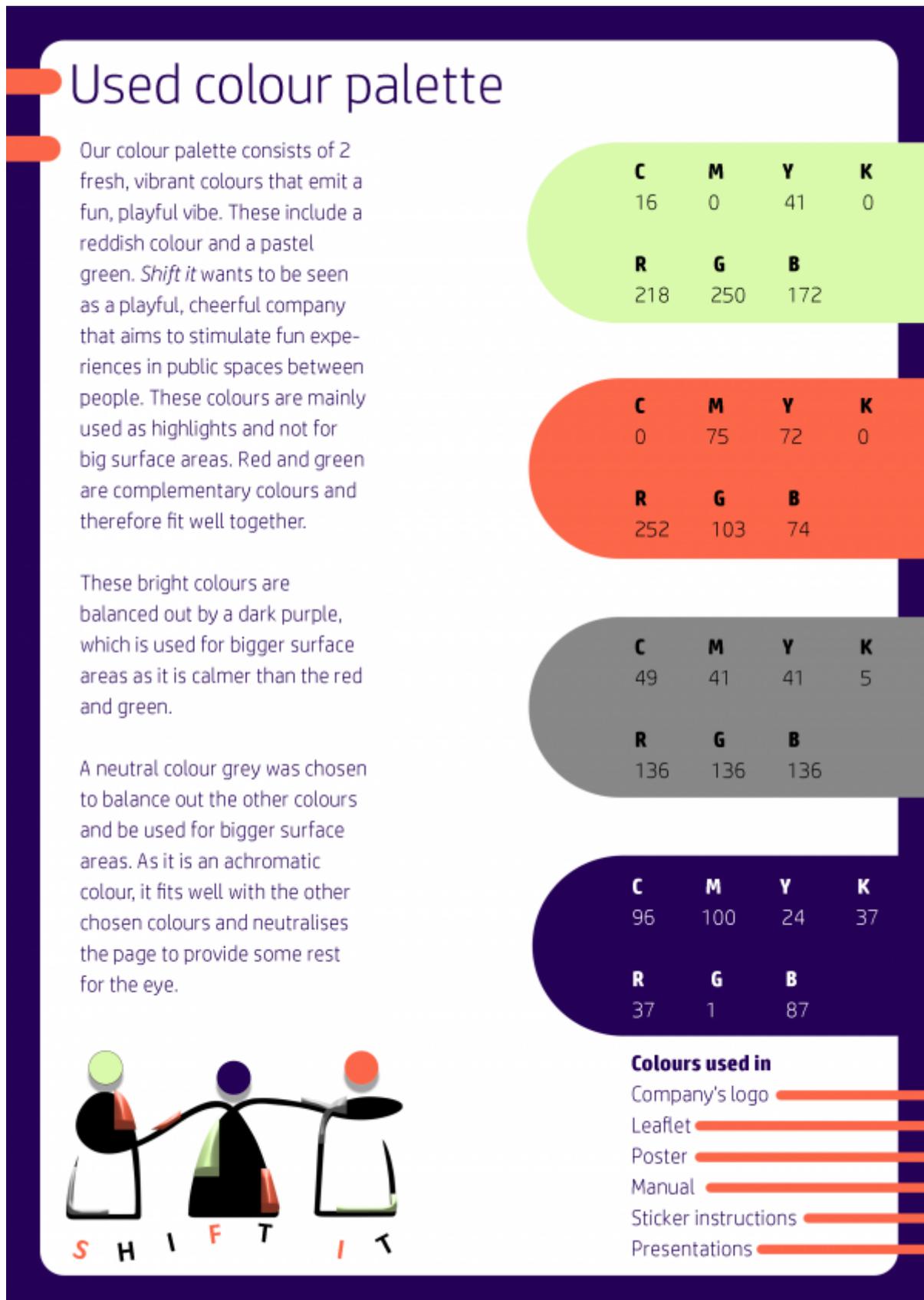


Figure 52: Color Palette

Once the puzzle table is installed in a public space, users need to know how to play. There will therefor be a user journey sequence in the form of stickers on the puzzle table for people to read. These instructions are images showing the user steps and context, enabling players to visually understand how to play. Refer to figure 53. These player instructions are also available as a small

booklet, as well as on the website when people scan the QR code. Shortened instructions are visible on the poster, flyer and leaflet too.

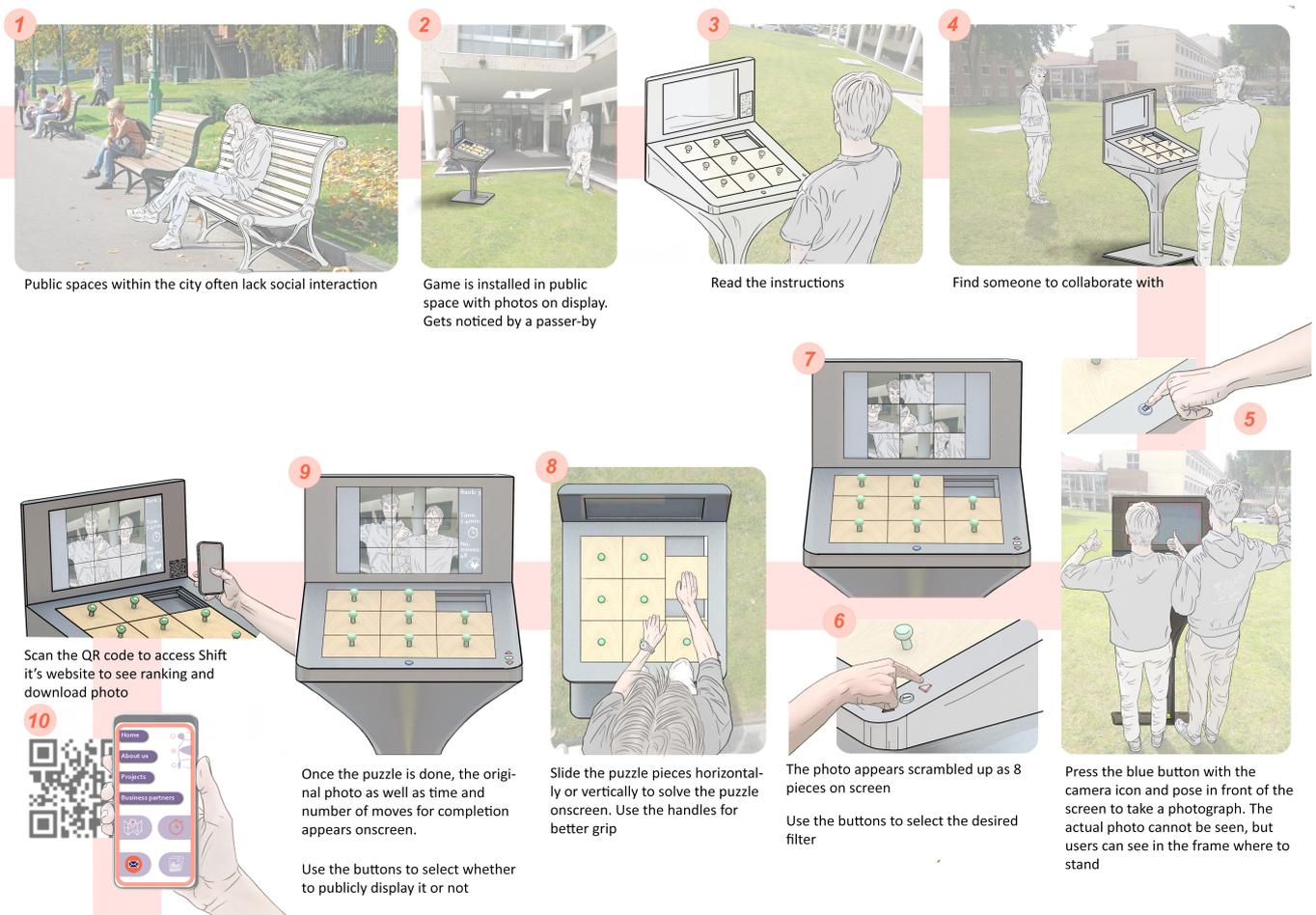


Figure 53: Player user journey instructions

Now that the design and dimensions are determined, the packaging for the different product components can be designed and developed. This is discussed in the following chapter.

7.4.6 Packaging

When it comes to packaging the puzzle, there are several aspects to consider to ensure that it is appealing to the target audience and meets their needs. Let's take a closer look at each of these aspects:

Packaging Design: The packaging design of the product should be eye-catching, informative, and easy to understand. It should communicate the concept of the puzzle, how it works, and the benefits it offers. The design should also be consistent with the image of SHIFT IT and convey a sense of quality and innovation.

Packaging Materials: The materials used in the packaging should be durable, eco-friendly, and easy to transport. Since the sliding is intended for public spaces, the packaging should also be lightweight and easy to carry. Using sustainable materials will also appeal to environmentally conscious consumers.

Packaging Size: The packaging size should be appropriate for the product and the target audience. It should be easy to store and transport, and not take up too much space. Consider the size of the puzzle pieces when determining the packaging size.

Packaging Information: The packaging should include all the necessary information about the product, including how to play the puzzle and the benefits it offers. This information should be clear and easy to read, with visuals to aid in understanding.

Packaging Promotion: The packaging can also be used as a promotional tool to attract potential customers. It is possible to use the packaging to display the brand logo, tagline, and other information that will grab the attention of the target audience. And also consider offering special promotions or discounts on the packaging to encourage customers to try our product.

- Choice of corrugated cardboard *Due to its inherent qualities, corrugated cardboard was the material use for the packaging. Corrugated cardboard is robust and durable while being lightweight. In order to preserve the puzzle pieces during transit, it provides great cushioning and stress absorption qualities. Corrugated cardboard is also economical, eco-friendly, and recyclable, making it a sensible and sustainable option for packaging solutions.*

- Choice of cardboard thickness *The gas lift is a heavier component than the other puzzle pieces, that is why it is better to package it in corrugated cardboard that is 4 mm thick and the other pieces of the puzzle with a 3mm thick cardboard . The gas lift will be safe and protected during handling and transit because to the additional strength and support that the 4mm increase in thickness offers. Because of its reputation for structural stability and capacity to support greater weights, corrugated cardboard is a great option for this use.*

The five packaging, refer to figures [54](#), [55](#), [56](#), [57](#) and [58](#), made to contain each piece of the sliding puzzle game are:

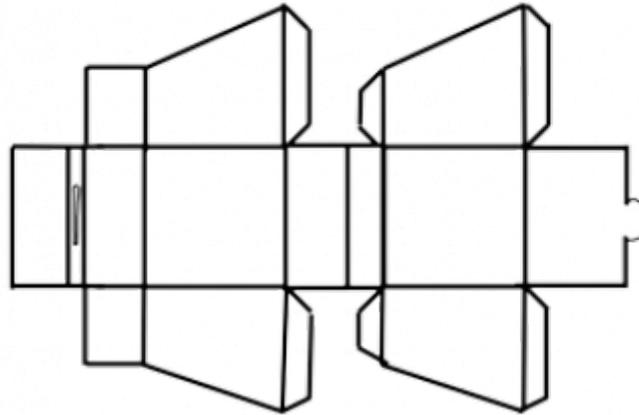
- Triangular piece Packaging:

Purpose: This packaging is designed specifically to hold a triangular puzzle piece.

Advantages: It provides a snug fit for the piece, preventing any movement or damage during transportation. It ensures easy identification and retrieval of the triangular pieces.

Disadvantages: The packaging may take up additional space and require a separate design and production process.

TEMPLATE



PACKAGING

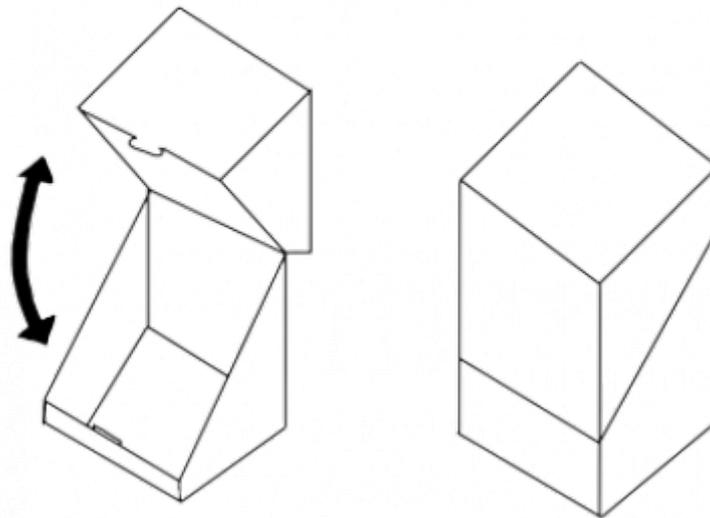


Figure 54: Triangle piece packaging

- Square pieces Packaging:

Purpose: This packaging is intended to enclose all the square puzzle pieces.

Advantages: It enables efficient organization and storage of the square pieces, reducing the risk of misplacement or loss. It simplifies the assembly process by keeping the pieces together.

Disadvantages: It may require a larger size or multiple boxes to accommodate all the square pieces, adding to the overall packaging bulk.

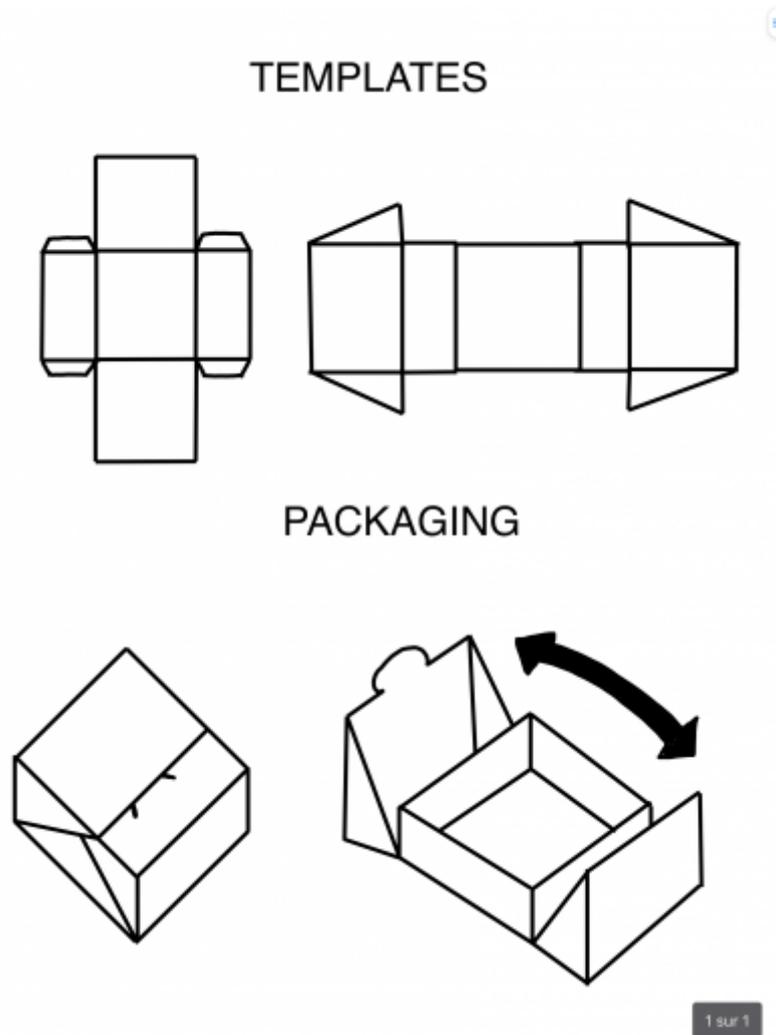


Figure 55: Square pieces packaging

- Electronic and Digital Equipment Packaging:

Purpose: This packaging is designed to hold the electronic and digital components necessary for assembling the puzzle.

Advantages: It provides a protective casing for delicate equipment, safeguarding them from potential damage during transit. It ensures that all the required components are conveniently stored in one place.

Disadvantages: The packaging might increase the overall weight and volume, potentially impacting transportation costs.

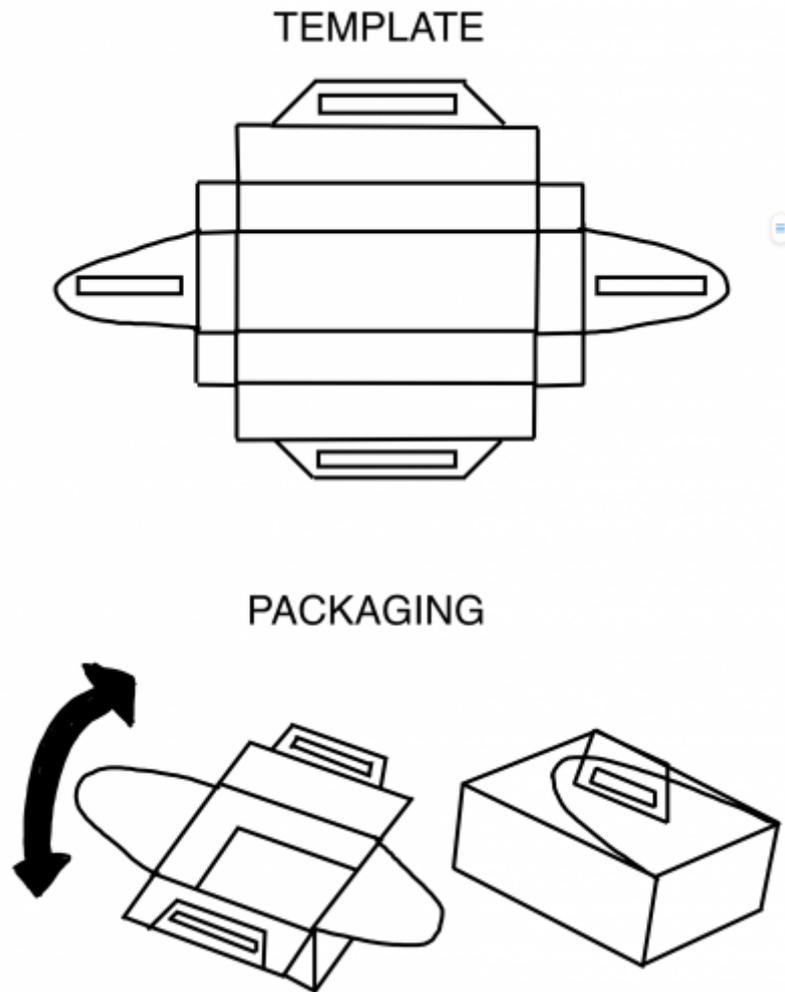


Figure 56: Electronic and digital packaging

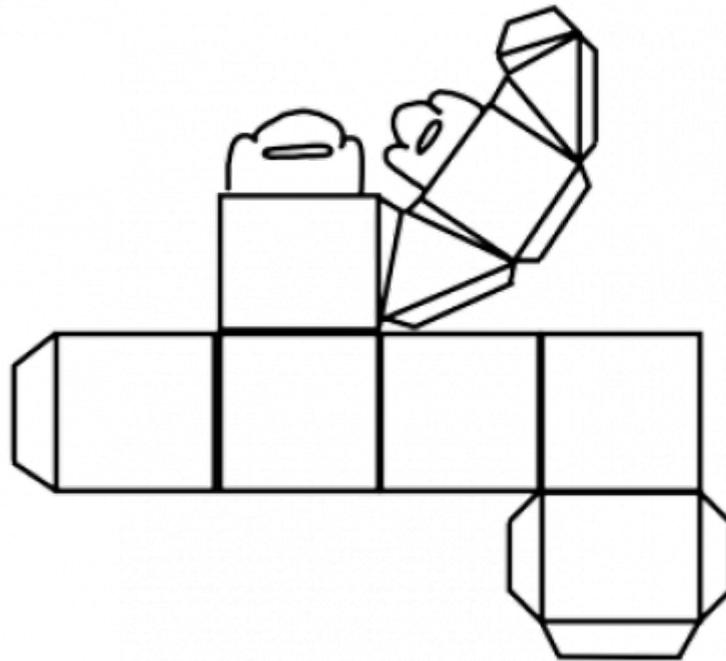
- Puzzle pieces Packaging:

Purpose: This packaging is meant to contain all the puzzle pieces, excluding the triangular and square pieces.

Advantages: It keeps the remaining puzzle pieces organized and easily accessible, preventing them from getting misplaced or mixed up. It allows for easy counting and inventory management.

Disadvantages: Similar to the square piece packaging, it may require additional boxes or larger packaging to accommodate all the puzzle pieces, increasing the overall packaging volume.

TEMPLATE



PACKAGING

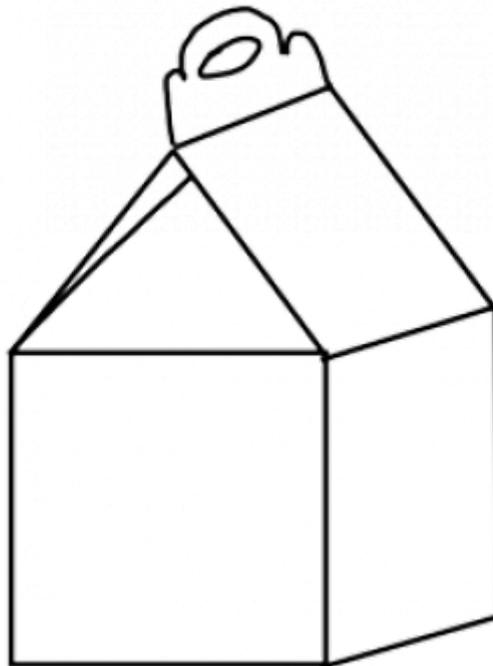


Figure 57: Puzzle pieces packaging

- Gas Lift Packaging:

Purpose: This packaging is specifically designed to hold the gas lift mechanism.

Advantages: It provides a secure and protected space for the gas lift, ensuring its safe transport and storage. It prevents any damage that could affect the functionality of the mechanism.

Disadvantages: The gas lift packaging might require specific dimensions and additional protective

measures, potentially adding complexity and cost to the packaging process.

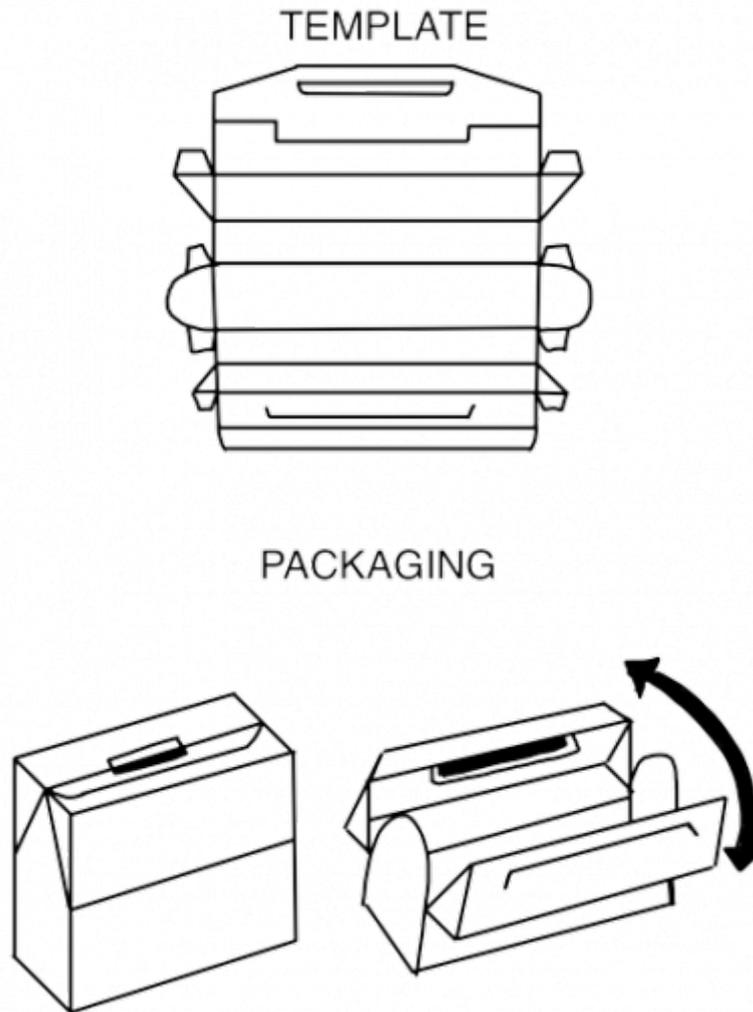
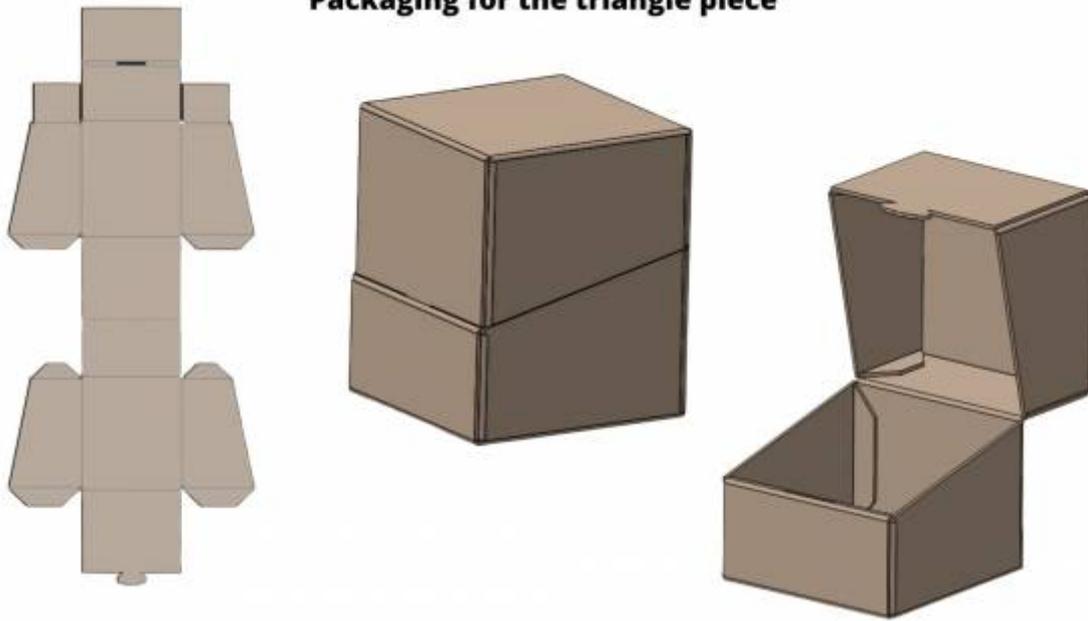


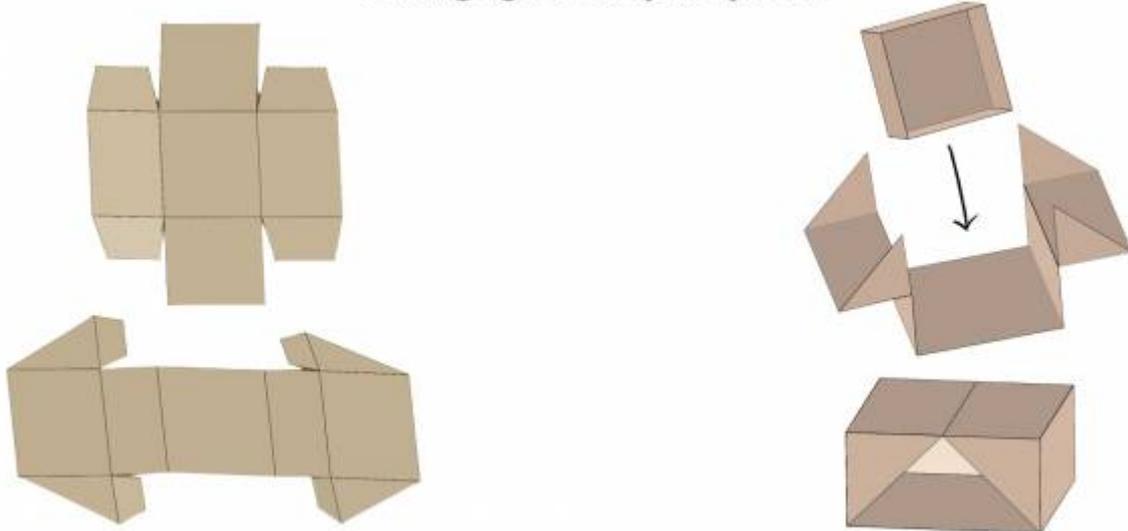
Figure 58: Gas lift packaging

Each 3D model of packaging was made on Solidworks, refer to figure 59.

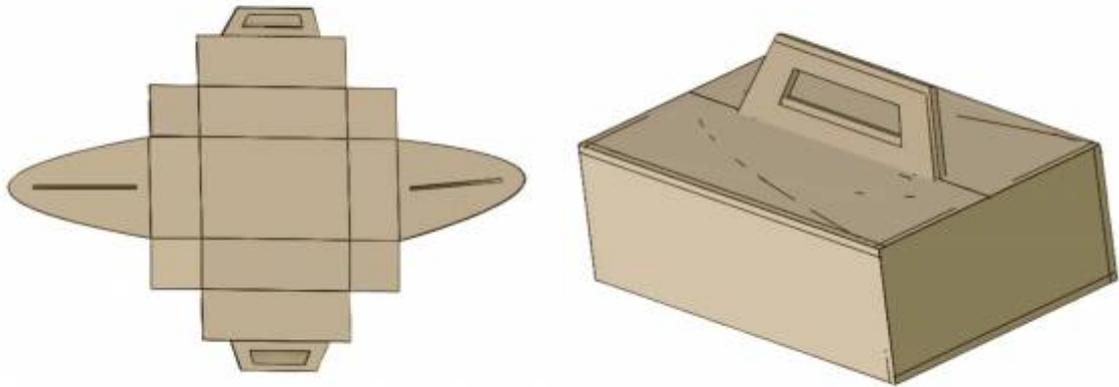
Packaging for the triangle piece



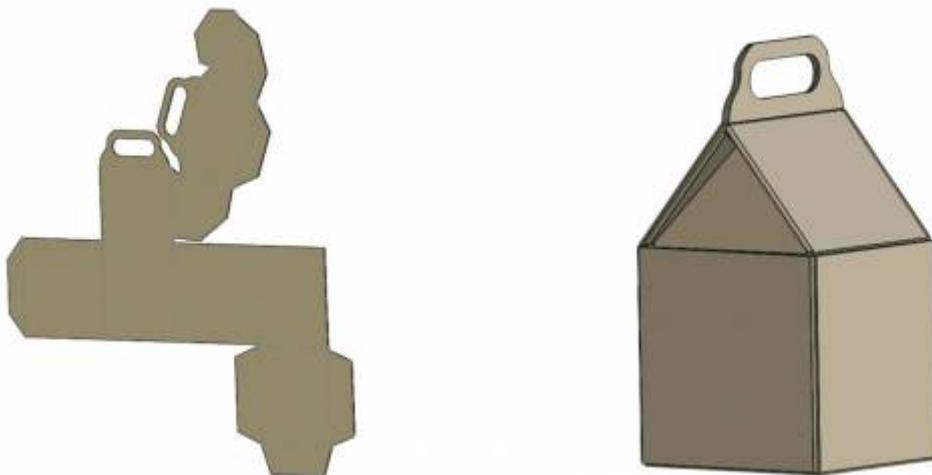
Packaging for all square pieces



Packaging for all digital pieces



Packaging for all puzzle pieces



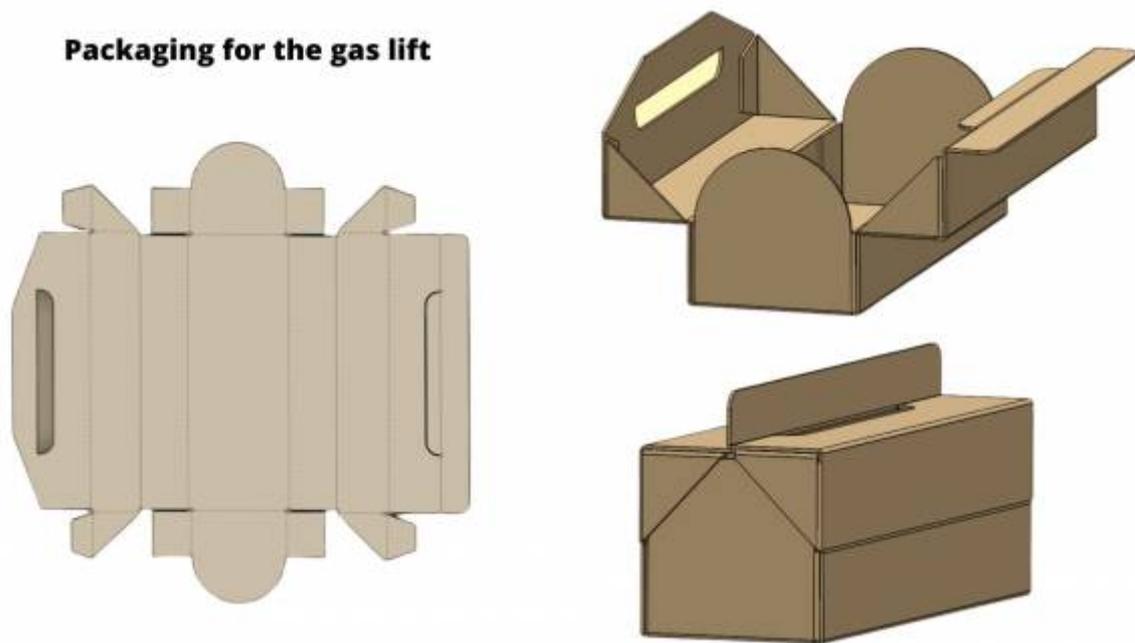


Figure 59: Packaging solutions

7.5 Prototype

The main changes seen in the prototype when it is compared to the final design are the materials and dimensions used and some differences in the functionalities and features that might not be exactly the same as the final, but still work as a proof of concept.

7.5.1 Structure

There were many adjustments to the designed final concept that needed to be made in order for the team to be able to build a proof-of-concept prototype. Originally the game would be quite big, life size of 760x760x1700 mm. The 2 main frames would be constructed from Aluminium and the puzzle pieces and puzzle frame from White Oak wood. A stronger and bigger pneumatic lift system would be used, the pedal would be made from steel, a different micro-controller was selected, and a LCD screen would be used

There would be a screen in the top aluminium frame and push buttons in the puzzle frame. A down-scaled version of the final puzzle table was constructed in order to prove that the concept is possible. The materials and components used for the prototype are listed below, followed by an explanation of how the prototype was constructed. The infrastructure, lab, machinery and help needed to build the prototype were provided by ISEP.

The prototype is constructed from a combination of both bought materials and components, and what was available to the group at the university campus. The budget of 100 euros was not exceeded.

- The puzzle pieces and frame are made from 5 mm plywood board. This puzzle section of the concept is at a scale of 2:3 with the original design.
- The puzzle pieces have wooden cupboard handles as handles to grip and slide the pieces.

- The Aluminium frames surrounding the puzzle assembly are for the prototype made from 10 mm plywood board.
- The adjustable height system was made re-using an office-chair gas-lift mechanism and turning it upside down.
- Instead of making a pedal in metal, the hand lever of the office chair gas lift system was re-used. This was possible because by turning the piston upside down, the hand lever came to be in the perfect position to use as a foot lever.
- The Screen is represented by a laptop screen connected to the sensors under the puzzle pieces.
- LDRs are used, which is the same as the final concept.
- A different micro-controller is used, Arduino Leonardo instead of Raspberry Pi 3.
- The push buttons are small electronic push buttons that are placed on top of the puzzle frame instead of in. This was done for convenience reasons.

The construction included the wooden assembly of the puzzle frame with the puzzle pieces and their handles being attached to the top of the office chair gas lift system to show how the height could be adjusted. Ideally the height can be adjusted by pressing a pedal with one's foot. The pneumatic lift of the office chair was turned upside down, and a plate welded to a pipe in which 2 different diameter holes were drilled, was placed over the piston of the gas lift. This was held in place by drilling a hole through the pipe and inserting a screw to keep the piston in place inside the pipe. The wooden puzzle assembly was then screwed onto the metal plate.

The 8 puzzle pieces are made of three 5 mm plywood squares glued on top of each other in shifted positions to create a lip and groove in each piece. The cupboard handles are screwed in place on the center of each piece. Three sides of the small puzzle frames are glued to the main puzzle frame and the last side screwed in place so that there is always the possibility to be able to remove the puzzle pieces from the frame. This was important in case adjustments had to be made to ensure the puzzle pieces slid smoothly within the frame. Some of the sides were sanded to ensure they slid better through the grooves- of the other pieces and the frame. The part of the process of creating the puzzle pieces is shown in Figure 60.



Figure 60: Puzzle pieces in the process of making.

The 5 mm plywood puzzle bottom was screwed in place to the frames under the puzzle pieces. The 10 mm plywood sides of the puzzle table were glued to the main bottom that was fastened to the metal plate. Finally, holes were drilled in the puzzle bottom underneath each puzzle piece to insert the light sensors. The cables and micro-controller were placed inside the wooden housing under the puzzle assembly so that they would be hidden from sight (refer to Figure 61).

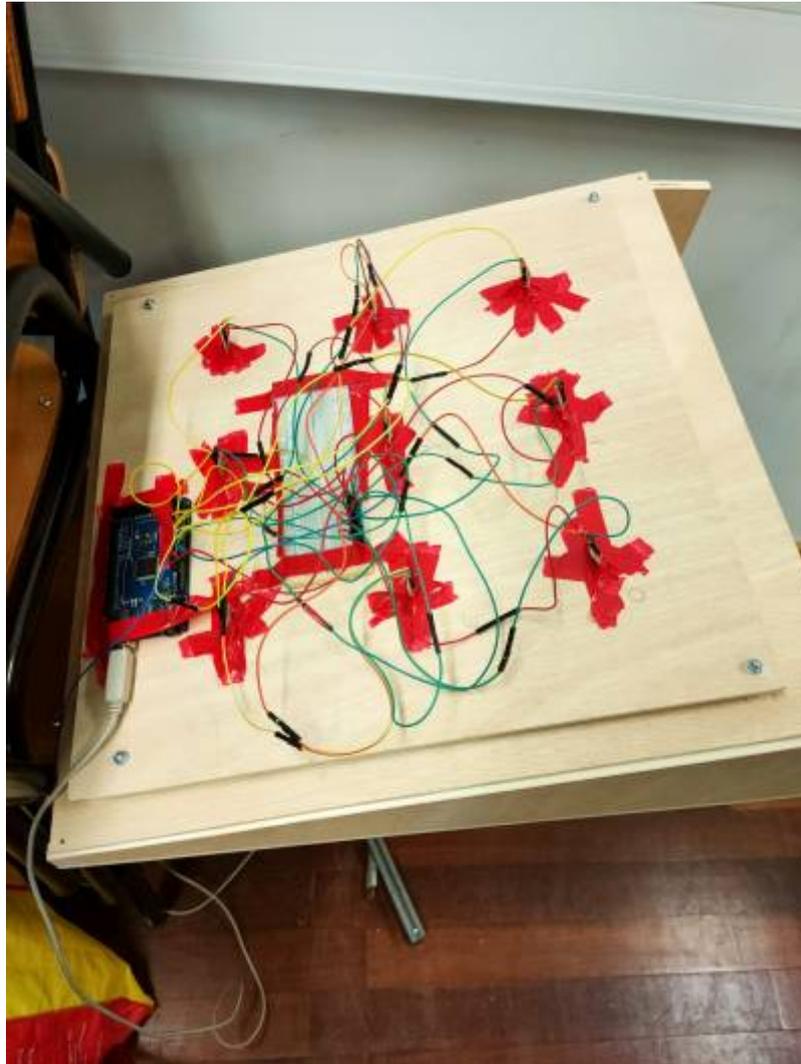


Figure 61: The cables and micro-controller on the wooden frame.

The laptop can then be placed inside the housing so that the screen sticks up in front of the player. This will allow the player to see the digital puzzle pieces move when he/she is sliding the wooden pieces on the board (Refer to Figure 62). The LDRs under the puzzle pieces communicate their position to the micro-controller by means of measuring how much light they are exposed to when they are either covered or uncovered by a piece. The software monitors the puzzle piece positions and can detect changes in their positions because it knows a specific piece has moved when the light sensors underneath it suddenly gets more light. This movement made by sliding the puzzle pieces will be shown on the laptop screen. The camera of the laptop is used to take the picture of the players. People can choose filters by pressing on the push buttons on the frame or by pressing on certain keys on the laptop. In the prototype, there will probably be nothing covering the gas lift, whereas in the final concept there is an aesthetic frame covering the mechanism. This is however not essential for proving that the concept works.

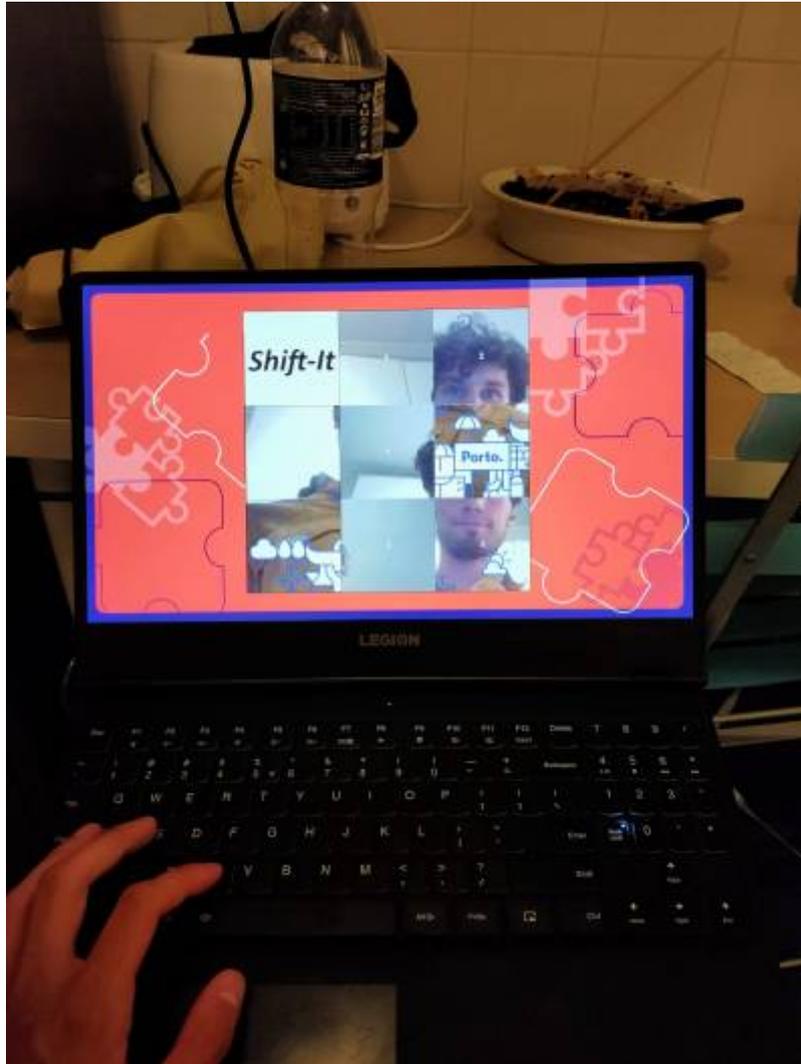


Figure 62: Puzzle display.

The final concept has a metal platform bottom and a funnel shape and cylinder enclosing the gas lift. The prototype's base was made by screwing 4 steel square profiles to the pneumatic lift mechanism's base re-used from the chair (Refer to Figure 63). These could be rotated to fold in to reduce space, or make different leg configurations. Spreading the 4 legs to the outside is the most stable option. At the end of these legs, for leveling feet were screwed in place so that the feet could be adjusted on uneven ground, enhancing the stability of the whole construction. Nuts were welded on the square profiles to provide the thread needed to screw the leveling feet on and attach the profiles to the base.



Figure 63: Pneumatic lift.

The final concept has rounded edges for safety and certain dimensions to make the product ergonomic, such as button and pedal size(Refer to Figure 64). These elements will be taken into account as much as possible in the prototype, but the overall size will not be the same.



Figure 64: The final prototype.

The size, design, aesthetics, materials and some components will be different from the final concept,

but the working of the main systems will be kept the same and will be shown. The most important aspects to prove are the sliding pieces, the communication between the physical puzzle pieces and the screen, and the height adjustment mechanism. A Solidworks model of the prototype design was made to aid the construction of it and envision how it would look. These files can be consulted in the deliverables.

7.5.2 Hardware

There are quite a lot of changes in the hardware for the prototype compared to the final version.

The main differences between the prototype and the final product are as follows:

- Arduino Leonardo instead of a Raspberry Pi 3.
- No analog-to-digital converter (ADC) because the Arduino has enough analog ports.
- Displaying the data will be done by a laptop screen directly connected to the Arduino instead of an external display connected to the video output of the Raspberry Pi.

The prototype will be made with an Arduino Leonardo instead of a Raspberry Pi 3 to allow for more rapid development and testing. The schematics for how the electronics would look are provided below. By using the Arduino Leonardo for prototyping we are sacrificing the ability to have a display output directly from the micro-controller, but this will be handled by the laptop that the Arduino is attached to instead. Below is a schematic of the workings of the electronics with the light sensors. This gives an idea of how the connections will be made between the electrical components for the working of the prototype (Refer to Figure [65](#)).

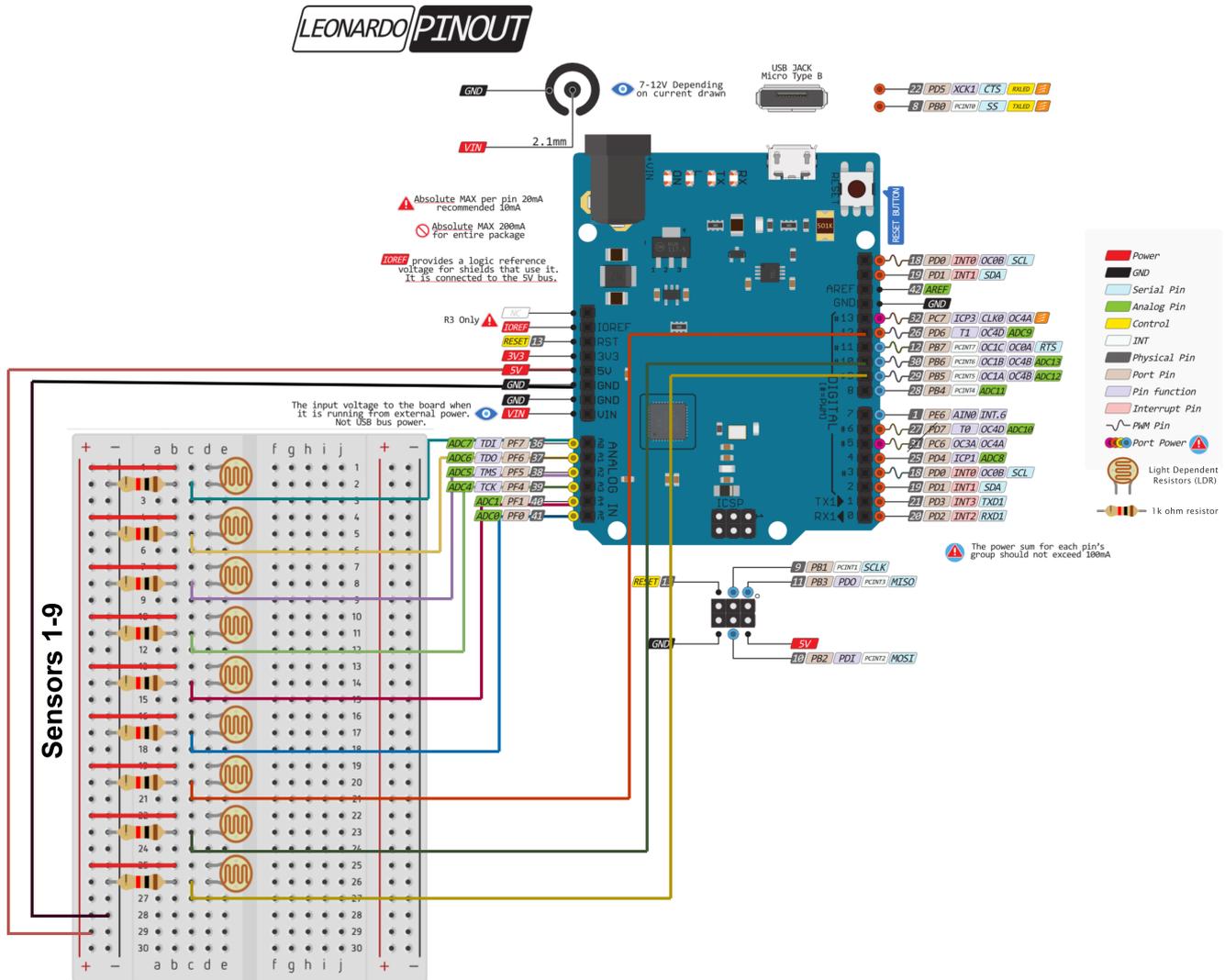


Figure 65: Electronics scheme for prototype

Possible alternatives

There was some research done in using an Arduino Uno for the prototype but this had one big problem, it only had 6 analogue inputs and the project needed at least 9. Luckily there are ways to use digital ports for these readings as well and initial tests seemed very promising. But in the end the idea to use these was dropped after further testing pointed out that we could only get a LOW or a HIGH reading from those instead of the actual value from the sensors. So the Arduino Leonardo was chosen as it boasts an impressive 12 analogue inputs.

LDRs are very sensitive to light, which is necessary in order to function properly. Using them for the prototype proved that they work very well in detecting the movement of the puzzle pieces, but this might be a different case in reality. In reality the product would be installed outdoors. This means that the readings from the LDRs would be affected by the amount of sunlight, shade, clouds, leaves and other debris or dust that fall on the puzzle table etc. This could lead to them not tracking the movement of the puzzle pieces properly which would mean players would not be able to play the game properly. In order to avoid this, an alternative solution to LDRs could be to use RFID tags instead. Sensors could be placed under each puzzle piece, which then scan and recognize unique tags placed on the bottom of each piece. By scanning the tags as the puzzle pieces are moved, the software can detect the movement and position and communicate this information to the micro-

controller. This alternative might be better than the LDRs because it is less affected by the outdoor conditions and external factors, making the technical side more trustworthy with more certainty that things will not go wrong.

Different sliding piece mechanisms were sketched out in the beginning, but the lip-and-groove system was chosen to be the best because it was functional and aesthetic and did not need too much space or complicated shapes of components to function.

A hand lever instead of a foot lever could be considered, but the foot lever was chosen because it is easy to press down as a person can just put all their weight on it, no matter the height or age of the player.

7.5.3 Software

The code developed for the prototype (smart device and apps) is described here using code flowcharts.

The Arduino Leonardo will be running the code for detection of movement on the puzzle pieces and then be displaying the result in the console (Refer to Figure 66).

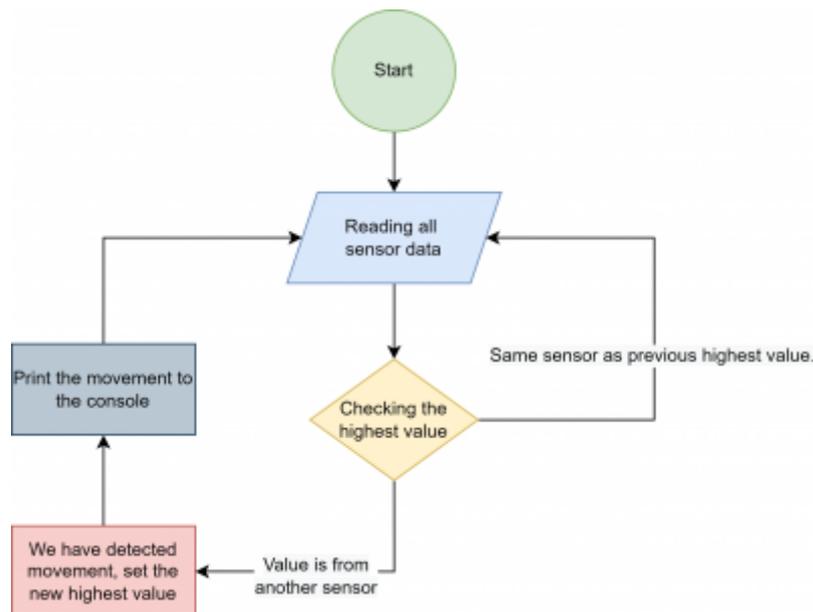


Figure 66: Overview Puzzle piece detection

A flow chart was made in order to better understand how the light sensors would work to detect the movement and position of the 8 puzzle pieces on the 9-piece grid and send it through to the display. Figure ##REF:flabel62## displays the decisions and actions the system goes through to detect the movement of the 8 puzzle pieces. The code part of this flowchart would be done in a variant of the C++ programming language and in Python.

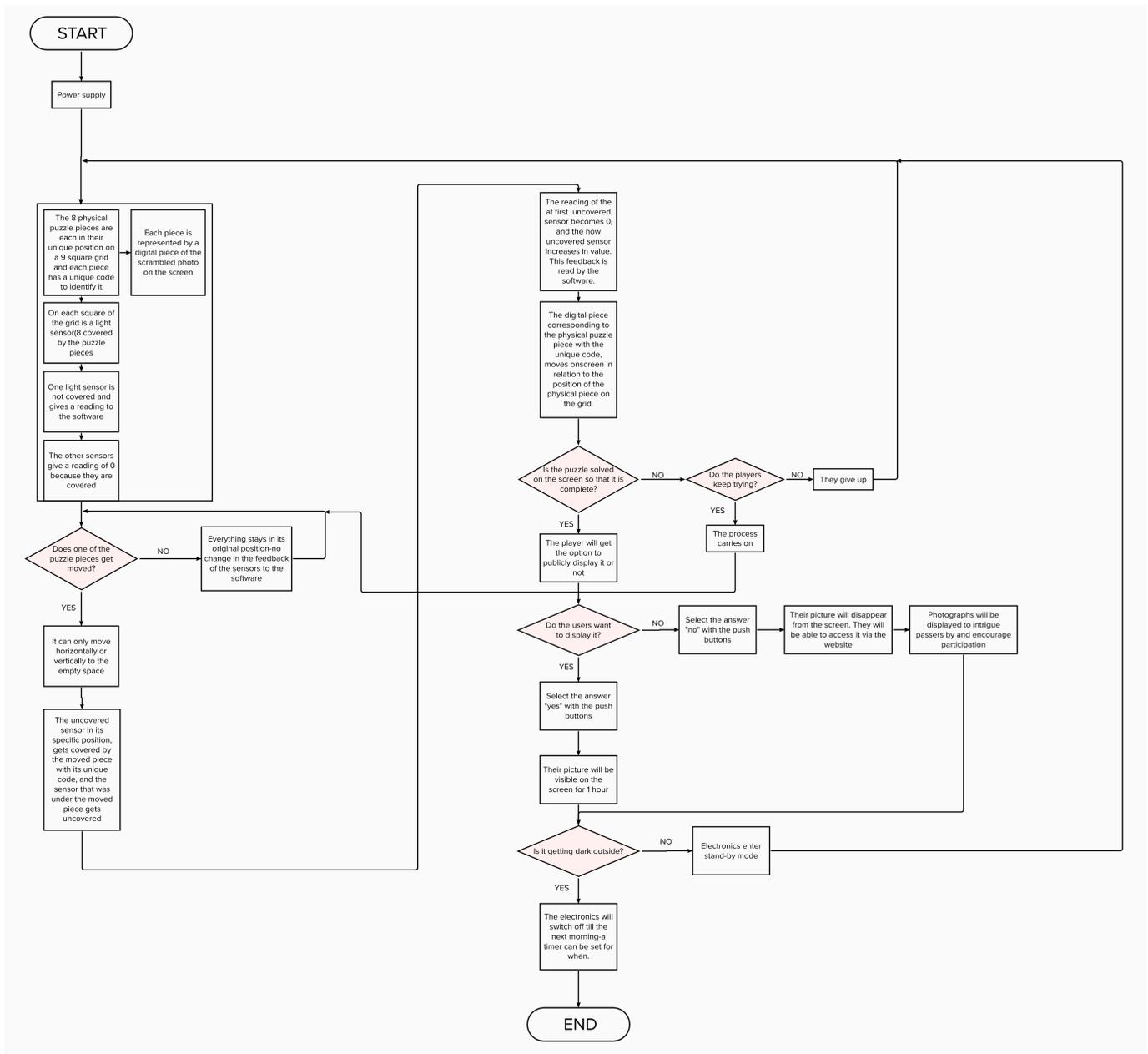


Figure 67: Flow Chart light sensors

7.5.4 Tests & Results

Hardware tests

The hardware test was done to determine if the hardware performs according to the specified hardware tests in chapter 1.6 functional tests. In the table below the tests that were done can be seen, as well as if they passed or failed. These tests relate to the physical prototype that was built, and aim to investigate how well it is built and whether the various mechanisms, functions and features work.

Table 36: Hardware tests

--

Functionality	Method	Result
Photoresistors	The sensor readings were tested in the Arduino code to check if they are correct and accurate.	Pass
Camera	Pictures were taken to check if users know where to stand and the image is shown on the screen.	Pass
Display	The functionality was verified by test images to check if the colours are being displayed correctly and if the photo is shattered.	Pass
Pieces movement	Calibration tests were performed to verify if the movement of puzzle pieces is correctly detected.	Pass
Actuator	The test was done by applying pressure on the pedal to check if the height of the game changed.	Pass
Sliding pieces	The test was done by applying a sliding force to a puzzle piece to check if the piece slides easily using the lip-and-groove system.	Pass
Communication	The buttons were pushed to check if these actions lead to the correct reaction on the screen.	Pass
Display of the score and count of puzzle movement	The test was done by team members timing their game time by themselves to check if the display shows the time correctly and if the software is keeping track of the puzzle movement.	Pass

Software tests

The intuitiveness of the website will be controlled by asking people outside the team developing the project to scan the QR code and visit the website. They will then be asked to find certain information in order to check how easy the website is to navigate. Participants involved in the testing will after the questions also be asked whether there is any information they think is missing from the website. There was not enough time to create a website with a functional and aesthetic interface and these user tests could therefor not be carried out. The final aim for further development would be to design a proper and fully functional website with which these tests could then be carried out.

The software test that was completed, consisted of accessing the website via a QR code eight times. The test was a success and revealed an exchange of 256 B with an average latency of 195.12 ms and a standard deviation of 51.8 ms.

More features could have been implemented for which we could have done software tests, but unfortunately time ran out. These features include a location map so visitors of the website could see the different locations and cities where the game is installed, a home page, a contacts page, "about us" page, a page where people can see their ranking and score and a gallery page where people can view all the photos players completed and allowed to be on display for the public. Now the website accessed by scanning a QR code, consists of just the gallery page and access to the player's individual photo to download.

7.6 Conclusion

The team used the design thinking phases of empathize, define, ideate, prototype, and test to develop the project. The basic idea was first identified and then structured as the project was being developed. The next step was to conduct research to define the principles for the product's design as well as its intended use. This study considered both aspects of the device's target market as well as currently available products serving the same function. From this study, empathizing with the target audience and establishing the key aim, the team launched the ideation phase, with the goal better defined.

Several potential designs for the product were examined through sketches and diagrams throughout the ideation process. This ideation step involved breaking up dialogues, generating new ideas, and creating a brand-new product. These factors led us to develop our concept for a puzzle game that encourages interaction. By first building a wooden frame and puzzle pieces that you slide to solve the puzzle, we can show how our prototype would function.

The software was subsequently developed to allow light sensors to track the placement of the puzzle pieces. Additionally, buttons were introduced so you could take a photo of your group and then alter the shot's filter. The puzzle can now be raised and lowered thanks to an actuator that was also attached. Overall, the product development was a success.

In the next chapter we are going to conclude the project and give some ideas for how we could develop our product in the future.

8. Conclusions

8.1 Discussion

Our project has come to an end, and a successful product has been produced. It took a while for our product, "Shift it," to arrive, but everything turned out well in the end. We wanted to make something for this project that we could all be proud of, and it worked out. After all, it was crucial to us that we function as a team, collaborate on decisions, learn from one another, and have fun. This was made possible by the group dynamic we established.

Initially we had a hard time deciding on our project but when we finally came up with "Shift it" it felt like we had found our project. But everything was not easy and there were a lot of bumps on the way. The prototype that we created looks and performs over the expectations that we had and that is largely due to the amount of time that was put into it. We achieved what we wanted to with the prototype by merging an old school puzzle game with technology. Our software were able to track the moving pieces and the game could be played as expected, but there is always things to better.

In our case the bottom part of the innovation would have to look more like the drawings because our prototype is not very stable. Other things that we maybe should have changed if we actually wanted to make it a real product is to change out the light sensors that we used to some other sensors that would also work in the dark, for example RFID sensors.

We made some requirements for ourselves for this project:

1. Maintain sustainability throughout the project, the product, and the packaging We were successful and employed many eco-friendly materials in the final product.

2. Our marketing must adhere to the principles of equality and not cross any lines: We were successful because we consistently involved everyone and every scenario in the promotion of our goods and wanted to make the product as inclusive as possible.
3. Avoiding unethical behavior: Successful.
4. Create a positive and enjoyable user experience: It's difficult to say whether we succeeded here because we would need to test the product for a while, but we believe we did.
5. Compliance with EU Directives: Accomplished.

All in all we are happy with our project and proud about the work we accomplished. The overall objective of the European Project Semester was to provide project-based learning opportunities and to test the collaboration skills of team members from various educational and national backgrounds. We can affirm as a group that we met this difficulty successfully.

8.2 Future Development

Our prototype has shown to be successful, therefore the next logical step is to create the finished product that can be sold. It also needs to be stated how to create it on a larger scale. The game can be changed in many ways implementing new kinds of competition and new filters. Another possibility is that the app in the future could be directly linked to different social media platforms where you would be able to post your picture instantly. A front-end application for municipal governments where 3D models and the associated data may be uploaded would be a potential future addition to the software. Additionally, it might have a feature that allows for the collection and export of user data and interaction statistics to offer more details on participation demographics.

Regarding marketing, we also want to sell our goods outside of Portugal and eventually outside of Europe. But first we must make sure to make it here in Portugal and in Porto. We want to continue to market our product and to find new channels to reach people. This still requires a lot of research and development, to enhance our product and continue to make it better.

There are also some features that we didn't have time to implement now in the prototype but still can be seen in the product development. To make the product even better we would like to implement a map where you can see where the games are located. Another thing that we would like to implement is a scoreboard and for that we would need some kind of authentication when you start playing. And lastly we would implement a board where you could see some facts about the environment around you for example air pollution and UV index.

Our goal still stays the same and we don't want our values to be changed and altered even though our product may change while developing it.

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