Interactive Art Installation for Togetherness

Bachelor Thesis

2020-02

University of Twente, Creative Technology

Author: M. C. Erel, s1997327

Supervisor: Dr. Ir. Edwin Dertien

Critical Observer: Dr. Ir. Wouter Eggink

Abstract

The Covid-19 pandemic has impacted people's ability to connect and interact and having a sense of togetherness has been hampered. Interactive installations have the potential to improve people's sense of togetherness by facilitating connection and communication between participants. In this project, how a design for an interactive installation can be set up for creating a sense of togetherness between participants was researched in order to come up with an effective intervention.As the methodology, Creative Technology Design Process was utilised in order to reach a product prototype that can be evaluated based on the requirements of this project. Through this process, new knowledge and insights were gained on the subject. The installation facilitates a common experience that fosters a sense of togetherness through provoking camaraderie and connection to form between participants with the aim of being a successful output.

Acknowledgements

I would like to thank Edwin Dertien for his efforts, insights and help during the project. I would like to thank Richard G.A. Bults for his support and lead in the graduation period. I would like to thank Wouter Eggink for supervising the project and providing unique knowledge. I would like to thank Wout Zweers for his advices of unmatched quality. I would like to thank Martina Raponi for her unique views and contribution. Finally, I would like to thank Mani, Ari, Edo and Annemiek for their help.

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CHAPTER 1: Introduction

1.1 Context

A strong sense of community is an integral part of any society and the mental well-being of people. The pandemic has significantly hampered our ability to relate and interact with each other and weakened our sense of community. Feeling a lack of support and community, I started to ask myself how to take a contrary (re)action towards social isolation and impaired sense of togetherness. Failed to give a definite answer, my design-focused thinking and background as a creative technologist led me to think of a cooperative play between people to raise the questions of togetherness and solidarity.

Interactive works can reactivate camaraderie through its experiential built environments, providing a space for shared experience. Costello and Edmonds [1] have referred to this phenomenon as a pleasurable experience generated through the evolution of amity, closeness, and communion. They have stated that in interactive works this phenomenon can occur with other human beings through the work inspiring or demanding interaction with each other. Otherwise, possible as well, through the creation of a surrounding that leads to social intercourse. They provide an example of co-creating a 'visual composition' with others with an interaction such as movement.

Interactive designs can provoke audience engagement, which can lead to a sense of togetherness through camaraderie. User-centred design (UCD) informs the interactions between the participants and between the work and the user. The guidelines on creating an interactive work that has effectiveness over interpersonal social dynamics and perception still require further research.

As an independent creative technologist, for my Graduation Project, I am researching and executing the materialisation of an Interactive Art Installation, facilitated by technology, that works to overcome the aforementioned problem. Where my client the artist and researcher Martina Raponi, with her company Noiserr, wants to feature it in WORM (an art and cultures institution). Currently one of the topics of her work is togetherness and ways it can be facilitated, she wishes to utilise the work as a part of her explorations.

Doing this work in the academic setting of creative technology allows me to express and build upon the skills I have acquired throughout the education, have access to experts and critical observers that provide further academic and professional insight. Also, it allows me to generate new academic knowledge on this new field through processing prior academic knowledge and building upon it to answer novel questions previously unanswered.

1.2 Research Questions

My goal is to invoke a sense of togetherness by a shared experience using an installation, and find the most effective ways to design the setup that results in the maximum impact for this purpose.

To achieve this goal, I need to answer the following questions:

-How can a design that evokes social togetherness by a shared experience be set up?
-What characteristics of an interactive installation can provide a sense of togetherness?

Additionally, the diverging sub-research questions, in figure 1, which will then be reduced as the scope becomes limited by the output of research.

CHAPTER 2: Background Research

This state of the art chapter is dedicated to existing installations that showcase person-to-work and person-to-person interactions. The aim of this research is to pinpoint design methods and elements that trigger engagement and generate interpersonal interactions and the characteristics and intensity of effects they produce. The main interpersonal interaction the graduation project aims to produce is camaraderie. In the context of this graduation project, camaraderie has been defined as "a pleasurable experience generated through the evolution of amity, closeness and communion". In broader terms, the interactive work needs to inspire or demand interpersonal interaction. The state of the art research will help contextualise and concretise 'interpersonal interaction'. In other words, it will clarify how 'interpersonal interactions' occur, what kinds of interactions these are, and what kind of actions are carried out for these interactions. These will be evaluated through existing works.

In addition to the interpersonal interactions, engagement is also an essential aspect of the graduation project. In broader terms, engagement is being involved with something. In the context of this graduation project, engagement is interaction with the work. What makes an interactive work engaging both in initiating and at the conclusion phases? This engagement phenomenon, in addition to being researched through state of the art works, has been addressed in the literature review process provided below, where four main elements have been identified and detailed on literature containing theory and case studies in order to inform design choices.

2.1 Analysis of Existing Works

In the analysis of existing works, 8 current interactive installations were detailed and then reviewed by analysing, in particular, their engaging factors and what kind of interpersonal interactions they engender and how they engender these interpersonal interactions.

2.1.1 Energy Carousel by Ecosistema Urbano, 2010

"Ecosistema Urbano's "Energy carousel" is an inventive, educative and multi-age friendly playful object. A play structure consisting of a tensegrity structure formed with ropes and textiles. The kinetic energy that is released by the children's movement is stored in a battery and supplied after to light up the structure." [2]

Figure 1: *Participants interacting with the Energy Carousel in a playful manner*

The energy carousel achieves engagement through play. It achieves interaction though design affordances of the ropes that convey the action of holding and pulling. The design provokes camaraderie through requiring collaboration towards a common goal, which is to move the heavy carousel and producing light. Through collaborating and playing together participants also learn and reflect on producing energy. The interaction, in this way, amplifies the take home message. Working together for a goal and playing together, participants develop positive interpersonal experiences.

2.1.2 Lamp Beside, Gustavo Prado, 2017

“Few things seem more isolating than a selfie – or, better yet, a mirror selfie – but self-reflection broadens into inclusion for Prado, who studied industrial design and philosophy before turning his attention to art. Viewers lured in by the sculpture’s polished finish will find their faces among others’, shattering the “illusion of fixed identity,” he says. “You are driven to approach the piece for a very selfish and individualistic reason – to see what it does to your own reflection, and what you get is this collection of parts of multiple bodies,” [3]

Figure 2: *The Lamp Beside the Golden Door installation*

Figure 3: *Participants interacting with The Lamp Beside the Golden Door installation*

The Lamp Beside the Golden Door installation is enticing due to its aesthetics, scale and most importantly its use of mirrors because a person's image is enticing for people. The artist uses this phenomenon to have participants notice others around due to the convex mirrors that create a wider field of vision. In this way participants are drawn closer and given a moment to notice each other.

2.1.3 Glowing Nature, Studio Roosegaarde, 2017

"As visitors walk around the installation, the pressure of their footsteps wakes up the algae, whose bioluminescence creates a mesmerising, ever-changing environment."

"GLOWING NATURE combines biology and technology to reflect on light and energy, and on nature's potential to provide the tools for a better future. GLOWING NATURE was first exhibited as part of ICOON AFSLUITDIJK at the Friesland bunker on the Afsluitdijk and attracted thousands of visitors. The art installation is now traveling to exhibitions around the world." [4]

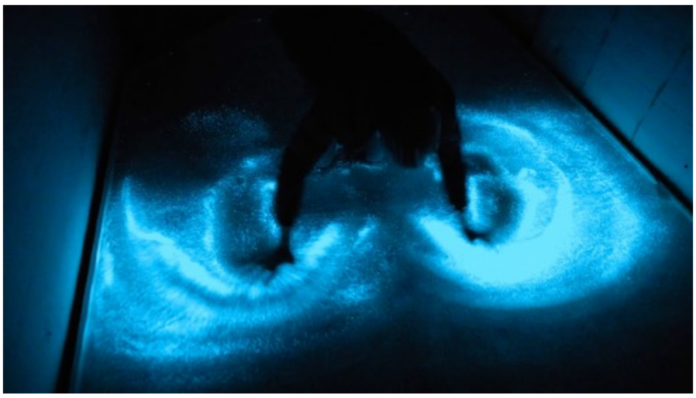


Figure 4: *The Glowing Nature, being interacted with and producing glowing formations*

The Glowing Nature installation becomes enticing due to its curiosity evoking interaction method. The interaction of applying force in various way is rewarded by a

striking glow visual. The participants have the ability to explore different methods of applying forces and can therefore create various forms of light patterns.

2.1.4 SYNC, Studio Roosegaarde, 2019

SYNC has its premiere at Art Basel 2019, taking place from June 13 through 16 June 2019. Client: BMW "Autonomous driving vehicles need a strong interaction and connectivity between humans, vehicles and their surroundings in order to flawlessly navigate cities. As we are facing more complex times this connectivity principle is also key for human interaction in today's societies. Roosegaarde's installation addresses this theme with new creativity and imagination, to show the importance of human connectivity and interaction."

Figure 5: *The SYNC installation with visual bonds formed between two participants*

"With more people the artwork creates shared spaces of light, making new interactive connections between people. Although high-tech, the artwork feels intuitive, with jelly-fish types of shapes occurring and disappearing. Accompanying the artwork is a special music soundscape, created by Berlin-based musical partnership "Tale of Us"."

Figure 6: *The SYNC installation with visual bonds between all participants*

“SYNC by Roosegaarde is an immersive art installation in which you create your own space. The artwork is a landscape of light where visitors can create their own favorite space, connect with others and visualize their ‘sense of place’.” [5]

The SYNC installation achieves enticement through the interaction method, environment and material choices. The dark environment and blue violet colour choices provide curiosity and mystery. The interaction produces visually appealing forms based on the participants’ movement and location. The soft changing ground is making participants more aware of their position where they are standing. The formation of visual bonds between participants make them more aware of each other and creates a moment for interpersonal interactions. Through these, it achieves its goal of creating human connectivity and delivering a message to be reflected on.

2.1.5 Liquid Spaces, Studio Roosegaarde, 2006

Series of LIQUID SPACES is made of steel, software, sound, electronics, mechanism, and sensors.

Figure 7: *Three participants dynamically interacting with the Liquid Space Installation*

“LIQUID SPACE is a series of sculptures which researches interactive architecture. As organic fusion of mechanisms, embedded electronics, sound and LEDs the artwork creates a playful dialogue with its visitors. Space cannot be only statically defined by walls and windows, but should interact with the presence of its visitors. “ [6]

The Liquid Spaces installation is enticing due to its visual and auditory aspects. The installation achieves engagement through responding to the movements of the participants and creates a moment for camaraderie as participants play and collaborate to transform the installation visually and auditorily.

2.1.6 Maja Petrić, We Are All Made of Light, 2019

The installation was first exhibited at Seattle's MadArt Studio. Its next showings will be at São Paulo's Santander Cultural centre and Wonderspaces Arizona.

“We Are All Made of Light is the first iteration of an immersive art installation about our interconnectedness. The installation utilises interactive light, spatial sound and artificial intelligence (AI) to create audiovisual trails of every person's presence in the exhibiting space, meshing it with trails of other visitors from the past, present, and connecting them with future visitors.”

Figure 8: *Participants observing previous participants in the installation*

“During experimentation across different media, she discovered that both natural and artificial light is an immensely potent tool to engage people’s perception, emotion, memory, and imagination. She combines the experience of light with various new technologies such as AI, computer vision and spatialized sound to manipulate senses through which space is experienced cognitively and emotionally.”

“Each new person visiting the space is immersed in starscape filled with light that marks the presence of everybody who was part of the piece. Over time, the exhibiting space becomes an archive of people's presence and evidence of how all of us are connected to others, past and present…?” [7]

The We Are All Made of Light is enticing due to its large scale, ethereal and aesthetically pleasing mysterious form and light movements. The interaction method is initially ambiguous, however, then becomes noticeable through reflecting the image of the participants in the grid of lights. The asynchronous nature of the interaction creates a sense of connection that occurs with the previous participants as opposed to the concurrent ones. In this way a sense of connection occurs more cerebrally and in a way in a more complex and deeper manner.

2.1.7 Cave of Sounds, Tim Murray-Browne, 2012

“Cave of Sounds began in November 2012 at London’s Music Hackspace as part of Tim Murray-Browne’s Embedded artistic residency with Sound and Music. The eight artists, led by Tim, each developed a musical instrument for what was, at the time, an imagined eight piece ensemble.”

Figure 9: *The Cave of Sounds installation with participants interacting with the devices*

“Cave of Sounds began in November 2012 at London’s Music Hackspace as part of Tim Murray-Browne’s Embedded artistic residency with Sound and Music. The eight artists, led by Tim, each developed a musical instrument for what was, at the time, an imagined eight piece ensemble.”

“Cave of Sounds connects music’s prehistoric origins with the technological radicalism of the music hacker scene. Eight bespoke instruments are exhibited in a circle. They are there to be played by the audience in an unmediated collaborative exploration.”

“The circular arrangement of the instruments facing inwards is inspired by prehistoric stone circles. It encourages collective play both between and for participants, rather than to an audience of spectators. We’re aiming to loosen preconceptions that participants have about performance, composition, collaboration and improvisation.” [8]

The Cave of Sounds installation is enticing due to its auditory output and novel methods of interaction that are still not challenging to execute. The participants can produce new sounds through interacting with one of the five “instruments”. The camaraderie occurs through collaboration as participants create music together. The circular arrangement also adds to this effect.

2.1.8 CLOUD, Nuit Blance Calgary, 2012

Figure 10: *The large scale light installation CLOUD*

The first edition of CLOUD was first created for Nuit Blanche Calgary (Canada) in September 2012. In early 2013, the artists built a second edition of the sculpture in Russia.

“CLOUD is an interactive sculpture created from 6,000 incandescent light bulbs by Canadian artists Caitlind r.c. Brown & Wayne Garrett. The piece utilizes pull chain switches and everyday domestic light bulbs, re-imagining their potential to catalyze collaborative moments and create an enveloping, experiential environment. During the exhibition, viewers interact with CLOUD by initiating impromptu collaborations, working as a collective to animate “lightning” on the surface of the sculpture.“

“Simple, bright, and playful, CLOUD is a barometer of social interaction, collaboration, and collective action, reflecting a whole that is greater than the sum of its parts. As viewers engage with pull chains, they become unwitting performers and puppeteers, orchestrating an uncertain spectacle for viewers outside the work. Subsequently the “inner” and “outer” spheres of the artwork pose different dynamics, inviting both participation and contemplation, spectacle and speculation, collective and subjective, harmony and chaos.” [9]

Figure 11: *The CLOUD installation with many participants pulling the switches*

The CLOUD installation achieves enticement through its large scale, affordance of the familiar rope switch associated with lights, and its aesthetically pleasing look. The participants are connecting through interacting together to create new lighting. The volume of participants also transfer this sense of connection to the viewers more strongly.

2.2 Background: Key Elements of Engagement, a Literature Review

As stated in the introduction, engagement is an integral aspect of the Graduation Project. Therefore, the process of engagement needs to be well understood to be integrated into the design. For the project to function effectively, the dynamics of participants’ engagement with the design need to be addressed. This literature review was executed in order to gain insight into the key elements that result in an effective form of engagement. In this literature review, four key elements that influence design choices have been identified and researched.

2.2.1 Introduction

A strong sense of community is an integral part of any society and the mental well-being of people. The pandemic has significantly hampered our ability to relate and interact with each other and weakened our sense of community. Lack of significant connections engenders physical and mental anxiety and degradation in their qualities. "Loneliness, anxiety drives, depression, panic states, mental disorders, health hazards, and many other issues" are affecting the world on both societal and personal levels [10]. The question on how to take a contrary (re)action towards social isolation and impaired relationships remains more relevant and significant than ever. Design-focused thinking can lead to thinking of cooperation between strangers/community members to raise a sense of togetherness in today's CoVid-19 climate.

Accordingly, for this issue, interactive installations have the potential to be an effective solution, as they can reactivate emotions through their experiential built environments, providing a space for play and shared experience, and interactive installations can provoke audience engagement [11]. This will be utilised for creating social togetherness.

For the Graduation Project to be successful, participants must be willing to interact with the installation. Therefore, the installation needs to be engaging to the participants. Since this is an integral aspect of the Graduation Project, knowledge of the prerequisites of engagement with an interactive installation is needed. In this literature review, four key elements for engagement with an interactive installation to occur will be investigated to provide information that will contribute to the design of the project. To achieve this outcome, this literature review will evaluate the four key elements clarity, sense of control, adaptability, and exploration and surprise by providing information on the description of the key elements and the different features they possess.

2.2.2 Clarity

One of the main facilitating concepts for an engagement with an interactive installation to occur is clarity. Unclear and inscrutable installations can cause participants to form conclusions that are unintended and unlooked-for through their interactions [12]. Bilda, Edmonds and Candy [13] carry this discussion further with more detail and lay out a prerequisite of engagement for participants as "informing them in a clear and encouraging, but not prescriptive, way as to what is going to happen". Also, they suggest making the initial interaction clear and attainable as a design principle for engagement. For this to be successful they detail the requirement for initial interaction to provide clear feedback that is promptly delivered. Additionally, they mention that clear feedback facilitates adapting to the interactions of the installation.

In support of this argument, contributing to this concept in practice illuminates the information more concretely. Hornecker and Stifter [14] supplement the importance of clarity on engagement through an analysis of an interactive museum installation. Analysing the least interacted installation, they identified one element of the reason behind the limited engagement as the unclarity of installation. It took participants a minimum of two minutes to realise how to interact with the installation, which led to a significant amount of participants abandoning the installation. However, they also state that the unclarity resulted in a few participants engaging for a longer time and in a more concentrated manner. In further support of this argument, Höök, Sergers and Andersson [15], in their study of an interactive installation, mention that the unclarity of recognising the interaction method with the installation leads to some participants' losing their will to interact; therefore, breaking the engagement. They also observe that some participants felt frustrated since they found the outcome to be unclear. This reduced the engagement as it resulted in those participants thinking that the installation did not alter through their input.

On the whole, concluding on the information provided by the various sources on clarity, clarity is a linchpin for the facilitation of engagement, as it provides encouragement and understanding for the extended process of interaction. Implementing timely and supportive feedback systems in the design process is instrumental in ameliorating issues in clarity, as it will bolster engagement by avoiding potential frustrations participants can experience.

2.2.3 Sense of Control

Sense of control is a crucial concept for engagement with an installation to be initiated and sustained, treating engagement cognitively and emotionally. Bilda, Edmonds and Candy [13] define control as "a stage where the audience is capable of setting a purpose for his/her actions and expectations about the interaction outcomes". They describe a sense of control as an essential ingredient for sustaining engagement as participants become more deeply engaged in the sustained interaction. Bilda, Edmonds and Candy justify this by stating that having control over the interaction outcomes creates a sense of achievement which is motivating since it is rewarding. Introducing a detailed point of view on the same effect, Hornecker and Stifter [14], analysing an interactive installation that has been engaged with the least, as reasoning, noted the usability issues making interaction more difficult to execute. In this installation, selecting moving visuals was difficult to control as it required the participants to be well coordinated to keep their hands steady while simultaneously following the movement of the selection item. Reflecting on this outcome, it can be concluded that the installation is not providing affordable control to the participants, since they find it challenging to get the interaction outcomes they desire that meet their expectations.

Supporting this argument, another view on the topic of sense of control is provided through a study of an interactive installation. Substantiating the effect of control on engagement through the following study of an interactive installation is beneficial to the understanding of expectation and outcome relationship of the participants' actions as the main ground for a sense of control. Höök, Sergers and Andersson [15], in their study of an interactive installation, describe the main reason for losing the desire to engage as frustration engendered by lack of control. The lack of control, in this case, was due to the participants having "a great deal of trouble figuring out the relationship between postcard and drawings". In this case, the 'postcards' were the input of the participants' actions and the 'drawings' were the outcome. Analysing these examples, firstly, it can be interpreted that the presence of ingredients of clarity in having a sense of control shows that clarity has an influence on control. Secondly, it can be interpreted that introducing a strong sense of control is necessary for both the interaction style and the feedback systems that are provided to the participant.

2.2.4 Adaptability

Adaptability is another concept that emerges as crucial in engagement, particularly concerning its function of facilitating the participants' interactions and giving them the flexibility and mental space to adjust to feedback. Participants should have time to adapt to the interaction methods with the installation. Bilda, Edmonds and Candy [13] articulate that while interacting, participants will be exposed to new changes in the environment based on their input. Through adaptation, participants learn the outputs provided by the installation based on their inputs. Until participants can understand and familiarise themselves with the new methods of interaction, giving too much feedback and change limits adaptation by the participants. If the interactions cannot be understood and the feedback is inconsistent, then the participant cannot adapt, leading to a loss of interest in the experience.

Providing a new lens on this argument on the topic of adaptability, Arfaoui et al. [16] bring in risk management as a concept that gives a useful perspective on adaptability of interaction. They provide four stages of managing risk that is going through assessing, decision-making, adapting to the unexpected, and managing. Therefore, for certain participants to engage, interactions should be based on or similar to the participants' "actual experience of the world" so that they can adapt better, leading to the facilitation of their engagement process. Commenting on the findings, it can be said that in order for engagement to be supported, adaptability can be implemented through designing interactivity based on the prior experiences of participants that are shaped by general life experience, in addition to the general cognitive capability of participants to perceive and adapt to feedback.

2.2.5 Exploration and Surprise

Exploration and surprise is the final critical concept in engagement that is handled. Its significance stems from its ability to entice the participants into the interaction and drive curiosity in them to provide a deeper form of engagement. Bilda, Edmonds and Candy [13], describing design principles for engagement, introduce the element of surprise, urging to "create situations where the audience may initiate an interaction unintentionally and may be surprised about the outcome". Surprise comes at an early period of engagement, where the participants receive feedback from the installation without having specific expectations. However, surprise also sustains engagement by provoking further exploration. Elaborating on Bilda, Edmonds and Candy's information, Pais [17] reports in the early exploratory phase of the interactive installations he is analysing, that participants, to '"create understanding about the work"', were eager to interact with the installations, producing the initial engagement. At this point, participants initiate exploring the installation by further engaging with it. After early exploration, receiving more material to explore benefits the engagement with the installation. In "the Legible City" installation, where participants ride a bike that controls the movements in a virtual city on a screen, participants described "the exploration of the different maps as a source of bodily pleasure that was engaging…".

Substantiating this argument, a contributing view is from Zheng, Adam and Woodcock [18]. They suggest that if unexpectedness is above a threshold subjective to the participant, then it will evoke surprise, causing the participant to be curious and explore, which will lead to adaptive actions. Sustaining surprise will sustain the cycle of surprise to the adaptation to the surprising stimuli. Whereby extending engagement by increasing interaction time. However, Soderman and Howe [19] warn about the dangers of having excessive surprise, noting that inability to follow surprise patterns logically leads to participants not feeling surprised. Therefore, it can be concluded that installations should fine-tune the balance between redundancy and surprise while avoiding both ends of the poles.

Overall, by evaluating the data from these sources, it can be deduced that exploration and surprise can be utilised in the early stage by generating the initial engagement through being enticing and sparking curiosity. And, in the later stages, this key element can be utilised by sustaining engagement through building on the curiosity and exploration with additional surprises and interesting novel feedback. Although, surprise must be well adjusted to be effective on engagement. Immoderate amounts of surprise that exceed the participants' attention and cognition will deem the elements of surprise ineffective, leading to a reduction in engagement instead.

2.5.6 Conclusion on the Elements of Engagement

The research aimed to identify key elements that provoke engagement in interactive installations in order to inform design choices. From this research, four key elements are identified: clarity, sense of control, adaptability, and exploration and surprise. For the participants to engage with the interactive installations, the interaction methods, as well as the feedback that they receive through interacting, should be clear to them throughout the engagement. While engaging, the participants should have a sense of control, where interaction methods are easy to control. Another prerequisite of control is the participants' ability to produce feedback that is in line with their expectations.

Through the engagement process, as participants interact, new incoming feedback and changes in interaction methods must provide a comfortable space for them to adapt to emerging situations. Moving to a deeper level of engagement, the participants need to have the ability to explore and be surprised by new events and feedback after they feel fully in control and understand the dynamics of the interactive installation.

In closing, the research has formed necessary descriptions and detailed characteristics of key elements of engagement in interactive installations and produced fruitful information from both conceptual and practical perspectives. The output of this literature research is capable of informing creators on generating engagement in their works through a more profound understanding of its key elements. However, the literature research was challenged by the relatively limited pool of sources in which it is arduous to access a variety of information.

To fill the gap between the limited information and the effectiveness of the engaging elements, it is necessary to carry out interviews with makers of installations and produce case studies of interactive installations that research and identify deeper level details of elements for engagement. Additional theoretical information on user interaction and experience is required which can be appropriated to the field of interactive installations and provide novel insights.

The topic 'elements for engagement in interactive installations' is an integral area of knowledge for interaction design, as in order to produce complex experiences that facilitate change and meaning-making, engagement is a prerequisite. Interactive installations are a novel field and there is limited knowledge on this field, therefore, generating knowledge on this topic strongly benefits the current knowledge gap.

2.3 Conclusions for the Graduation Project

In general, interactive installations are individual experiences. Participants can be together; however, they do not pay attention to each other; they are occupying the same space physically, but not mentally. These installations were chosen in particular, as they overcome this barrier. The graduation project aims to be placed in the same style. The project aims to provoke camaraderie through co-operation in creating together or drawing participants closer through the interaction. Even thought the existing works have partial elements informative to the graduation project's research question, there is not one that answers the research question.

Concluding on the state-of-the-art review, the design is informed by the following aspects. The installation has enticing elements that trigger people to start interacting with it. This is achieved through aesthetics and providing an initial curiosity evoking feedback. The interaction methods with the installation and the feedback they receive from the system have high clarity. The participants through interaction feel in control and have ease of use, where they can form expectations that match with the installation's output, so they do not feel frustrated. As participants are in engagement, novel feedback and changes occurring in the environment happen at a pace that the participants can adapt to these new situations. As the engagement continues, the participants should be able to explore the interaction possibilities or be surprised by new input. The interactive installation gives grounds for camaraderie to develop between participants. Therefore, the installation requires and encourages interpersonal interactions and/or provides a space for social interaction.

According to the rules of proxemics, for the best facilitation of interpersonal interactions, the participants are between 1.5 to 3.7 meters apart to be encapsulated in social space without moving too close to personal space or too far toward public space.

For participants to have an effective sense of togetherness or connection, emotional reciprocity to occur, the pace of the interaction is slow, participants are visually available, and participants have the space to recognise the behaviour and emotions of the other participants. This allows the participants to build on top of and react to the behaviour and emotions of each other. Similarly, mirroring also works within this region, and through mirroring participants internally 'feel' the emotions of others by mirroring them mentally.

2.4 List of Requirements

Summing up the conclusions of the literature background research, a priority list emerges as follows:

1. The design must engender a sense of connection between participants,
2. The design should be enticing, participants should be compelled to interact with the installation,
3. The design should be for at least 2 people and can be expandable to 8 people,
4. The design should be transportable easily, therefore should be modular so that it can be broken down and rebuilt efficiently,
5. The design should have participants standing between 1.5 to 3.7 meters apart,
6. The mechanics of the installation should not take the attention away from the interaction,

Chapter 3: Methodology

The methodology chosen for this project is the Creative Technology Design Process [20] in addition to a conclusion and discussion with future work. Creative Technology Design Process is composed of Ideation, Specification and Realisation that lead to Evaluation. Then a conclusion is drawn on the research question and comments are made on future work.

The Ideation Phase develops on the project knowledge and results in an elaborated project idea and a list of requirements that will be carried though the project. The process utilises creative thinking methods to achieve its purpose.

The Specification Phase provides a detailed product specification that encapsulates experience specifications and functional specifications. This phase concludes on the design and functional elements that will build the prototype.

The Realisation Phase takes the output of the Specification Phase and transforms it to a prototype outcome through realising the required components and integrating them for the final output.

In the Evaluation Phase, the product prototype is then evaluated in relation to the experience and functional requirements. This is followed by a conclusion on the outcome of the project in relation to the research question and future work conclusions.

Chapter 4: Ideation

This chapter aims to develop a more elaborated product idea through the requirements list listed at the end of chapter 2. The ideation phase will conclude with the elaborated product idea and a list of requirements for the specification phase. To achieve this conclusion, mind-mapping was used to develop the experience and the design of the initial idea. Then, digital mockups were made on a 3D design software simulating the potential experience of the interaction. These digital mockups were used to further conclude on the output of this chapter.

4.1 Mind Map

Mind-mapping was chosen as one of the tools for facilitating the decision of the product idea. It was utilised to explore potential components of product ideas under experience and function. The output of the mind-mapping process were used in the decision making process of the initial idea.

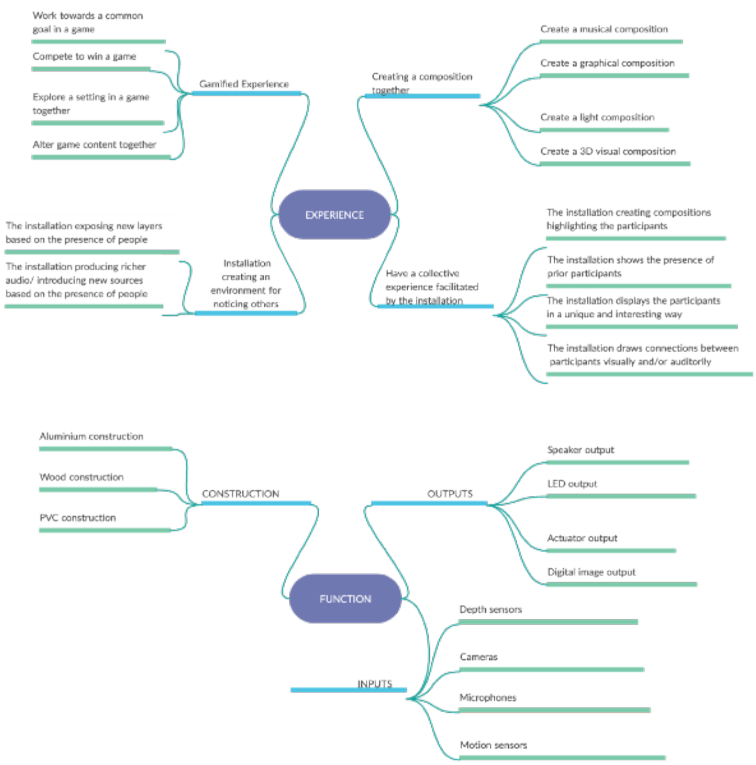


Figure 12: *The Mind Map for the product idea separated into experience and function*

4.2 Ideas for the Design

4.2.1 Initial Idea

One of the considered ideas was having the participants gather to make a composition together and experience camaraderie. The circular formation and composition making concepts were adapted from the installation Cave of Sounds [8] and CLOUD [9] installations. For this, triangular shapes were considered as an idea for composition making.

4.2.1.A Digital Mockup for the Initial Idea

The digital mockup of this idea was done in Maya3D 3D modelling software. Imagined positioning of participants and their potential interaction were considered. The interaction was considered to be done through movement sensing.

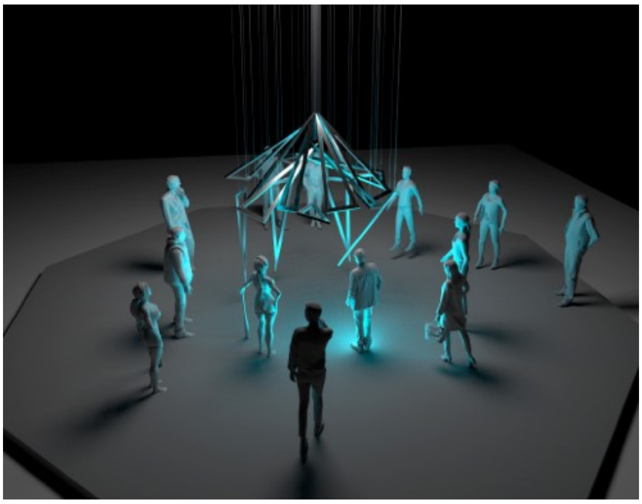


Figure 13: *The digital mockup with gathering participants*

4.2.1.B Evaluation of the Initial Idea

This idea formed limitations in construction price and difficulty. Despite having camaraderie and social togetherness potential, it was considered out of scope, and its enticement and social connection aspects were considered for improvement.

4.2.2 Second Idea

The second idea was built on the initial idea, but the enticement and social connection aspects of the idea were considered upon. The concept of using mirrors was adapted from the CAROUSEL [2] and LAMP [3] installations to make the installation enticing.
The self-image of participants was used as a tool to make participants more engaged with the experience. A more intimate experience of two participants was considered for

more focus on each individual where emotional reciprocity and mirroring could occur more clearly.

4.2.2.A Digital Mockup for the Second Idea

The digital mockup of the second idea was done in the same software. The triangular shapes were considered having mirror surfaces. The participants were imagined to interact with the installation and the other participant. The interaction was considered to be done through movement sensing. The angle of the shapes were changed based on the position of the participants. The experience was considered through the lens of a viewer from outside and through the lens of a participant.

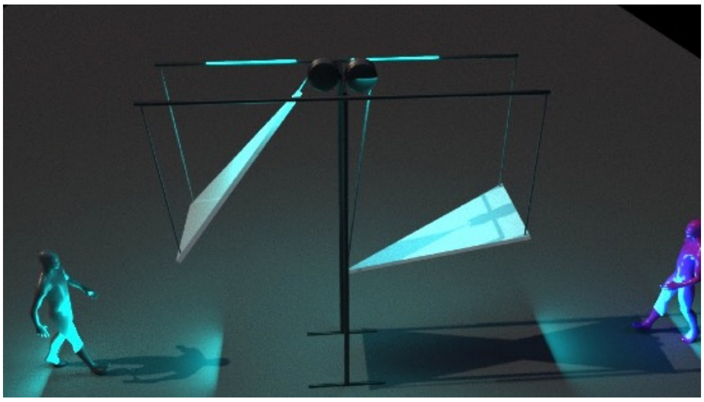


Figure 14: *The digital mockup with the test setup of triangular mirror structures*

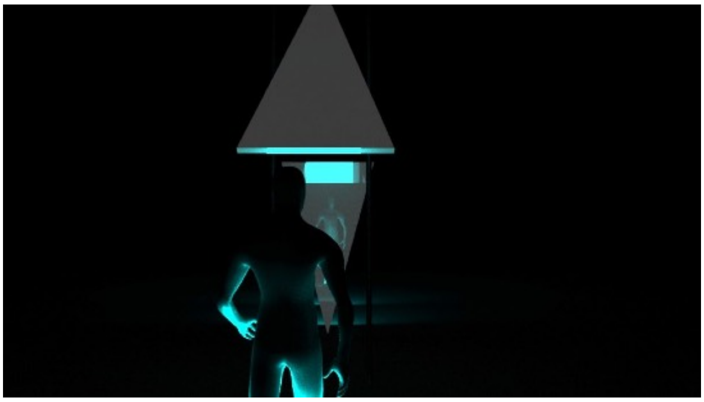


Figure 15: *The digital mockup from the participant's perspective*

4.2.2.B Evaluation of the Second Idea

The explored effect of utilising the reflection of the participants was considered to be valuable in the enticement and emotional reciprocity. However, the angular movement made the user invisible after a small number of approximately 15 degrees. Due to its potential effect on the quality of engagement, reflective surfaces were added to the idea, but its movement methods were reconsidered.

4.2.3 Final Elaborated Idea

For this idea, the image of the participants are used to make the installation more enticing to interact with. This is facilitated by mirrors. The main experience of the installation will be to utilise the self-image of the participants through the use of mirrors. This image is then subtracted by the movement of the mirrors, revealing another participant. It can be for 2 people or be expanded to more. The interactive installation will use multiple frames of mirrors as objects for manipulation. The objects will be translated vertically, this will be based on the input registered of the positions of participants over time, which is based on the participants' movements. The movement will be facilitated by actuators. Microcontrollers will be used to control the system. The experience and the functionality will be specified in the specification phase.

4.2.3.A Digital Mockup for the Final Elaborated Idea

The digital mockup of the final idea was made in the same software, where due to the movement issue of the second idea, angular movement was reconsidered into vertical movement. The triangular mirrors were also reconsidered into rectangular mirrors to provide more visual space and create a more clear visual separation. Two versions were made, one with 8 participants and another with 2 participants.

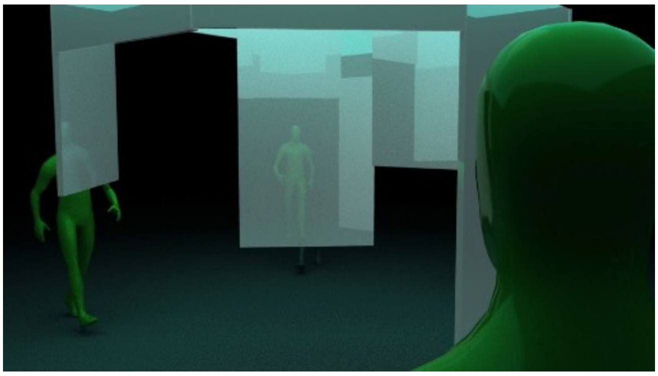


Figure 16: *The digital mockup from the participant's perspective with 8 participants*

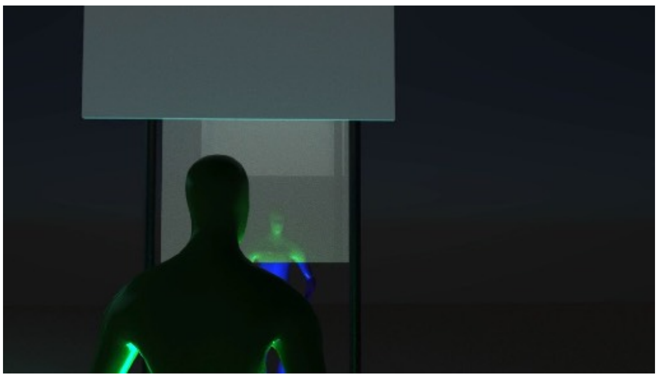


Figure 17: *The digital mockup from the participant's perspective with 2 participants*

4.2.3.B Evaluation of the Final Elaborated Idea

The final idea provided a more evolved and improved idea that leads to the specification phase. The interaction method showed potential to lead to an enticing and engaging installation that can facilitate interpersonal connection through emotional reciprocity. The final product experience and the functional specifications is needed for a product prototype that attempts to show positive effects of interpersonal nature through the shared experience it produces.

4.3 List of Requirements

The list of requirements was formed to facilitate process of the final elaborated idea transitioning into product prototype that evaluates the research question. The requirements that the research question demands on the product idea were considered in two categories, experience requirements and functional requirements.

4.3.1 Experience Requirements

1. The design should be enticing, participants should feel inspired to interact with the installation.
2. The experience must engage the participant in a strong manner.
3. The experience must engender a sense of connection between participants.
4. The experience should lead participants to form a critical reflection.

4.3.2 Functional Requirements

1. The design should be transportable easily, and be easily changed.
2. The mirrors should deliver the experience at the required speed and position.
3. The construction should be sturdy and deliver the experience reliably.
4. The design should be for at least 2 people and can be expandable to 8 people, where participants face each other.
5. The design should have participants standing between 1.5 to 3.7 meters apart.

Chapter 5: Specification

In this chapter, the behaviour and the physical design of the installation are decided on. Following the requirements set-up in the ideation phase, the functional and experience specifications are made through early experience and functional testings. The specification phase concludes with the product specification that contains the specific experience design and the functional design elements in terms of construction, software, sensors, actuators and processors that the experience demands.

5.1 Experience Specification

The experience specification forms, in detail, the experience that will be used for the realisation of the product prototype. The experience specification was built on the final two person concept in the final elaborated idea in the ideation phase. In order to fulfil the experience requirements efficiently, the experience specification process has researched the experience possibilities of the final product idea and constructed a form of experience specification that can answer these requirements. The experience specification was arrived at through reflecting on user testings. The experience was formed of introduction, engagement, surprise, reaction and reflection phases based on the experience specification process.

5.1.1 User Testing

The user testings for experience specification was done to extract the details of the experience phases. In order to specify the experience of the installation, the details of the interaction method and the engagement details had to be identified. The user testings evaluated the fulfilment of the requirements during the process, which was used to make changes and conclusive specifications.

5.1.1.A Mirror Movement Test

This user testing was done to test the vertical movement of the mirror. The testing was done with participant A, a 58 year old female. For the user testing, the mirror frame was moved vertically based on the position of the participant, where the movement of the mirror frame was linear with walking. The researcher was positioned stationary behind the mirror frame and relocated it with a wire coming from below based on the position of the participant. The participant was asked to move towards the mirror frame at slow (0.1 m/s) , medium (0.25m/s) and fast speed (0.5 m/s) for a total of three times. The researcher observed as a stationary participant.

5.1.1.A.1 Prototype for the User Testing

Two 80 cm by 60 cm plexiglass mirrors were adhered together to make a frame of two sides with mirrors. Two hinges on both top ends were applied to the frame with masking tapes. The hinges then were connected with transparent heavy weight wires and placed over a 1.5 meter wide aluminium profile. The aluminium profile was held by a 1.8 meter metal tube with 4 legs 15 cm high, and the wires were looped from the legs for control by pulling.

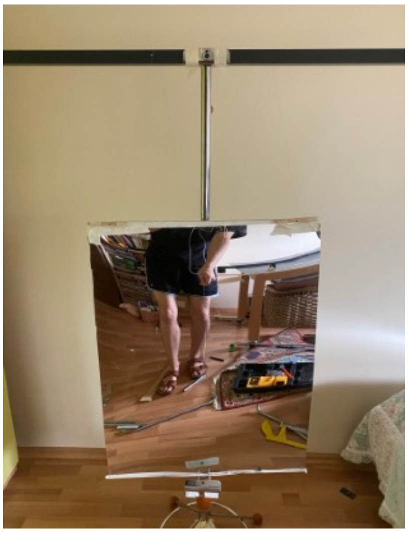


Figure 18: *Showing the metal frame and the two sided mirrors*

5.1.1.A.2 Conclusions for Experience Specification

The process showed limited support for the linear interaction experience in its ability to facilitate a dynamic interplay between the image alterations that occur though the reflected self image that could lead to a clear emotional connection that can form a sense of togetherness, the experiences of the participants show to be too separated from each other to for mirroring effect, emotional reciprocity and/or camaraderie to be formed.

It also showed to not be enticing enough to draw in an elevated engagement where the participant is more invested in the intake of the experience openly. The interaction method of the experience did not display the possibility of the requirements being met in a satisfactory manner.

Only the test with a very high motion speed provided an insight into a dynamic with high potential. The immediacy of the shifting of the self-image reflection to the visual image of the participant that is revealed through the interaction has provided significant outcomes that can answer the requirements. The participant reacted to the experience with a smile and an overall elevated mood, unlike the earlier tests where the participant seemed to be in a critical and analytical mindset toward the experience.

5.1.1.B Mirror Interaction Test

This user testing was done to test the interaction between the participant and the mirror frame, for the mirror shape, a more complex convex shape was decided to be tested, the test was done for increasing the enticement and engagement value of the design. The testing was done with participant A, a 58 year old female, and participant B, a 60 year old male. In isolated instances, the participants were asked to interact with the convex mirror frame as if they were in a gallery/cultural institution setting and came across it.

The optical effect of the convex mirror was stabilised for the most clear and highlighted self image at a distance of 1 meter, as participants need to be between 1.5 and 3 meters for a distance that facilitates social interactions. The behaviour and general interaction with the convex mirror frame was observed and conclusions were made.

5.1.1.B.1 Prototype for the User Testing

A 80 cm by 60 cm plexiglass mirror was placed horizontally and a V shaped metal frame was made that has a hinge in the centre. The plexiglass was attached to the metal frame with clamps from the behind. The angle of the metal frame was altered to create the wanted optical effect from 1 meter observation distance, which made the width 73 cm from 80 cm. The convex mirror setup was placed on a table of 80 cm, the frame was elevated enough for the user height by stacking planar objects to have vision for participant A at 160 cm and participant B at 175 cm.

Figure 19: *Showing the effect at keeping the one meter distance, the participant is highlighted and zoomed on, and the background is blurred, reflected and morphed based on the view angle and distance, as seen with the green closet shown reflected and morphed.*

5.1.1.B.2 Conclusions for Experience Specification

The design showed an improvement on the enticement and engagement of the experience. Participant A has spent 12 seconds in front of the concave mirror, where the participant first observed herself with different closeness and view angles looking at different morphing and alterations of the reflection of herself. The participant then moved left to right periodically in a dancing manner until the end of the 12 seconds, which gives a visual of morphing and expanding of the self. The participant stayed around a meter away throughout the process.

Participant B has spent 7 seconds in front of the concave mirror, and looked at the reflection at a specific closeness and view angle until the last few seconds where he did the same left to right periodic motion.

The mirror shape showed functioning as a booster of engagement and enticement requirements, since the participants were engaged with the reflected self image in a dynamic and invested way. The duration and actions of the interaction indicated that the optical effects have elevated the enticing value of the design. The experience dynamic has provided details on the distance, duration and position of the participant in the process of engagement.

5.1.2 Conclusion on the Experience Specification

The dropping interaction has formed a sense of surprise through the switch between the reflected image of the participant's self and the visual image of the other participant. The surprise of the experience has created a shared experience whose content is formed through the images of the participants. The reaction to the surprise generates the possibility of generating an elevated sense of connection between participants.

This possibility is through the experience of surprise leading to mirroring to occur, as a participant mirrors the reaction emotion of the other, and also the participants have the possibility to build emotional reciprocity, where an emotional reaction is formed and then the other participant builds on it by reciprocating with their own emotional reaction to it.

The experience is engaged and saturated enough to potentially lead to a reflection period where the participant reflects on the meaning of the experience in their own terms, as due with artistic experiences. However, whether the requirement of evoking critical reflection in the participants is fulfilled needs more data.

The concave frames have bolstered the enticement aspect of the design, and the engagement with the installation, where it made it more invested and dynamic, serving the delivery and intensity of the surprise experience that give rise to the raising of a sense of togetherness.

5.1.3 Resulting Experience Specification

The experience specification, based on the outputs of the testings, has been established, and been divided into phases that lead to the delivery of a sense of togetherness through a common experience. The mirrors are joined to have the experience as a common experience that the installation facilitates through surprise, when participants on both sides reach the end of the engagement phase, the joint experience of surprise is facilitated. Then participants react to the experience of surprise through each other where emotional connection and communication occurs, facilitating togetherness.

5.1.3.A Introduction Phase

In the introduction phase the participant recognises the installation for the first time and forms and idea and an expectation on the installation and evaluates whether to expand on the relationship with the installation or cease it.

5.1.3.B Engagement Phase

In the engagement phase, the participant has decided to interact with the installation and interacts with analysis and observation from an interaction distance and later moves into a closer proximity critical distance where the participant engages with the installation through the optical effects of the concave mirror frames and self-reflection.

The critical distance is the observational distance of about 1 meter, the high engagement duration is set to 6 seconds, to be a guarantee from the minimum 7 second interaction in the test, and on the uncertainty of the general viewer population. The interaction distance is higher than 1 meters, and can be considered up to approx. 2 meters.

5.1.3.C Surprise Phase

Participants reach the surprise phase simultaneously, which occurs after both participants go through the critical engagement time. The participants are surprised with the visual image and presence of the other participants, which transformed from an enticing and concentrating image of the self-reflection in the concave mirror. This is the common experience that the participants experience.

5.1.3.D Reaction Phase

Participants experience the reaction phase from the surprise that created a common experience and participants react together and on top of each other. Communication develops between participants, and this communication that encapsulates emotions give space for a sense of connection between participants, leading to togetherness. This can be through social elements such as emotional mirroring, reciprocity, verbal communication.

5.1.3.E Reflection Phase

After reacting to the common experience of surprise, the participant reflects on the experience cognitively and emotionally. The participant gives a meaning to the experience based on their independent meaning-making process and assigns a value to the experience. This process happens after the reaction has occurred and can last for a short moment or an extended time frame.

5.2 Functional Specification

The functional specification serves the duty of facilitating the experience specification in an efficient and effective manner. The functional specification elaborates on the building elements of the installation as well as the behaviour of the software that facilitates the specified experience. The functional specification handled each main component separately and made specifications that effectively fulfil the components and lead to an effective realisation process.

5.2.1 Dynamic Mechanics

In this product, the experience arch is delivered through the mechanics of the dynamic behaviour of the installation. The system requires a movement of 0.5m/s. In order to provide the experience effectively and accurately, the ingredients of the setup of the dynamic mechanics system need to be specified for the realisation of the prototype.

The specifications that need to be done on the mechanical setup are the actuators and the hardware that deliver the functioning of the actuators. For the installation, the ingredients of the dynamic mechanics are 2x stepper motors, 2x digital stepper motor drivers, a 24V 7A power supply, 2x flange couplings and 2x reels attached to the flange couplings. The system will be controlled by an Arduino Mega.

5.2.1.A Stepper Motor

As the main actuator that delivers the movements, stepper motors were selected due to the ability to deliver low audible noise and precise location movement in addition to the ability to alter acceleration and velocity components solely through software in a dynamic manner. The stepper motor type selected was a Nema 17 stepper motor with at least 4kg torque that allows for the moving of the mirror weight within safe boundaries. For this, a 4-wire Usongshine 17hs4401 Nema 17 motors with 1.5A peak current was selected based on its ability to fulfil price and safety requirements.

5.2.1.B Driver

For the driver of the stepper motor, parameters were accuracy of stepping, audio noise levels, current delivery and heating. For the driver, hybrid drivers with current switches and aluminium casing, small circuitry stepper drivers and analog drivers with current switches and aluminium casing were tested.

Figure 20: *The GSTD2542 hybrid driver*

The drivers were the GSTD2542 hybrid driver, the CWD556 hybrid driver, the TB6600 analog driver, the DRV8825 and A4988 drivers and the TMC 2226 and TMC5506 drivers. The drivers were tested with acceleration to 2000 steps/sec speed for a duration of a minute. Then the drivers were tested with a pulley setup of four 2cm radius pulleys attached to 50 cm high and 40cm wide table structure that approximately holds the weight of the mirrors, weighing at 550 grams each.

Figure 21: *The pulley and weight setup for testing the drivers*

The GSTD2542 and the CWD556 hybrid driver, were the only two drivers that were silent, deliver enough current for strong torque and reliable for step accuracy and heating. The GSTD2542 was selected due to having more lower current options than the threshold compared to the CWD556. The TB6600 analog driver created noise that caused shaking and loudness. It missed steps and lost resolution at certain velocity frames of the acceleration. The DRV825 and A4988 drivers were producing relative noise and overheated. The TMC 2226 and TMC5506 drivers at high speeds, had a short period of losing steps. The TMC drivers could not provide enough torque to pull the weights despite maximum reference voltage.

5.2.2 Sensors

For sensing to produce the effect that needs to translate accurately from the experience process, specific position values of the participants need to be registered reliably. For the sensing, depth sensing was selected for its ability to discern the distance to the closest object in the sensing field of the sensor. For this, Depth Sensing Cameras of

IntelRealsense d435 and Kinect v2, Rotational Lidar RPLIDAR A1M8, sonic distance sensors of HC-SR04 and HRLV-Maxsonar were considered. The sensors were evaluated mainly on their price, reliability and the accuracy of the data.

5.2.2.A Depth Cameras

The IntelRealsense depth camera was out of budget considering multiple cameras were needed. The Kinect v2 cameras proved to be more applicable to the project. It could provide the position data well, but it had problems with stabilising the closest point of the closest object. The Kinect also was a pricey choice, and both required a computer to be added to the installation for it to work; thus, were not considered.

5.2.2.B Rotational Lidar

The RPLIDAR device had issues with reliability due to the fact that it had to be coded to ignore certain angles that contain the installation since it is 360 degrees. The sensor when it reads the closest surface, it considers the whole surface, so if a part is in the correct field and one part is not, it provides inaccurate data and false positives. The device also created relatively audible noise.

5.2.2.C Sonic Sensor

The sonic distance sensor HC-SR04 registered inaccurate datapoints, therefore was tested with indexing to a 100 readings and then averaging the value to provide accuracy and reduce noise, however, this still provided too many inaccurate datapoints to be utilisable despite the desirable beam pattern which provided a decent field for person recognition.

5.2.2.D Sonic Sensor Choice

The HRLV-Maxsonar sensor was selected, due to its very reliable data even at close range despite its relatively high price. The EZ 0 version was decided on due to its favourable beam pattern in person detection considering the close range readings that are smaller than 2 meters.

5.2.3 Construction

The construction of the installation provides the structure for all components to effectively function in relation to each other. The construction has the main duty to support and display all components of the installation. The construction is composed of the elements main frame, mechanical components and the mirrors. The construction is required to respond to modularity, so it is reconstructed and transported easily.

3.Y.1 Main Frame for the Mirror

The main frame is the main structure, and it requires durability, stability and modularity. The main frame, therefore, needs to be sturdy against shaking and be able to house the weight of the mirrors and the mechanical components. Therefore, an aluminium profile construction was selected due to its ease of modification, durability and modularity. Aluminium profile types were evaluated, and after some samples of a 90 degree construction, 5 cm by 7 cm profiles were chosen for the realisation process.

Chapter 6: Realisation

In this chapter, the project was brought to a product prototype utilising the final specifications made of the components of the product. This process was done through realising components and integrating them together to a functioning prototype that delivers the specified experience.

6.1 Realisation of Components

The realisation of the components for the prototype has been done individually for a strong delivery to the integration process. This process has been done for the sensing of the system, the dynamic mechanics and the construction of the installation.

6.1.1 Sensing

The installation is using the position of the participants with respect to the installation and this is done for both sides of the installation front and back. For this, 2x HRLV-Maxsonar EZ0 sensors were connected to the same Arduino board, the pulse width data was used for sensing the distance. Each sensor data was used for each participant.

6.1.1.A Software

For the functioning of the sensing process, the product requires the recognition of the distance between the participant and the installation and categorise it accordingly per each participant. The distance data is received through pulse width representation and in meters. This data is converted to centimetres and separated per participant.

```
sensor = pulseIn(pulsePin, HIGH);
userDistance= sensor/10;
if (userDistance > interactionBoundary)
{
  //convey No Participant is present
}
else if (userDistance <= interactionBoundary && userDistance > surpriseBoundary)
{
 //convey that the Participant starts the engagement process
}
else if (userDistance <= surpriseBoundary)
{
  //convey that the Participant is in critical engagement process
}
```

Figure 22: *The receiving and categorising of the distance input for the participants*

6.1.2 Dynamic Mechanics

In order to set up the system that facilitates the motion of the mirrors, the components that determine and function the stepper motor behaviour have been realised. The dynamic mechanics sub components have been integrated and the behaviour was set up in the software based on the experience. For this, a 24V 7A power source was connected to the two GSTD2542 stepper drivers through the V and Ground pins. The stepper motors were connected to the drivers. The motors facilitate the same movement for the left and the right side each. The drivers were connected to the Arduino with Direction and Pulse pins, where the same signals are sent to the drivers through parallel connection.

6.1.2.A Software

The dynamic mechanics of the installation works by receiving the categorised position of the participants and comparing it to the states determined for functioning. The software uses boundaries and variables set up for the experience specification. For this, Accelstepper library was used. The software creates conditions for no participants being present, any participant being in general interaction distance, any participant being in critical interaction distance, both participants being in critical interaction distance, surprise time condition and surprise completion. The software utilises timers for conditions for smoothing, and checks for a set duration in exiting a state.

```
if ((isInInteractionRange == true || isInInteractionRange2 == true) && thisUserInCriticalTime == false){
  //for versions that have an interaction for the starting of the engagement process
  timerStartedForInteractionStopping = false;

}
else if (isInInteractionRange == false && isInInteractionRange2 == false){ //if outside interaction boundary
  // wait for 3 seconds
  currentTimeForInteractionStopping = millis();

  if(timerStartedForInteractionStopping == false && currentTimeForInteractionStopping - previousTimeForInteractionStopping >= timeForInteractionStopping){
    //if within 2 seconds user is not present stop the introduction interaction
  timerStartedForInteractionStopping = true;
  previousTimeForInteractionStopping = currentTimeForInteractionStopping;
  }

  if(timerStartedForInteractionStopping == true && currentTimeForInteractionStopping - previousTimeForInteractionStopping >= timeForInteractionStopping){
  previousTimeForInteractionStopping = currentTimeForInteractionStopping; //reset timer for interaction ending, as it has ended
  timerStartedForInteractionStopping = false;

  }
}
```

Figure 23: *The condition of a participant being in interaction range*

```
//A CRITICAL RANGE TIME CHECK
if (isInSurpriseInteractionRange == true){ //YES USER CHECK TIME

currentTimeForSurprise = millis();
if(timerStartedForSurprise == false && currentTimeForSurprise - previousTimeForSurprise >= timeForSurprise){
 timerStartedForSurprise = true;
 previousTimeForSurprise = currentTimeForSurprise;
}
if(timerStartedForSurprise == true && currentTimeForSurprise - previousTimeForSurprise >= timeForSurprise) {

  thisUserInCriticalTime = true;
}

}
```

Figure 24: *The condition of a participant being in critical interaction range and timing for surprise for the participant being set up*

```
if (thisUserInCriticalTime == true && acrossUserInCriticalTime == true){
  // If both users are in critical time start surprise

  stepper.setMaxSpeed(10000);
  stepper.setAcceleration(3000);
  mustBeLoc = 0;
  //SURPRISE occurred
  }

 stepper.moveTo(mustBeLoc);

 stepper.run();
```

Figure 25: *The condition of both participant being in critical time leading to the surprise event*

6.1.3 Construction

The construction of the prototype encapsulates the main frame and the mirror motion system which include the mechanical set up for the mirror movements as well as the convex mirrors. The construction was ensured to be stable in the building process.

6.1.3.A Main Frame

The main frame is composed of 5 cm by 7 cm aluminium profiles and aluminium extrusions that provide stability and connect both sides together. The main frame component were being built parallel to the specification phase, and it was reconstructed to the form of the prototype. The main frame was built where the aluminium profiles were cut to the closest to 1 meter pieces and blocks of corner type and joining type were placed in between for reassembly with screws.

Figure 26: *The removable corner joined by screws and supported by extrusion from the bottom*

Figure 27: *The modular construction broken down for transport showing joinings*

The main frame was then constructed as 2.3 m tall with 90 cm legs giving stability that are on either side. The left and right parts were connected together with 84 cm extrusions between the mirror sides. The front and back sides were connected together with 19 cm extrusions. The final dimensions of the main frame are 2.4 m x 0.19 m x 2.3 m.

Figure 28: *The construction being reconstructed for the size of the mirrors with extrusions between two sides on the bottom corners*

6.1.3.B Mirror Motion System

The mirror motion system includes the mirrors and the mechanical system that functions with them. This system was built with a pulley above each top corner of each mirror for a total of 4 pulleys. The top corners of each mirror on the left side were connected together with heavy weight transparent wires of the length of 3 meters as it should be more than 2 times the traveling distance of 130 cm. Then a counterweight of 600 grams was placed on both sides between the two pulleys per side. The pulleys were attached to the long extrusions connecting the top parts.

Figure 29: *Attachment of the pulleys and wires*

The mirrors were bonded together at the centre in a line. The mirrors were attached connection points where they align with the pulleys and the wires were attached to the connection points.

Figure 30: *The final form of the convex mirrors and the positioning with respect to the frame*

6.2 Integration

Following the realisation of the individual components, these components were integrated together to form a cohesive product prototype. This was done through connecting sensing and dynamic mechanics, then integrating the dynamic mechanics with the construction. The integration process concluded with the product prototype that functions as the minimum viable product.

6.2.1 Sensing and Dynamic Mechanics

The sensing data and the dynamic mechanics were integrated through software, where the distance data were converted to booleans that lead to the decision of which state the system must be to execute a function. Thus, a final joint software was made.

```
if (userDistance > interactionBoundary)
{
  isInInteractionRange = false;
  isInSurpriseInteractionRange = false;
}

else if (userDistance <= interactionBoundary && userDistance > surpriseBoundary)
{
  isInInteractionRange = true;
  isInSurpriseInteractionRange = false;
}
else if (userDistance <= surpriseBoundary)
{
  isInInteractionRange = true;
  isInSurpriseInteractionRange = true;
}
```

Figure 31: *The integration through position boundaries that alter boolean statements*

6.2.2 Construction and Dynamic Mechanics

The dynamic mechanics initially were attached to the system through wires that are coiled inversely on the same reel's left and right parts where one wire is connected to the counterweight and the other on the mirrors' connection point. The step motors holding the reels were placed on both ends. However, the reel did not fit in width and coil correctly to be able to function. Therefore, the prototype was repurposed for one-way motion so that the experience and the other components could be evaluated.

A stepper motor with a reel was screwed on 3 layers of plywood and metal bars were placed over the plywood for weight. It was placed exactly at the centre and attached to the middle centre between the convex mirrors. The issues were addressed in a newer version, which is in the section of the final Hi-Fi prototype.

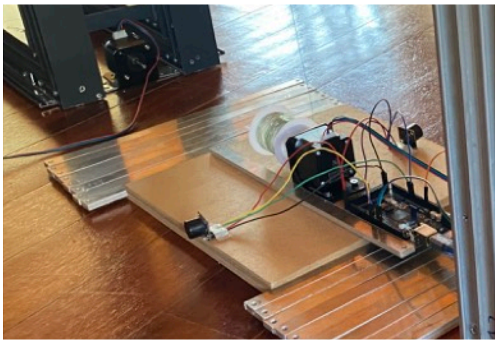


Figure 32: *Showing the initial placement of the left stepper motor under the left leg and the repurposed placement of the right stepper motor placed in the centre*

6.2.3 Initial Hi-Fi Prototype

The integration process led to an initial Hi-Fi product prototype that was constructed to fulfil the requirements set up in the design process. The final software is available in Appendix H.

Figure 33: *The prototype with the parts integrated*

6.2.3.A Conclusions on the Initial Hi-Fi Prototype

The initial Hi-Fi prototype, through evaluation, has shown effectiveness in terms of the delivery of the designed experience; however, has not functioned correctly in terms of the mirror movements. The linear motion of the mirror motion system needs to be redesigned for executing bi-directional movement, which is crucial for the independent repeatability of the experience. Additionally, the design would benefit from a larger mirror, which would aid in providing a larger space and field of view for the experience.

6.3 Concluding Hi-Fi Prototype

The integration process concluded with a final Hi-Fi prototype that was developed to tackle the limitations of the initial Hi-Fi prototype and improve the addressing of the requirements. Therefore, the prototype frame was scaled up to 120 cm in width and the mirror frames were scaled up to 130 cm in width and 100 cm in height.

Figure 34: *The final Hi-Fi prototype with the improved functionality and design aspects*

6.3.1 Sensing of the Final Hi-Fi Prototype

The sensing of the final Hi-Fi prototype was largely identical to the initial Hi-Fi prototype. The sensing was improved in reliability through utilising an external power source of 5V and 1A specifications for the powering of the sensors, instead of the microcontroller itself.

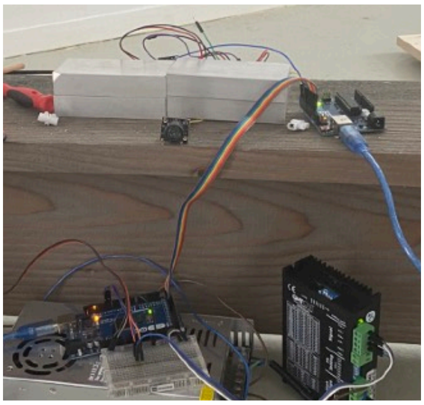


Figure 35: *The sensing improved in reliability*

6.3.2 Construction of the Final Hi-Fi Prototype

The construction of the Final Hi-Fi prototype had been altered to a wooden construction in order to overcome the functional issues of the initial Hi-Fi prototype by allowing more freedom of manipulation and boundary explorations in terms of placements and relative locations between the ingredients of construction. It was altered to a wider size and all sides of the construction was unified for more stability and working space.

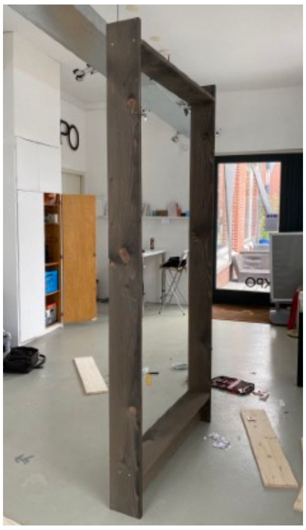


Figure 36: *The construction of the frame with unified structure*

The mirror motion system was adjusted to the larger mass of 2.5 kg of the larger mirror frame and additional pulleys were added internally to redistribute the directional force between the mirror frame and the counterweights.

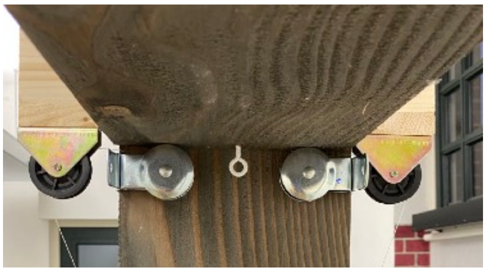


Figure 37: *Additional internal pulleys (in silver) for force distribution*

6.3.3 Dynamic Mechanics of the Final Hi-Fi Prototype

The dynamic mechanics the final Hi-Fi prototype holds the identical design of the initial Hi-Fi prototype, with corrected linear motion through separating the counterweight mirror connections from the linear motion provided by the stepper motors. These were attached together through a coupling of steel wire connectors. The coilings into the relays were aligned through the use of 2 10mm eye screws on each side with smooth glazing for low friction. Both sides were made identical with the same tension on the wires. The relay releases coiled wire on one side, while the other side collects the wire being released from the opposite side through opposite coiling. The top and bottom eye screws centred on both edges limit the motion to a strictly linear motion on the Y axis.

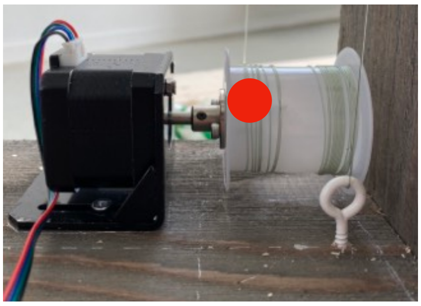


Figure 38: *The stepper motor coupled to a relay with eye screw centred for linear motion and red circle over the secondary eye screw collecting and releasing to the position*

Chapter 7: Evaluation

This chapter evaluates the prototype that was formed through the Creative Technology Design Process in order to determine the extent at which the requirements of the project have been addressed. The evaluation process is divided into experience requirements evaluation and functional requirements evaluation. Each requirement of each aspect has been addressed individually.

7.1 Experience Evaluation

The experience evaluation drew conclusions through considering the resulting experience the prototype produces with participants. This has been analysed and concluded through user testing. Then, an evaluation was made of each experience requirement.

7.1.1 User Testing for Experience

The user testing was done to test the resulting experience of the prototype and evaluate the effects it produces in the participants. The user testing was evaluated through the specified five phases of the experience: introduction, engagement, surprise, reaction, and reflection. This testing was done utilising the initial Hi-Fi prototype.

The user testing was done with two participants: participant A and participant B. Participant A is a 58 year old female and participant B is a 60 year old male. The participants were asked to enter the room and proceed as if in a gallery/cultural institution setting.

The participants were not told the purpose of the installation or given pre-knowledge related to the experience. This was done to avoid influence and to find the meaning creating potential of the installation and to evaluate if the meaning extracted by participants relates to the intention of the installation.

Due to the non-verbal nature of the experience and the interaction between the participants, evaluations of the outcome of the experience were done through video recording. The participants then were asked to recount their experience and then asked what meaning they made from the experience. The video recording leads to the identification of the surprise and reaction phases. The recounting has informed the evaluation of the introduction and engagement phases with the question informing the evaluation of the reflection phase.

7.1.1.A Results of the User Testing

The results of the user testing have been processed through the five phases of the experience: introduction, engagement, surprise, reaction, and reflection based on the collected data.

7.1.1.A.1 Introduction Phase

In the introduction phase, the participants immediately went to the installation.

7.1.1.A.2 Engagement Phase

The participants were on the same spot and placed themselves at around a meter, which was in line with the design intent. The recounting of the experience revealed complex and independent experiences during the engagement phase.

Participant A recounted that she was observing the change of the size of her body based on how she looked at the convex mirrors and judging her body image. Participant B recounted that he was observing and criticising the details of his facial features due to the zooming of the reflected image at the centre.

7.1.1.A.3 Surprise Phase

The participants both had the surprise experience, it was a common experience that they had simultaneously. The recounting of the engagement phase reveals that participants were invested and focused on the reflections and went in the surprise phase at the right viewership open to the image of the other participant. The video analysis show that the dropping of the mirror frame happened quick enough to be surprised by the other participant as opposed to following the mirror go down first.

7.1.1.A.4 Reaction Phase

Following the surprise phase, the participants entered the reaction phase in a deeply engaged manner. The phase started with both participants smiling, then participant A started the non-verbal interaction by bringing her hands to her chest in a praying motion. Participant B mirrored this action, and then built on the emotional and physical communication by opening their hands wide in a hugging motion and hugged himself. This was also mirrored by participant A, then the emotional reciprocity was advanced by participant A who brought hands through the frame for fist bumping that participant B mirrored as well. The phase took 13 seconds.

Figure 39 and 40: *The emotional communication initiated by participant A that were mirrored and reciprocated*

***Figure 41 and 42:** The emotional communication initiated by participant B that were mirrored and reciprocated.*

7.1.1.A.5 Reflection Phase

The reflection phase showed independent meaning-making that is unique to the participant. Participant A reflected on her experience with the warping of the reflection where she noticed she could make herself wider and narrower, and made a positive self-reflection about not being affected by body image issues. She noted emotional experience as a moving one without philosophical or cognitive explanations and identified it as happiness and joy.

Participant B noted that he had a systematic approach and tried to identify the meaning of the installation at first. He said he experienced two realities at once. He contemplated on the "artificial barrier" and the living image dynamics and paralleled it to the experience of video meetings during the pandemic and mentioned being reminded of the energy of face-to-face interactions.

7.1.2 Evaluation of the Experience Requirements

1. **The design should be enticing, participants should feel inspired to interact with the installation.**

The participants directly gravitated towards the installation; however, the setting was relatively small compared to a gallery or a cultural institution setting. The mirrors' reflectivity and shape were confirmed as apt and enticing for the purposes of this project by the design expert Dr. Wouter Eggink of the University of Twente.

2. **The experience must engage the participant in a strong manner.**

The participants noted profound and complex cognitive and emotional processes during their engagement and participated in the interpersonal interaction in an elevated manner. This was also evident in the complexity and uniqueness of reflections made on the experience.

3. **The experience must engender a sense of connection between participants.**

The participants were mirroring each other and displaying emotional reciprocity through mirroring and responding to the emotional mannerisms of each other and building a non-verbal dialogue. The common experience and deep engagement in the communication are strong factors of a sense of togetherness.

4. The experience should lead participants to form a critical reflection.

Due to the cultural context of the project, provoking a reflection is important for the value of the installation. The participants formed unique and independent critical reflections that serve each individual. One participant also noted the parallelism of the Covid-19 pandemic.

7.2 Functional Evaluation

The functional evaluation was addressed through various components of the installation, such as the construction, motion and system behaviour among others. An evaluation was made of each functional requirement.

7.2.1 Functional Testing

The functional testing was executed in order to evaluate the quality of the mechanics and the delivery of the experience. The functional testing was done through in depth testings of the sensors and the motion. The functional testing was carried out on the final Hi-Fi prototype.

The sensing set-up was tested through documenting the collected data though serial communication and identifying any outliers. The data from each sensor was collected simultaneously, but labelled separately with each collecting data at a fixed position. The data collection was done over 15 minutes with 3 separate trials.

The motion set-up was tested through repeating the lowering and lifting motions 15 times in a row. The test was repeated over two days with 3 occurrences per day. The motions were observed perpendicularly with the locations over time were checked for shifting.

7.2.1.A Results of the Functional Testing

7.1.1.A.1 Sensing

The sensor data was reliable in all trials, no incorrect data or noise was observed outside of ± 1 cm. The data were identified and processed correctly and accurately.

7.1.1.A.2 Motion

The largest observed linear shifting of the frames was approx. 2 cm which is in a 2% boundary of error, and 2° angularly calculated through trigonometry with the mirror frame size. The final locations of the frames were accurate linearly and angularly, shifting only occurred during motion and self-corrected by landing. The frames did not oscillate.

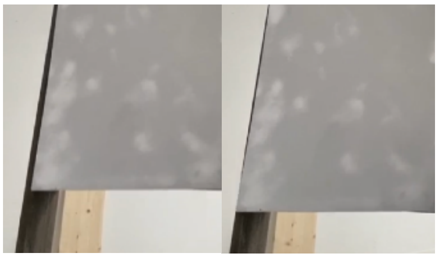


Figure 43: *Left, the 2 cm shifting mid-travel, exposing the frame and right, self-corrected upon landing*

7.2.2 Functional Requirements

1. The design should be easily transportable and changed.

The construction was built with connection points being fastened with screws that can be removed and placed back, with sturdy joinings that connect pieces at correct angles. All pieces were expected to be under 1 m height, however, this was abandoned for the benefit of mechanical functionality. It is possible for the design to be manipulated and changed through the course through treating the wood with various equipment. Despite the 2.5 m height, all pieces of the construction can be carried in a large car or any van-type vehicle in an efficient manner.

2. The mirrors should deliver the experience at the required speed and position.

The mirrors' movement is reliable and moves to the correct location at the correct speed by the pulling force from the stepper motor. The prototype functions in both directions, within a 2% boundary of error linearly, and 2° angularly therefore, this requirement is fulfilled satisfactorily; however, would benefit from improvements.

3. The construction should be sturdy and deliver the experience reliably.

The construction is strong and sturdy, it was resistant to jerking or shaking by hand. With the motor facilitated movements, the pulleys and the dynamic mechanics function reliably. The wiring of the counterweight and mirror structure did not break down; even with multiple days.

4. The design should be for at least 2 people and can be expandable to 8 people, where participants face each other.

The prototype has been made for 2 participants and participants face each other throughout the experience. However, the concept of the design does not directly allow for an expansion to 8 people in a way that provides a simultaneous common experience. The concept allows for multiple products to be placed in the same setting.

5. The design should have participants standing between 1.5 to 3.7 meters apart.

The participants stand about 2 meters away from each other.

Chapter 8: Conclusion

Research questions were formed in the tackling of the project problem that engendered this project. The conclusion chapter elaborates on the extent of the answering of the research questions that were set up in this project. This chapter also encapsulates the context and suggestions provided for future work.

8.1 Conclusion of the Research

The development of this research was in the context of the adverse effects of the Covid-19 pandemic on social connection and a sense of togetherness, with the goal of researching and identifying through what intervention this societal issue can be ameliorated in individuals. The project was made for a cultural public setting, and was made in the form of an interactive installation. The installation was made with Martina Raponi of Noiserr as a client, who has subjects like togetherness and gathering in her interest of research and wants to have it featured in an arts venue.

The research was built upon the Creative Technology Design Process and after problem analysis and background research, went through an ideation phase identifying potential ways to address the research with a product idea. This phase explored methods of interaction and technology that facilitate it, comparing it with experience design possibilities to come up with a product idea that is an effective solution. Requirements for experience and functionality were determined through the product idea, which then entered a process of specification.

The specification process delved into the details of experience and functionality and delivered an experience and functionality specification that address the requirements, leading to the realisation of the product prototype. The product prototype has delivered the experience that was evaluated through user testing. The two way motion of the installation was not successful at first but an effective solution was realised with a new Hi-Fi prototype. The functional evaluation for the part of the dynamic mechanics system was redone with a successful outcome. The evaluation of the outcome of the experience of the installation was done through a limited sized user testing that concluded with deeming the solution effective and with potential.

8.2 Research Questions

The requirements derived from the research questions have been answered through the Creative Technology Design Process and an effective solution was formed. The research questions that were determined in the research were as answered as the following:

-How can a design that evokes social togetherness by a shared experience be set up?

The process of answering this question is initiated in the wider context of interactive installations, therefore the requirements of being enticing and engaging introduce themselves. The enticement factor is a facilitator of engagement and renders viewers to become participants. Having aesthetic quality, being curiosity evoking or mysterious are effective methods of achieving this. The design of the installation was therefore made with the rules of the state of the art on installations. The minimal open and curiosity evoking design with reflections answered this.

The engaging quality of the installation, building on enticement, allows for a better delivery of the experience and the effect if there is a deep engagement. The convex mirrors facilitated this through the use of the self-image of the participant and optical effects created on it. A shared experience is a way of evoking social togetherness, as an interactive installation experience can reactivate emotions and generate camaraderie between participants though creating intimacy. Possibilities of setting up this experience have been presented in the ideation process. The project identified having a collective experience facilitated by an installation as the most apt set up, and created this experience through a joint experience of surprise.

-What characteristics of an interactive installation can provide a sense of togetherness?

The requirement of having participants facing each other answers conditions of creating intimacy, as through this mirroring can occur between participants and a connection can be formed that can get more intimate through emotional reciprocity where participants respond to each others' emotional expressions. This connection can be facilitated by creating a visible emotional reaction in participants that can start the mirroring and emotional reciprocity process. In the project this was done through demanding a reaction by creating a surprising moment. In the context of this project, this is thought to be more pronounced and effective if the installation can demand self involvement and deep engagement. Also, offering mental space for the processing after the experience could bolster the quality and can deepen the meaning making and elevate the general reflection process for a more meaningful effect of the togetherness that was experienced.

8.3 Future Work

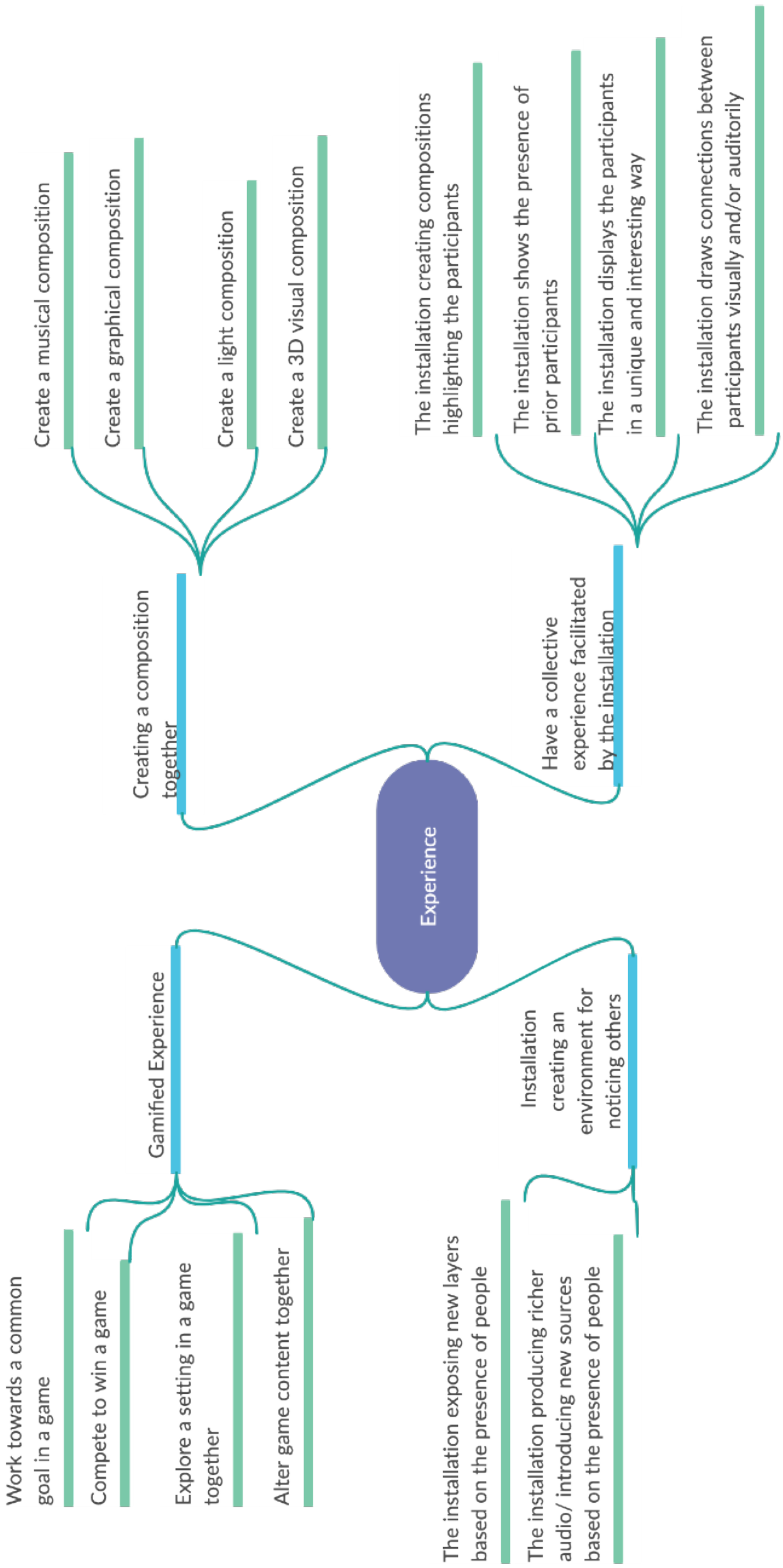
The research questions have been answered effectively; however, the project calls for future work in terms of further research and product improvements for the development of the final products. For the research, further understanding into ways emotional reciprocity can be produced to be implemented into methods of interaction. The experience of this project needs to be researched further through user testings done with a wider demographic of participants. Especially, the effects of the experience on people with different levels of relationships from not knowing at all to being very close is lucrative for generating knowledge and bringing insights. Moving towards a final product, the movement of the installation needs to be innovated upon and a more functional and efficient mirror frame should be designed. Then the system should be further function tested and be confirmed for further extended use.

Appendix A: Sub-Questions

People-People Interaction/Togetherness/Collectivity	Interaction	Individual Psychology
What characteristics of an interactive art piece can provide a sense of togetherness?	What qualities must be present for an interactive installation to engender new forms of interactions between people?	What aspects of an interactive installation induce what psychosocial changes/effects on the individual?
What qualities must be present for an interactive installation to engender new forms of interactions between people?	What interaction between people and the interactive art piece is necessary to facilitate interpersonal interaction?	What psychosocial changes does an interactive art installation produce on the individual?
How does collective behavior influence interaction with an interactive installation?	How do the first people interacting with the interactive art piece affect the bystanders?	How does the play characteristic of interactive art affect the dynamics of a participant behaviorally?
How does interactive art change interpersonal behavior?	How does mirroring effects affect interaction between people and the interactive piece? How does mirroring effects affect empathy between people? (Not very clear but personally meaningful)	How does interactive art affect people? (Blank in people?)
How does play induce interaction between people making use of my installation?	What effect does beauty have on openness for interaction with an interactive art piece?	What demographics possess the most openness to interpersonal experience?
What characteristics should be present in an interactive art piece in order to facilitate connection?	What does the failure of the interactive art piece to provoke intrapeople interaction communicate/inform?	How does the speed of motile objects affect people? What speed boundaries limit anxiety?
How can a setup be designed so that it creates shared experiences?		

	Atmosphere	Social Psychology
How does the impact of situatedness inform design choices of an interactive art piece? (Question is informed by the answers of other questions)	What atmoshperic qualities augment the necessary qualities for social comfort and lead to openness to experience?	What aspects of an interactive art piece can draw people closer?
How does a perspective of situatedness inform constraints on an individuals behavior, as opposed to internal reasoning?	What audiovisual input promote provoke interaction with interactive art?	How does co-interaction with an interactive art installation affect people to people interaction?
How does the perception of others' perspectives and behaviours affect intrapeople interactions?	What is the effect of musicality (defined as rhythmic, tuned signals) on willingness of interaction with interactive art?/What is the effect of musicality (rhythmic, tuned signal) on willingness of interaction with others?	How does the play characteristic of interactive art affect participants /social dynamics of participants?
What initial outcomes of the experience are necessary for a positive reflexivity? (therefore lead to positive change of taken for granted assumptions?)	What effects does seeing one's reflection have on an individual?	What characteristics of an interactive art piece can improve social dynamics of participants?
How do multiple perspectives on the individuals' experience during interaction inform the effectiveness of the purpose of the interactive installation?	How do darkness and lightness affect an individual's willingness to interact with an interactive art piece? How do darkness and lightness affect an individuals willingness to interact with others?	How can an interactive installation be transformed into a collective interaction, opposed to cohabitation (and individual experience)?
		What is the distance between people necessary to provide comfortable interactions between people?

Appendix B: Mind-Map



Appendix C: The Arduino Code

```
#include <AccelStepper.h>
#define dirPin 6
#define stepPin 7
#define motorInterfaceType 1 //means driver

bool timerStartedForSurpriseStopping = false;

bool timerStartedForSurpriseStopping2 = false;

bool timerStartedForSurprise = false;
bool timerStartedForSurprise2 = false;

bool thisUserInCriticalTime =false;
bool acrossUserInCriticalTime = false; //change in working

bool acrossUserInSurpriseInteractionRange = false;
bool isInInteractionRange = false;
bool isInSurpriseInteractionRange = false;
bool isInInteractionRange2 = false;
bool isInSurpriseInteractionRange2 = false;

int stepLoc = 0;
int mustBeLoc;
int stepperMovementCoeff;

int speedMax = 20000;

int accelAmount = 200;
int microStep = 4;
float rotationDistance;

float radius= 1.5;
int oneRotation;
float cmToStepsCoeff;

int positionAtNonInteractionPin;

int positionAtInteractionPin;

int positionAtAfterSurprisePin;

AccelStepper stepper = AccelStepper(motorInterfaceType, stepPin, dirPin);

void setup() {

pinMode(pulsePin, INPUT); pinMode(pulsePin2, INPUT); pinMode(nonInteractionPin, INPUT);
pinMode(interactionRangePin, INPUT); pinMode(surpriseRangePin, INPUT);
pinMode(switchForMinHeight, INPUT); pinMode(switchForMaxHeight, INPUT);

// pinMode(positionAtNonInteractionPin, OUTPUT); // pinMode(positionAtInteractionPin,
OUTPUT); // pinMode(positionAtAfterSurprisePin, OUTPUT);

//Serial.begin(9600); delay(3000);

const int pulsePin = 2;
```

```
const int pulsePin2 = 3;

long sensor;

long distance;

long sensor2;

int distance2;

int userDistance = 0;

int userDistance2 = 0;

int switchForMinHeight = 40;

int switchForMaxHeight = 42;

int nonInteractionPin = 22;

int interactionRangePin = 24;

int surpriseRangePin = 26;

int nonInteractionPin2 = 30;

int interactionRangePin2 = 32;

int surpriseRangePin2 = 34;

int interactionBoundary = 200;
int surpriseBoundary = 100;

int interactionHeight = 160;

int nonInteractionHeight = 100;

unsigned long currentTimeForSurprise;
unsigned long previousTimeForSurprise = 0;
unsigned long currentTimeForSurpriseForStopping;

unsigned long previousTimeForSurpriseForStopping = 0;

unsigned long currentTimeForSurprise2;
unsigned long previousTimeForSurprise2 = 0;
unsigned long currentTimeForSurpriseForStopping2; unsigned long
previousTimeForSurpriseForStopping2 = 0;

unsigned long currentTimeForInteractionStopping; unsigned long
previousTimeForInteractionStopping = 0;

int timeForSurprise = 6000;
int timeForSurpriseStopping = 2000;

 int timeForInteractionStopping = 2000;

bool timerStartedForInteractionStopping = false;
```

```
stepper.setMaxSpeed(10000);

stepper.setAcceleration(3000);

rotationDistance = 2*3.1415*radius;

 oneRotation = 200*microStep;
cmToStepsCoeff = oneRotation/rotationDistance;

mustBeLoc = nonInteractionHeight*cmToStepsCoeff;

{
isInInteractionRange = false; isInSurpriseInteractionRange = false;

}

else if (userDistance <= interactionBoundary && userDistance > surpriseBoundary)
{

isInInteractionRange = true;

isInSurpriseInteractionRange = false; }

else if (userDistance <= surpriseBoundary) {

isInInteractionRange = true; isInSurpriseInteractionRange = true;

digitalWrite(positionAtNonInteractionPin, HIGH);

digitalWrite(positionAtInteractionPin, LOW);
digitalWrite(positionAtAfterSurprisePin, LOW);
timerStartedForInteractionStopping == false;
timerStartedForSurpriseStopping == false;
timerStartedForSurprise == false; }}

void loop() {

sensor = pulseIn(pulsePin, HIGH);

distance= sensor/10;
// Prints the distance on the Serial Monitor

//Serial.print("Distance: ");

//Serial.println(distance);

userDistance = distance;

//Serial.println(userDistance);

//delay(50); //creates a 1 second change gap

//do second distance sensor

sensor2 = pulseIn(pulsePin2, HIGH);
```

```
// Calculating the distance
distance2 = sensor2/10;
// Prints the distance on the Serial Monitor

//Serial.print("Distance: ");

//Serial.println(distance2);

userDistance2 = distance2;

//Serial.println(userDistance2);

 //delay(50); //creates a 1 second change gap

if (userDistance > interactionBoundary)

if (userDistance2 > interactionBoundary) {

isInInteractionRange2 = false; isInSurpriseInteractionRange2 = false;

}
else if (userDistance2 <= interactionBoundary && userDistance2 > surpriseBoundary)
{

isInInteractionRange2 = true;

isInSurpriseInteractionRange2 = false; }

else if (userDistance2 <= surpriseBoundary) {

isInInteractionRange2 = true; isInSurpriseInteractionRange2 = true;

}

if ((isInInteractionRange == true || isInInteractionRange2 == true) &&
thisUserInCriticalTime == false){

timerStartedForInteractionStopping = false; mustBeLoc =
interactionHeight*cmToStepsCoeff; stepper.setMaxSpeed(10000);
stepper.setAcceleration(3000);

}
else if (isInInteractionRange == false && isInInteractionRange2 == false){ //if outside
interaction boundary

// wait for 3 seconds

currentTimeForInteractionStopping = millis();

if(timerStartedForInteractionStopping == false && currentTimeForInteractionStopping -
previousTimeForInteractionStopping >= timeForInteractionStopping){ //if within 2 seconds
user has not returned

timerStartedForInteractionStopping = true; previousTimeForInteractionStopping =
currentTimeForInteractionStopping; }

if(timerStartedForInteractionStopping == true && currentTimeForInteractionStopping -
previousTimeForInteractionStopping >= timeForInteractionStopping){ //if within 2 seconds
user has not returned move to 140 non interaction
```

```
previousTimeForInteractionStopping = currentTimeForInteractionStopping; //reset timer
for interaction ending, as it has ended

mustBeLoc = nonInteractionHeight*cmToStepsCoeff;

timerStartedForInteractionStopping = false; stepper.setMaxSpeed(2000);//
(speedMax*microStep); stepper.setAcceleration(150);

//  digitalWrite(positionAtNonInteractionPin, HIGH);
//  digitalWrite(positionAtInteractionPin, LOW);
//  digitalWrite(positionAtAfterSurprisePin, LOW);

previousTimeForSurpriseForStopping = currentTimeForSurpriseForStopping;
timerStartedForSurpriseStopping = false;
thisUserInCriticalTime = false;
timerStartedForSurprise = false; //stayed out for 2 seconds go out

} }

//B for Surprise
if (isInSurpriseInteractionRange2 == true)
{ //check if in surpriseRange, if not wait 2 seconds and then check again if still not
turn off boolean in range

timerStartedForSurpriseStopping2 = false; }

else if (isInSurpriseInteractionRange2 == false) //if outside of the surprise Boundary
wait 2 seconds to complete and stop the surprise preparation {

currentTimeForSurpriseForStopping2 = millis();

if(timerStartedForSurpriseStopping2 == false && currentTimeForSurpriseForStopping2 -
previousTimeForSurpriseForStopping2 >= timeForSurpriseStopping){

}

}

}

timerStartedForSurpriseStopping2 = true; previousTimeForSurpriseForStopping2 =
currentTimeForSurpriseForStopping2;

//A for Surprise
if (isInSurpriseInteractionRange == true)
{ //check if in surpriseRange, if not wait 2 seconds and then check again if still not
turn off boolean in range

timerStartedForSurpriseStopping = false; }

else if (isInSurpriseInteractionRange == false)
Boundary wait 2 seconds to complete and stop the surprise preparation {

currentTimeForSurpriseForStopping = millis();

if(timerStartedForSurpriseStopping == false && currentTimeForSurpriseForStopping -
previousTimeForSurpriseForStopping >= timeForSurpriseStopping){

timerStartedForSurpriseStopping = true;
```

```
previousTimeForSurpriseForStopping = currentTimeForSurpriseForStopping; }

if(timerStartedForSurpriseStopping == true && currentTimeForSurpriseForStopping -
previousTimeForSurpriseForStopping >= timeForSurpriseStopping){

if(timerStartedForSurpriseStopping2 == true && currentTimeForSurpriseForStopping2 -
previousTimeForSurpriseForStopping2 >= timeForSurpriseStopping){

previousTimeForSurpriseForStopping2 = currentTimeForSurpriseForStopping2;
timerStartedForSurpriseStopping2 = false;
acrossUserInCriticalTime = false;
timerStartedForSurprise2 = false; //stayed out for 2 seconds go out

}

 }

//at the end of this, if the user is in surprise range then in range is true, then if
they are out of it and 2 seconds passed, in surpirse range is false

//CRITICAL RANGE TIME CHECK A
if (isInSurpriseInteractionRange == true){ //YES USER CHECK TIME

currentTimeForSurprise = millis();
if(timerStartedForSurprise == false && currentTimeForSurprise - previousTimeForSurprise
>= timeForSurprise){ //if 3 seconds passed

timerStartedForSurprise = true;

previousTimeForSurprise = currentTimeForSurprise; }

//if outside of the surprise

if(timerStartedForSurprise == true && currentTimeForSurprise - previousTimeForSurprise
>= timeForSurprise) {

thisUserInCriticalTime = true;

}

}

//CRITICAL RANGE TIME CHECK B
if (isInSurpriseInteractionRange2 == true){ //YES USER CHECK TIME

currentTimeForSurprise2 = millis();
if(timerStartedForSurprise2 == false && currentTimeForSurprise2 -
previousTimeForSurprise2 >= timeForSurprise){ //if 3 seconds passed

timerStartedForSurprise2 = true;

previousTimeForSurprise2 = currentTimeForSurprise2; }

if(timerStartedForSurprise2 == true && currentTimeForSurprise2 -
previousTimeForSurprise2 >= timeForSurprise) {

acrossUserInCriticalTime = true; }
```

```
}
// at the end of this, if user is still in range or havent been completely out in 2
seconds, and 3 seconds in total has passed while in the surprise range //the user is in
critical time is turned on

if (thisUserInCriticalTime == true && acrossUserInCriticalTime == true){ // CHECK IF
ACCROSS USER ALSO

stepper.setMaxSpeed(10000);//(speedMax*microStep); stepper.setAcceleration(3000);
mustBeLoc = 0;
//SURPRISE occurred

} stepper.moveTo(mustBeLoc); stepper.run();

//potentially can have limitswitch adjustments if (digitalRead(switchForMinHeight) == 0)
{ stepper.setCurrentPosition(0);

}

if (digitalRead(switchForMaxHeight) == 0)
{ stepper.setCurrentPosition(interactionHeight);

}

}
```

Appendix D: Consent Form

Consent Form

Statement by the Researcher

I **M. Can Erel**, declare that I have provided ample information about the research and the nature of the project to the participant on this Graduation Project. I have prompted the participant to request further information and ask questions and responded to these requests of information fully. I recognised that the participant was capable of fully understanding the information provided and acts at free will.

Date:

Signature:

Statement by the Participant

I (Initials)……………………………………………………….., declare that I have understood the nature of the research and my participation in it. I declare that I have been informed clearly and amply about the research process and my role in it. I have asked all questions I had and received all information that I have requested. I voluntarily agree that the data received through me in my participation in this research can be used by the researcher whose name mentioned above. **I am aware that I can withdraw my consent at any time without having to give any reasons.** I allow the research results to be published without disclosing my name and giving details that reveal my personal identity. **I give consent** to the use and processing of my speech, recordings and writing relating to the research process.

Notes:

Date:

Signature:

Appendix E: Reflection Report

1. Description of the Project and Vision Statement

The project is an interactive art installation, where technology and design are utilised to create a set up that creates the most impact on the sense of social togetherness. It works by having participants interacting together, where elements are providing means for the participants to notice each other and have an intimate moment and experience camaraderie. This is in response to the severed sense of togetherness due to the *Covid-19* experience and its impact on individuals and the society. This solution is important because interactive installations have the ability to provoke audience engagement, and can lead to a sense of togetherness through play experience and camaraderie. It is non invasive, inclusive and culturally impactful solution.

The project creates a space for recognizing the beauty and excitement of forming connections, at a moment of heightened isolation. This moment is generated by concave mirrors that present a high definition and detail image of the self while leaving the surroundings distorted and blurry. The only subject one can look at is the self; looking anywhere else in the mirror comes at the expense of eye pain due to the eyes' inability to focus. When two participants across each other have been looking at their own reflection for a period of time, the mirrors in front of them drop, and they are left with the image of each other instead.

2. Engaging the Design through Moral Values and Ethical Decision Making

2.1 Moral principles

A main moral principle at the centre of my project is **distributive justice**. In my project I have fairness and equality as a central figure to the design of the product's experience. This moral principle can be defined as a fair and equal "distribution of benefits and burdens". Fairness is concerned with each individual receiving what they are due, in this scope I deal with what one is due as their human rights. This distributive justice can also be concerned with need, where it is morally important for individuals who are in a less preferable position to get more benefits [22]. This moral principle is important for my project because it deals with wellbeing and since my work is addressed to public and public interactions, it is important to create fairness and equality.

This has influenced my design in that I have made decisions in the interaction methods that allows for the largest demographic possible to make use of the benefits of my product. I have made the interaction slower, more understandable and accommodating in its technology as well as found the most inclusive venue I could afford to find.

Beneficence and non-maleficence are also at the centre of my project. According to Jahn, **beneficence** is "a moral obligation to act for the benefit of others". The execution must benefit people and weigh the benefits and harm. This includes preventive measures against the risk of harm. He also states that **non-maleficence** " is an obligation not to inflict harm on others". The application of this principle should result in no pain or distress to people [23]. In my work, I address social issues and, in the case of my Graduation Project, I am addressing the severed sense of togetherness in the Covid-19 climate.

Since this the project is addressing an issue affecting individuals and communities by offering well-being for the end users the moral principles of non-maleficence and beneficence are important for my project. These principles have influenced my design by focusing on the effect and functionality of the design and keeping that as more important than the designer's values and wishes. It made

made choose design choices based on function as opposed to aesthetics of the design or impressiveness of the technology being used.

Another central moral principle of my project is the **principle of utility**. The principle of utility states that actions should bring the most amount of benefits and the least amount of harm. "Equal amounts of happiness are equally desirable", no matter experienced by whom. Therefore, actions are right to the degree of happiness they create, and wrong to the degree of harm they bring [24]. As the project is relative to the number of people who experience it, it is important to consider the collective beneficial output the project creates. It is a factor that guides decision making in interaction decisions, and the principle has guided the design to be most impactful to the most amount of people in general as opposed to targeting limited amounts of people very high benefits.

2.2 Key Ethical Dilemmas

2.2.1 Safety and Utility

A. Moral problem statement

Should I allocate resources to safety improvements in line with non-maleficence or to increasing public utility by adding more features that increase the functionality?

B. Problem analysis

Relevant stakeholders is the client, the venue and the participants.

In final products, especially for constructed and technological ones, prices go up substantially based on material and device choices. For example, the motor type that I use can vary from price x to price 10x. Using many motors, this price multiples. Additionally, building structures, the material price for construction with plastic vs metal causes a significant price difference. Using cheaper parts would allow me to create improved functionality and stability, such that I can use stronger and more motors and/or add more detailed mechanical pieces that would create more reliable interaction where it is less likely for the interaction to fail.

Cheaper construction is still tested to be reliable and products are in line with the standards, the chances of potential unsafe results such as a short circuit and objects hitting the viewer are even though extremely rare, to a degree, higher. Both options are legal and according to standards; however, there is still differences between safety and how well the product works.

The interests of the stakeholders of the venue, participants and the client agree with each other. For the venue and the client, a well performing product that provides the best experience or the best public utility is valuable. This will boost their success and image. For the participants, also their positive experience maximised is the most valuable, this will increase their sense of wellbeing and honour their time investment. Safety of the product is very important as well, any risk to a participant is not only a physical risk but also a risk to the integrity of the venue and the client.

C. Options for actions

The options for actions is a distribution of material and design choices toward either safety or public utility through better functionality that leads to increased well-being. The choices are on, electronic parts, construction materials and mechanical devices. Opting for complete safety is chasing the strongest construction materials, high quality production electronics, and simple and reliable mechanics. Opting for boosting the functionality would be to use cheap construction materials, cheaper built but more functionally advanced electronics and more intricate mechanical systems.

D. Ethical judgement

From the perspective of utilitarian ethics, delivering an output that results in a more reliable interaction secures the long term positive impact of the output on people. Compared to this, the safety risk is very minimal to begin with. However, from a deontological consideration, applying universality, one would conclude that risk of safety should come first in all engineering/design choices. If a plane would be more functional and widely available at the exchange of a very minute risk of safety, nobody would agree with it. It would also break respect in the deontological sense, as the viewers then would be treated as a 'means to an end'.

My duty as a professional in the engineering field is to consider safety first, and to opt for functionality to achieve public utility and technological advancement means that I am leaving behind maximum safety to achieve something else, as looking solely at the decision of choosing safety or not, I would readily opt for maximum safety. Then, my choice to allocate the resources to increased functionality and public utility is a means to an end and undutiful [23]. Through an informal ethical framework, intuitively, I would argue that opting for the public utility option is the ethically more correct choice.

One reason for this is that the technology is trying to be a disruptive novel product for people, and as one of the earlier ones in this field, maximising the functionality and effect of the product is going to allow new technology makers to be inspired, and learn from it. Safety concerns are something to be collectively dealt with in this field, and any point of failure, given does not cause irreparable damage, is a learning point for further investigation. Additionally, looking at the works of others in this field shows that not going below the certain general safety standards is sufficient, as there has not been a well known case of harm produced due to lack of safety.

E. Reflection

The moral acceptable decision making is eventually at a need of a reflective equilibrium of the following beliefs. Allocating resources to functionality is the best (belief a). Looking at public utility, this will provide the most wellbeing to the stakeholders of the designer, client, venue, and the participating public (belief b) and be the best according to utilitarian ethics (belief c). Safety should be maximised, non-maleficence must be upheld (belief d). According to duty, safety should be maximised without considering the consequences this is the most dutiful choice in line with deontological ethics (belief e). The beliefs a, b, c, d and e are incoherent.

Considering public utility and deciding for better functionality, inarguably makes me have a better product and be more successful in my work, it allows the client and the venue to be better off, having a stronger experience felt by viewers and increasing the stakeholders' value. It leads to participants have a more increased sense of wellbeing. However, it might be that the version where safety is maximized, also achieves such an effect similarly, as experience and perception are subjective and it is virtually impossible to determine it beforehand. It could be that a feature added could have a very strong effect, strongly bolstering public utility by providing a transformative experience that was not expected or undermined. It has been discussed that looking at choices at hand without consequences, isolating safety choices, that one would choose maximum levels of safety, and it is undutiful to act as a means to an end.

However, looking at safety decisions *sans* consequences, choosing safety features that fulfil international safety standards, local professional standards and the successful industry choices also is dutiful. It can, therefore, be argued that safety standards are set-up professionally and has been generated dutifully. In this marrying the beneficence term of how much safety can I afford to add? Is a helpful formulation. Taking it to an extreme, should we not put out inventions to production and to public without researching and building new technologies and systems of safety, where does it end, how many years and how much money would be 'enough' for such a condition? It is in this sense sensible to add limitations to the deontological argument, limited by exhaustible resources of reality.

With this statement, it is sensible to give up the belief e, and consider safety choices and regulations holding up a minimal standard does not provoke maleficence. Reconsider belief d, and consider acting in line with the international and local safety set-up by professionals and law makers as a collective is a morally valid choice and still in line with non-maleficence. Overall, solving the incoherence, I conclude that deciding on functionality for maximum public utility is the morally strongest decision.

2.2.2 Accessibility and Utility

A. Moral problem statement

Should I spend my time and resources on making the product more fair by making it more accessible and create distributive justice, or provide greater public utility by spending them on creating better functioning and effectiveness for the dominant population?

B. Problem analysis

With the latest version of the project, the interaction is functional for people within the dominant general height, anyone who is out of the approximate 150-195cm height is not going to be able to make use of the functionality effectively, even though it will work it will not create the necessary experience to create wellbeing. The accessibility concern in this context is for people who are outside of this height boundary which can be due to developmental issues or disabilities that renders a person unable to stand. In terms of viewerships, museums and galleries are becoming increasingly more accessible for people with disabilities. As Argyropoulos et al. [26] notes, "access to culture has been recognised as a right of people with disabilities in the Convention of the Rights of Persons with Disabilities".

When it comes to the stakeholder of participants or viewers, the vast majority of people are able bodied and belong to the dominant height standards. Given the time frame of the product's presentation of a few days or weeks, it is very possible that not a single person will be out of the height range. However, the venue is accessible to people outside of the height range and even one person having a discriminatory experience with the technology is a significant occasion.

For the stakeholder of the client and the venue, it is not a widespread value to have a non-discriminatory artefact, as long as it is not avert and intentional. This is a novel field of knowledge and many are not informed and have not developed discriminatory artefacts as a value. It could be that disclosure and the performance of the product as a discriminatorily aware one could inform and create new value and utility in that sense. Yet, better functioning and effectiveness for the maximum number of participants is more valuable for these stakeholders and will yield more utility. It goes without saying that in terms of utility as an additive value, the same applies to the participants and viewers; maximum number of people being affected the most positively.

C. Options for actions

One option for actions is spending resources on creating distributive justice through fairness for people outside of the heigh norms by creating a more complex recognition system that adapts to the height of the user. The other option is to spend these resources on providing greater public utility by creating better functionality and effectiveness of the product for the majority that fall in the height norms through improving the interaction technology and mechanics instead. Since other potential discriminatory aspects for demographical access have been addressed through ethics analysis prior, as much as it is affordable, the options for actions is limited.

D. Ethical judgement

The action to create greater public utility by improving the functionality from the utilitarian framework, will bring forth the greatest benefit and minimum amount of harm as a whole. Since a vast majority of participants will not experience any issues in terms of functionality and benefit from the experience with the product. The product itself does not have an intent of casting out potential participants, it is unable to afford it. From a deontological aspect, to protect individual and universal rights, and treating everyone with respect, it is more dutiful to create distributive justice by having more fairness and honouring people who do not conform to height norms. Considering the outcome and the point that nobody who is outside of the height boundaries might not even participate is irrelevant, since these are consequential outcomes.

For the equality principle, benefits are divided less equally among people in the case of opting for better functionality and effectiveness. In line with this, looking at distributive justice from the need principle, people outside of the norms can be in more need of the benefits of the product and that they need greater amount of addressing.

Judging from the non-maleficence point, choosing to improve functionality without putting in the system to avoid potential harm that could happen through the experience of being 'othered' is violating the principle. As, from functionality perspective, acting with the value of this principle and creating a more fair product does not violate this principle even though the general functioning of the product is less effective or even if it results in errors/non functioning.

Using informal frameworks, looking into the dominant value method, it is obvious that most designers and engineers opt for the public utility and make their artefacts most beneficial additively. It can be argued that with proper knowledge the dominant value systems could be shifted, however, in this scope it is inconclusive to determine such potentiality. In a intuitivist framework, I would argue that unless it is an extremely effective product ie. a medical device that can save lives, it is critical to consider inclusivity and fairness. Respect of life and value is extremely important and often overlooked, it is a moral duty for creators who have the awareness and the resources to do so to change the norms.

E. Reflection

The application of various ethical frameworks in the Ethical judgement phase leaves conflicting situations. The following beliefs should be brought into a reflective equilibrium. Making the product adaptive to people outside of the height norms is the best decision (belief a). Looking at fairness a more inclusive design will be the most effective (belief b). In terms of need, a more inclusive design leads to a more just distribution of resources (belief c). A more inclusive design honours non-maleficence through acting with due care (belief d). For public utility, the most amount of benefits and least amount of pain is the best outcome (belief e) justified by utilitarian ethics (belief f). Decisions should be made with respect towards all people, protecting their universal rights and not be based on consequences (belief g) in line with deontological ethics (belief h). The beliefs a, b, c, d, e, f, g and h are incoherent.

It is a fact that, without further improved functionality and effectiveness of the product experience, the product will still yield to benefits in an efficient manner, and the stakeholders of the designer, the client, venue and participants will benefit from the product in a satisfying manner. The fact that nobody outside of the height norms might even experience the product guides belief e in the direction of making the product more functional and effective as opposed to accessible, however, this argument comes at odds with belief d, and even though nobody outside of the height norms might not see the product, due non maleficence, failing to act without due care violates this principle even if no harm results.

As a conclusion, the respect and honouring of rights outweighs the justification of utilitarian additive benefits. Therefore in this scope, it is justifiable to give up the belief of making the product more effective and functional for the majority population that conform to height norms yields in the most public utility. This brings the remaining beliefs a, b, c, d, g and h in harmony. Overall, I conclude that deciding on chasing to make the design more inclusive is the morally strongest decision.

2.3 Code of Ethics

1. The designer should act for the best of the public interest regardless of circumstances.

This code provides a profound foundation for the moral principles of beneficence and non-maleficence. Creating an artefact for the public wellbeing, the project requires a code of ethics as such that ensures other interests such as the client's or designer's to not interfere with the public interest as the main focus. This guides me to focus on the well-being impact of the designs, which will guide me to overcome future ethical dilemmas by prioritising the well-being and safety of people instead of factors such as but not limited to: aesthetics, feasibility, and recognition.

2. The designer should consider the current conditions of the world in terms of but not limited to the environmental, social, political, cultural and economical.

This code ensures that the design process is informed by the pressing issues of today and boosts a more beneficial delivery through addressing current issues better. Since the project deals with the effects of Covid-19 on the psychology of the society, this is important. This has forced me to think about the circumstances and context of the society and the users more in depth that I translated to design choices. Considering this principle gives me the moral obligation to delve into civic affairs by addressing public issues that citizens face through multiple perspectives.

3. The designer should consider the interest of their client above self-interests, there should be no conflict of interest

This code enforces the interest of the client to be considered above the designer. This allows me to make decisions in a more adherent manner without self centred judgement or emotional decision making. This has led me to decide through the lens of the client and allowed me to discard implementations that are interesting to me but of no use to the client.

4. The designer is stimulated to bring new insights to academic and engineering/design discourse and disseminate this knowledge to the public and peers.

This code brings importance to not only to the beneficial effect of the output product itself only, but also the larger intellectual and cultural sphere it exists in. The designer therefore, considers creating novelty and bringing new information to the public as opposed to simply creating a product that has a certain function. Since I am generating information in a new field, this information could impact other students and professionals working in this field currently and in the future.

5. The designer should have accessible outputs that distributes benefits in a fair and equal manner.

This code warrants decision making to keep justice at the centre of focus for decision making. It allows for thinking errors and incorrect judgements to occur when considering the users and their context. It especially has informed the design process in creating more a inclusive product experience that aims to be used by a wide demographic without creating discriminatory side effects.

3. Ethical Analysis

3.1 Fledderman's Flow Chart

3.1.1 Safety and Utility

The main requirement of construction of the product is to have high quality interaction. Despite being in line with the (legal) quality of safety standards, the design can be made in a safer way. However, increasing the standards of safety can possibly lead to a reduction in the quality of the interaction by interfering with the interactive design elements; for example by making them slower. The engineer while designing the construction of the product has to consider these elements and solve the ethical problem. The positive paradigm in this case is to build the safest possible version of the product. The negative paradigm in this case is to ignore safety options and build the design that yields the best quality of interaction.

The moral principle of beneficence directs balancing benefits and risks. The most benefit occurs through the best interaction quality. Not choosing the safest option also conflicts with non-maleficence, as it is violated by negligence.

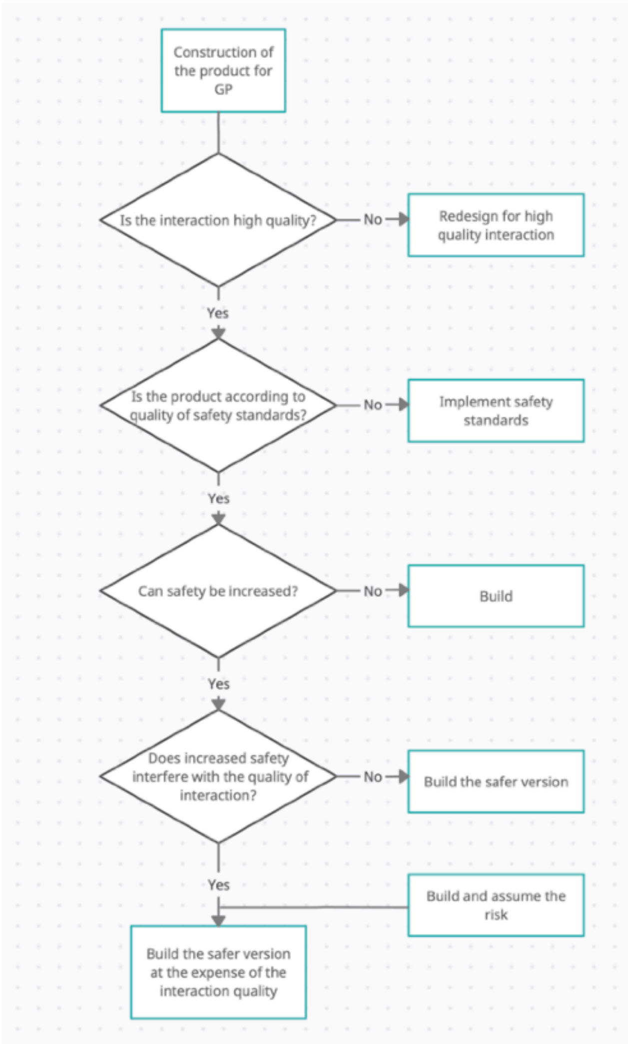


Figure 1: Flow Chart for the safety and utility dilemma

3.1.2 Accessibility and Utility

The main purpose of the interaction with the product is to create a sense of wellbeing in the user/participant. However, there is a threshold of the product benefiting the user/participant and above it there is a surplus of resources. The allocation of these resources needs to be determined, which creates a moral dilemma. The flowchart was constructed to analyse the dilemma and emphasise the fairness and equality aspect. In terms of fairness and equality, the positive paradigm is to allocate all surplus resources to making the interaction most inclusive. The negative paradigm in this case is to ignore inclusivity and focus on the functionality of the interaction. Here, equality, fairness, utility, non-maleficence and beneficence are at play. The flowchart clarifies decisions for the allocation of resources in a responsible and ethical manner.

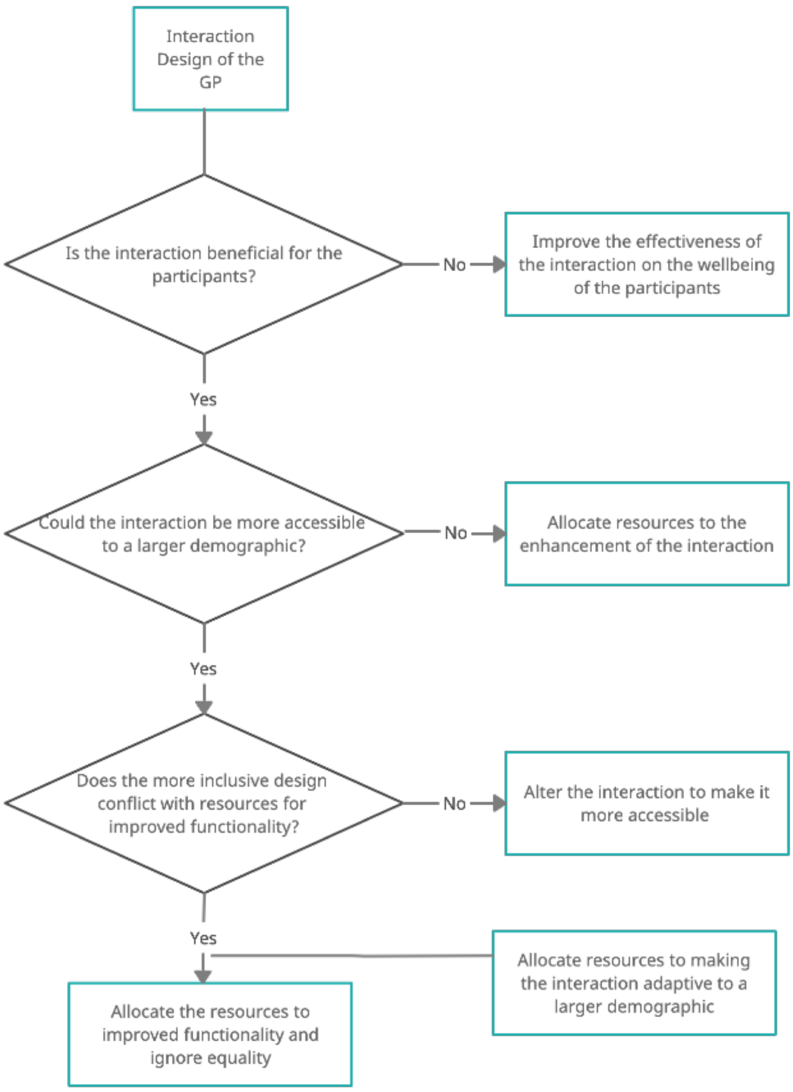


Figure 2: Flow Chart for the accessibility and utility dilemma

3.2 Markkula Center for Applied Ethics' Tool 5: Remembering the Ethical Benefits of Creative Work

This tool emphasises the positive outcomes that ethics bring about. It is a significantly useful tool to reinvigorate a sense of aim towards advancing the betterment of humanity [27]. The tool has brought forward the 'less ethically grounded' benefits for the designer that blur the ethical decision making process by creating false input. This tool has clarified the process by answering the questions of:

-The intent of the actions and its beneficial consequences,
-Objective betterment of/value creation for the society and the world by addressing authentic needs,
-Having the ethical beneficence as the focal point in the work and thought processes,
-Willingness of loss for ethical decision making

Figure 3: Chart for the tool of remembering the ethical benefits of creative work

This tool has highlighted and informed ethical decision making process, and the process of working toward designing and thinking. It has emphasised the importance of inclusivity and the impact on public's relationships and wellbeing. Perhaps, as otherwise due to the obscurity of the fact, brought the importance of acting as a disruptive technology and introducing discrimination-conscious artefacts. What could have become over the process a burdensome requirement has shifted into becoming an exciting challenge that has a potential to alter the world positively in significant ways.

4. Theoretical Discussion, Impact Statement, Limitations, and Concluding Remarks

The problem I am trying to solve is the severed sense of connection due to the pandemic. Application of technology experience in large groups that is outside the field of entertainment purposes is a new and growing field. In that sense people working on it now are relatively leaders, and need to work extensively to provide true utility. Unfortunately, the project lacks the ability to be larger scale and impacting a larger amount of people. It also lacks the ability to be inclusive and accessible to an even wider demographic and accommodate disabilities. These should be considered by the future society and designers/engineers.

From observation, general public can conclude that art viewership, especially in the West, is generally not diverse. Clayton Lord on his Arts Diversity Index presents an analysis of 500,000 theatregoers in 5 cities of the Bay Area, and concluded that "White, Not Hispanic" participants is at least twice the amount of the distribution of the general population. He also shows the difference of average household income between the general population and theatregoers from 18,000 to 58,000$ [28].

Anna Bergling, in her writing states "it's extra important to create settings in which the audience feel comfortable" [29]. In United Nations 2030 Agenda for Sustainability, Goal 10.2 states the goal as bolstering the "social, economic and political inclusion of all irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status"[30]. The field and viewership of Art is an extension of social inclusion, and my design and presentation choices attempts to serve as a case of a "driver for change" by being a disruptive technology. The product has characteristics of disruptive technology engendered by breaking the norms of traditional art viewership and interactive works aiming to change the common practices, being more inclusive in its interaction methods, tries to overcome being a discriminatory artefact.

This is tried to be achieved through the following. The current placement consideration for the installation is WORM, Rotterdam and their mission and vision include having an "inclusive, horizontal and fluid approach" and pay attention to the "wealth in cultural diversity"[31]. Promoting social inclusion by having a diverse crowd of viewership is an approach diverging from the established art viewership culture that has debatable "power dynamics". For the interaction, I have considered diversity in age and physical disabilities by using elements that provide feelings of safety, and in return comfort, through having a large personal space and slow interactions that can accommodate motion limitations. I am trying to implement an adaptable interaction to accommodate height limitations, due to age or disability.

Art&Design without accommodation of diversity, creates "Discriminatory Artefacts" and similar to the hammer example of Wittkower, where the tool becomes discriminatory by its design giving male carpenters "an unearned privilege"; privileged audience like abled and younger audience gain "an unearned privilege" in a similar manner. As he further states in "Embodiment Technics", standardisation of design also leads to the user to direct the fault on themselves instead of the artefact that is interacted with. Therefore, awkwardness or limitations experienced by certain groups can create an "enigma position" [32]. My attempt to be inclusive in presentation and design choices strives to change common practices affecting society through inclusion. My project, being informed by the ethical reflection process, has attempted to make the best decisions keeping in mind distributive justice, non-maleficence, beneficence, (public) utility, as well as informal methods as well as through the consideration of utilitarian and deontological ethics to provide design that is the most beneficial and inclusive as possible.

References

[1] B.Costello and E. Edmonds. A Study in Play, Pleasure and Interaction Design. In Proceedings of the 2007 Conference on Designing Pleasurable Products and Interfaces (DPPI ’07). ACM, New York, 2007. doi: 10.1145/1314161.1314168

[2] "ENERGY CAROUSEL – ecosistema urbano", *Ecosistemaurbano.com*. [Online]. Available: https://ecosistemaurbano.com/energy-carousel/.

[3] “The Lamp Beside — gustavopradostudio", *Gustavopradostudio.com*, 2021. [Online]. Available: https://gustavopradostudio.com/1_a_Lamp-Beside.

[4] “Glowing Nature | Studio Roosegaarde", *Studioroosegaarde.net*. [Online]. Available: https://www.studioroosegaarde.net/project/glowing-nature.

[5] “SYNC | Studio Roosegaarde", *Studioroosegaarde.net*, 2021. [Online]. Available: https://www.studioroosegaarde.net/project/sync.

[6] “Liquid Space", *Studioroosegaarde.net*. [Online]. Available: https://www.studioroosegaarde.net/data/files/2018/08/326/liquidspacefactsheetroosegaard.pdf.

[7] “We Are All Made of Light", *Frameweb.com*, 2019. [Online]. Available: https://frameweb.com/project/we-are-all-made-of-light.

[8] "Cave of Sounds", *Caveofsounds.com*. [Online]. Available: https://caveofsounds.com.

[9] "CLOUD", *Caitlind r.c. Brown & Wayne Garrett*. [Online]. Available: https://incandescentcloud.com/aboutcloud/.

[10] J. Singh and J. Singh, "COVID-19 and Its Impact on Society," *Electronic Research Journal of Social Sciences and Humanities*, vol. 2, no. 1, pp. 168-171, 2020. Available: https://www.researchgate.net/profile/Ali-Hasan-36/publication/340769976_COVID_-_19%27s_Impact_on_the_Society/links/5e9c7948a6fdcca789282c41/COVID-19s-Impact-on-the-Society.pdf.

[11] A. Morrison, S. Viller, and P. Mitchell, "Open-ended art environments motivate participation," in *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE '11*, Lisbon, Portugal, 2011. doi: 10.1145/2071423.2071479.

[12] A. J. Morrison, P. Mitchell, and M. Brereton, "The lens of ludic engagement: evaluating participation in interactive art installations," in *Proceedings of the 15th international conference on Multimedia - MULTIMEDIA '07*, Augsburg, Germany, 2007, p. 509. doi:10.1145/1291233.1291358.

[13] Z. Bilda, E. Edmonds, and L. Candy, "Designing for creative engagement," *Design Studies*, vol. 29, no. 6, Nov. 2008, pp. 525–540. doi: 10.1016/j.destud.2008.07.009.

[14] E. Hornecker, M. Stifter, "Learning from interactive museum installations about interaction design for public settings," in *Proceedings of the 18th Australia Conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*, ACM, New York, 2006, pp. 135–142. doi:10.1145/1228175.1228201.

[15] K. Höök, P. Sengers, and G. Andersson, "Sense and sensibility: evaluation and interactive art," in *Proceedings of the conference on Human factors in computing systems - CHI '03*, Ft. Lauderdale, Florida, USA, 2003, pp. 241-247. doi: 10.1145/642611.642654.

[16] A. Arfaoui, G. Edwards, E. Morales, and P. Fougeyrollas, "Designing interactive and immersive multimodal installations for people with disability," in *Virtual Reality and Its Application in Education*, IntechOpen, 2021, pp. 1–23.

[17] F. Pais, "Experience and Meaning-making Process in Interactive Arts", Ph.D thesis, College of Eng., Porto University, Porto, January 4, 2014. [Online]. Available: https://repositorio-aberto.up.pt/bitstream/10216/73695/2/31349.pdf

[18] S. Zheng, M. Adam and A. Woodcock, "Surprise and Illusion: Design strategies for Interactive Museum Exhibits".

[19] B. Soderman and D.C. Howe. "A Critique of Surprise in Generative Art," in *Algorithmic and Generative Art*, Leonardo Electronic Almanac 22, no. 4, Mar. 2019.

[20] A. H. Mader, W. Eggink, "A Design Process for Creative Technology," Proceedings of the 16th International conference on Engineering and Product Design, E&PDE 2014. Bristol, UK: The Design Society. 2014. p. 568-573.

[21] P. Vallentyne, Ed., *Distributive Justice*. Wiley-Blackwell, 2007.

[22] W. T. Jahn, "The 4 basic ethical principles that apply to forensic activities are respect for autonomy, beneficence, nonmaleficence, and justice," Journal of Chiropractic Medicine, vol. 10, no. 3, pp. 225–226, Sep. 2011, doi: 10.1016/j.jcm.2011.08.004.

[23] R. B. Edwards, "The Principle of Utility and Mill's Minimizing Utilitarianism," *The Journal of Value Inquir*, vol. 20, pp. 125–136, 1986.

[24] B. Roby, "Virtue Ethics, Deontology, and Consequentialism," *Student Research Submissions*. 292, University of Mary Washington, Washington, 2018.

[25] V. Argyropoulos et al., "Current and future trends in museums regarding visitors with disabilities: the case of visitors with visual impairments," *9th ICEVI European Conference,* pp. 32–33, 2017.

[26] V. Shannon, B. Green and I. Raicu, "Ethics in Technology Practice," The Markkula Centre for Applied Ethics, Santa Clara University, Santa Clara, pp. 12-14, 2018.

[27] C. Lord, *The Arts Diversity Index: Measurement of and Impacts on Diversity In Bay Area Theatre.* San Francisco: SMU DataArts, 2013.

[28] A. Bergling, "Art for an audience that rarely meets art", *Bibu.se*, 2020. [Online]. Available: https://bibu.se/en/articles/art-audience-rarely-meets-art.

[29] *Transforming our World: The 2030 Agenda for Sustainable Development.* United Nations, 2015.

[30] "Mission / Manifesto", *WORM*, 2021. [Online]. Available: https://worm.org/about/organisatie/.

[31] J. Pitt and A. Shew, *Spaces For the Future*. New York: Routledge Taylor & Franics Group, 2018.