USING VIRTUAL REALITY TO ENHANCE CURRENT ART GALLERY EXPERIENCE AND ENCOURAGE PURCHASES

Master Graduation Thesis

Xiaoying Chen

Nov, 2019

USING VIRTUAL REALITY TO ENHANCE CURRENT ART GALLERY EXPERIENCE AND ENCOURAGE PURCHASES

XIAOYING CHEN

Master Thesis
November, 2019

Using Virtual Reality to enhance current art gallery experience and encourage purchases

Master Thesis
November, 2019

Author
Xiaoying Chen
Design for Interaction (MSc.)
x.chen-10@student.tudelft.nl / sz_miko@hotmail.co.uk
www.xiaoyingchen.com

Supervisory team
Project Chair:
Dr. Doris Aschenbrenner
D.Aschenbrenner@tudelft.nl

Project Mentor:
Dr. ir. Willemijn S. Elkhuizen
w.s.elkhuizen@tudelft.nl

Industrial Design Engineering, Delft University of Technology
Landbergstraat 15, 2628 CE Delft
+31 (0) 15 278 9807
http://io.tudelft.nl

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to my great supervisors Doris Aschenbrenner and Willemijn Elkhuizen for supporting and guiding me through this project. I remember that you told me although this was an individual project, you were always there to help because we were a team. Thank you for sharing knowledge with me, encouraging and inspiring me to do more than I thought I could do.

Thanks to Marcel, Charles and Alex who made this great project happened. Your collaboration from research to prototyping phases helped me to realize my ideas.

Thanks to all the fellow students and friends who participated in the interviews, co-creation and user tests. This project could not be done without your enthusiastic help. Even small feedback may give me a whole different perspective to see.

A special thank to my boyfriend for always supporting and encouraging me to move forward when I was stuck.

Last but not least, my deepest gratitude to my parents and my family, especially to my grandpa. Thank you all for giving me endless love, support, and understandings.

ABSTRACT

In order to attract a broader audience and encourage the user group to buy artworks after visiting a gallery, this project aims to create a new gallery concept combining the physical and the virtual dimension. The main objective of this master thesis is to use virtual reality to enhance the current art experience and encourage their purchases, designing intuitive interactions between the viewer and the virtual art gallery.

The project started with researching from three aspects, including human, technology and business, to explore the current situation of the galleries and customers, as well as the possible design opportunities. The result showed there were mainly two reasons why more galleries closed because of few customers in recent years. On the one hand, current galleries often couldn't attract customers to view around for a long time. On the other hand, novice customers don't have an easy and friendly way to purchase artworks. Therefore, it requires the design to find a proper way to help the small art businesses adopt a more modern way of selling artworks, and attract younger customers. The desired user experience focusing on three key elements (approachable, emotions, purchase) is determined after analysing.

During the conceptualization, three concepts focusing on three key elements were developed by conducting co-creation sessions. User evaluation was conducted using paper prototyping to test certain features and people's likelihood of use. Six key elements that should be included in the final concept was concluded from the evaluation.

By conducting the prototyping process, four steps of building a virtual gallery were found, and the process is able to be used as a guideline for researchers or designers who want to develop a virtual gallery. In order to find a relatively better interaction for certain functions, two gallery concepts were created to compare the interactions.

In the last evaluation phase, the design concepts were tested with potential users to get critical feedback and suggestion. The recommendations and limitations were discussions as well in the end.

CONTENTS

A

INTRODUCTION

01 ORIENTATION

This project has been initiated out of a combination of interest for art and worries for its transition in the digital era. This chapter discusses the background of this project and what approach has been used to complete it.

1.1 Problem definition

Art is a great way to express emotions, imaginations and creativities. Art is everywhere, whether we talk about the music we listen, the designs of our houses, the lifestyle we choose and much more. You may be not an artist, but you can experience the essence of art in an inspiring way if you visit an art gallery. However, people who have never or rather seldom visited a gallery tend to think that these are exclusive places in which they are not welcomed.

More and more galleries are closed (de Jong & Wolters, 2017) due to fewer customers in recent years. General artists encounter poor sales due to various reasons: the public is overwhelmed with plenty choices, only top artists can earn good money, and traditional galleries are closing while the fine art market has not found a good way to go online.

1.2 Opportunity

The commercialization of new display technologies, like virtual reality (VR), create an interesting opportunity to remedy these problems. What if it could be possible to use digital content to enhance the current gallery experience? And what if an endless number of artworks can be explored just in a 20 m^2 coffee shop? This project was initiated to investigate these opportunities, by developing a new gallery experience that includes VR technology to bring the art of independent small art collectives to a broader audience and to encourage purchases.

1.3 Scope & Approach

In order to achieve a significant result in the limited available time, the scope of this project has been limited to design a new gallery concept, which combined a 'real-world' exhibition of selected artworks with a larger virtual gallery, whichcan be explored using VR technology. The specific focus is to attract people to adapt to the new VR gallery and to encourage them to purchase artworks. To achieve this goal, an approach has been created that consists of five phases:

- Analysis
- Conceptualization
- Detailing & Prototyping
- Evaluation
- Conclusion & Recommendation

This project is associated with an artists' collective called “GSA” (Goois Scheppend Ambacht), Galerie Hilversum, and the company Sonolux for technical support in building the VR gallery. Due to fewer customers in recent years, Galerie Hilversum was closed in 2017, they approached to set up this project to improve the current situation of the artists. They will function as the clients in this project.

1.4 Deliverables

The final deliverables that will result from this project are:

- A final report that details the process of research, analysis, conceptualization, prototyping, evaluation and recommendation.
- A VR gallery prototype
- A demonstration video on the use of the new gallery

B

ANALYSIS

The potential opportunity in combining a physical gallery with a virtual gallery with virtual reality technology sounds good in theory, but is it feasible? To answer this question, the human, technology and business aspects need to be analyzed. This chapter aims to bring these fields of knowledge together to define the desired user experience. This user experience will be quantified in a design requirements, creating a design space that allows a solution to be found in the conceptualization phase.

CHAPTER SUMMARY

The project started with researching from three aspects: human, technology and business, in order to explore the current situation of the galleries and customers, as well as the possible design opportunities.

The human aspects revolve around the target user, who has been defined as the young group of 20 to 40 years old or customers that fall into the category which was named by Sinus-Milieus as "Adaptive Navigators" (SINUS, 2018). For this type of consumers, it is most important for the galleries to be easy and enjoyable to explore. Evoking the emotions of amazement, curiosity and belonging play a main role in creating a positive experience.

From a technology perspective, the 3D scanning of the artworks would prefer to be drawing, painting and photography. Laser scanner or structed light scanner are suitable to use. Unity will be used to build the virtual space that will run in a virtual reality head-mounted display (VR HMD) device.

The analysis of the business aspects has found out that in order to gain a competitive advantage, the envisioned gallery should be as approachable as a casual café, providing explorable contents and offers competitive price to encourage purchase.

These aspects combined into the desired user experience, which can be formulated as a value proposition:

"The envisioned new gallery will offer a more approachable way of visiting a gallery. The novice art buyers should feel comfortable to enter the café-like gallery, where they can explore different forms of interactions to have continuous stimulation. Furthermore, after the experience, they should be motivated to spread the words and a competitive price should be offered to encourage the purchase of artworks. If no purchase has been made, they should be offered possibilities to schedule next visit or glancing desired artworks online. "

The knowledge gained in this chapter resulted in a design requirement, defining the design space for the conceptualization phase. The analysis strategy is illustrated in *Figure 1*.

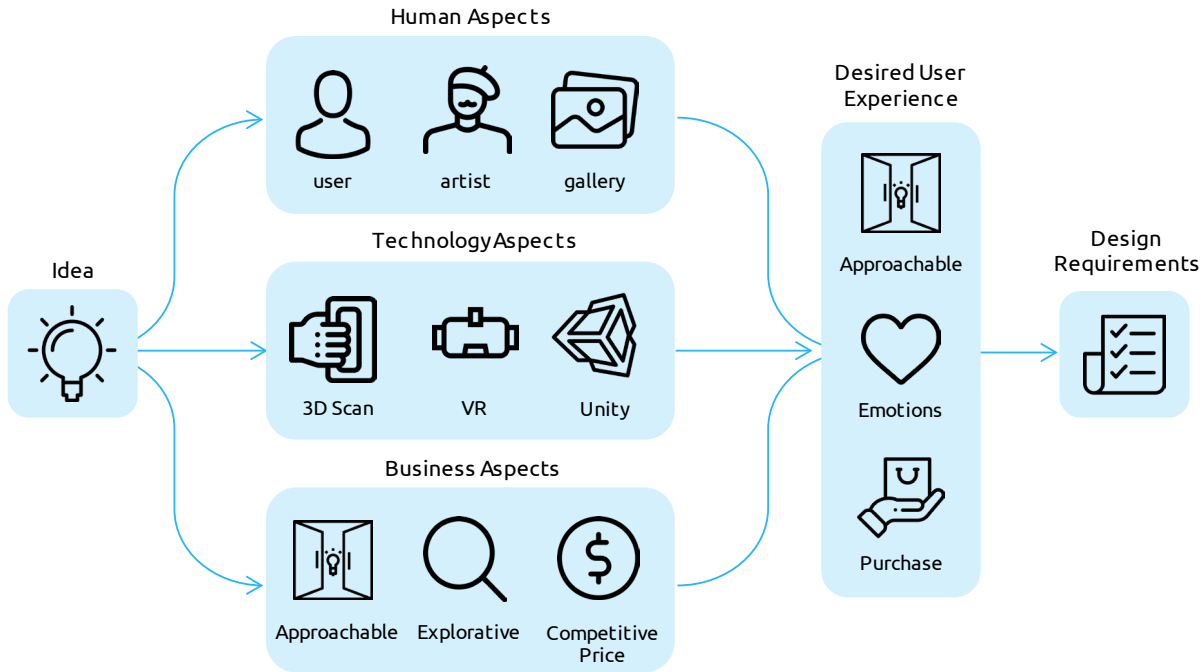


Figure 1. Analysis strategy

01 HUMAN ASPECTS

In order to enhance the experience, this project started by studying the current status of the gallery experience from the perspective of different stakeholders, which including the current art buyers, target users, the artists and the galleries.

1.1 Current Art Buyers & Purchase Behaviors

The client of this project, Galerie Hilversum, was closed in 2017, and now it is only exhibiting via online gallery. It is very difficult to get in touch with the visitors of the online Galerie Hilversum, and the context of this project is also a physical space for people to visit. Therefore, secondary research and contextual inquiry on general Dutch galleries were used for gathering information.

Motivation International B.V. conducted an investigation (Damen & Cachet, 2017) with 307 people on the demand side of contemporary visual art in the Netherlands in 2017. This investigation was repeated in 2006, 2010 and 2014. These investigations aimed to study the changes in the art market, all art forms and media art are included. By contemporary it means art made after 1945. The following sections (1.1.1 – 1.1.9) give a summary of the main findings of the latest report (Damen & Cachet, 2017), related to purchasing behavior, annual spending and expectations for improvement. The general descriptions of the population included:

- Art buyers are equally divided between gender, where 87% are highly educated (*Figure 2*).
- Art buyers are higher educated and older than the average Dutch population, and they more often live in the three largest municipalities (Amsterdam, Rotterdam and The Hague).
- More than half (60%) of the buyers are older than 50 years old, while 21% are between 20 and 40, and 12% are between 41 and 50 years old (*Figure 3*).
- 18% of the art buyers regard themselves as professional art buyers, they buy art for their own collections, private collectors, company collections, museums or galleries.
- 38% of the respondents work in the cultural sector, 18% of them are artists (*Figure 4*).

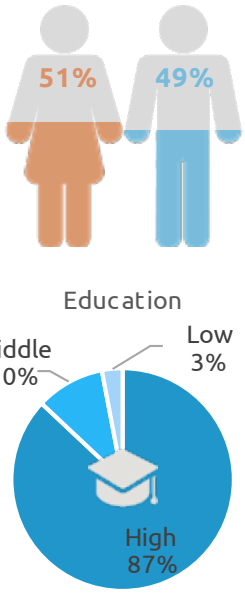


Figure 2. Gender ratio and Education level among art buyers

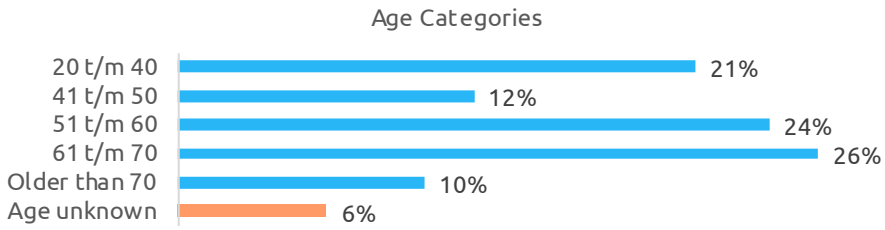


Figure 3. Age categories among art buyers

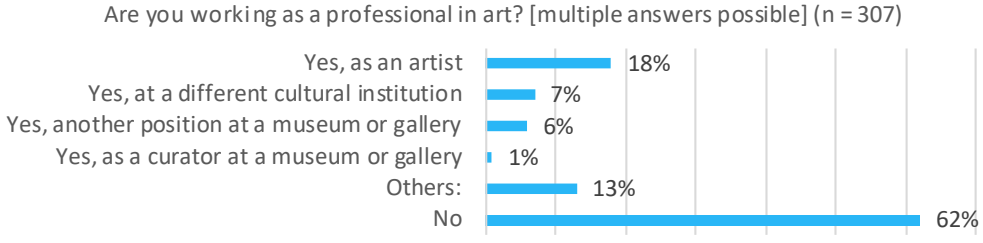


Figure 4. Occupations among art buyers

1.1.1 Purchasing Behavior

The investigation (Damen & Cachet, 2017) showed that the purchasing behavior from 2015 to 2017:

- 71% of the respondents bought artworks, and 3% both purchased and borrowed art (*Figure 5*).
- 24% of the respondents didn't purchase or borrow any contemporary visual art during the three years, which was slightly lower than in 2014 (which was 30%).
- Among the people who purchased artworks, 40% indicated that they bought an art piece once to twice, 35% bought three to five times, while a quarter purchased six times or more.

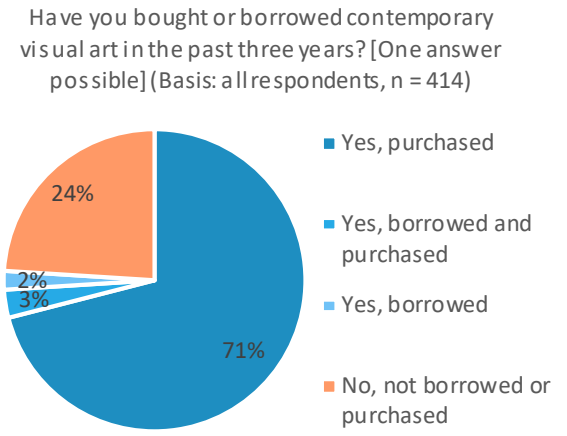


Figure 5. Purchase behaviour during 2014 - 2017

1.1.2 Annual spending in physical galleries and online galleries

People spent considerably more money on art in physical galleries than online. Most people (27%) spent between €1,000 and €2,499 on average annually in physical galleries (*Figure 6*), while almost half of the people (47%) buy artworks online in the lowest defined spending category (€0 - €499) (*Figure 7*).

1.1.3 Types of art purchased

The most purchased art form is "drawing and painting" (81%) (*Figure 8*). In addition, a relatively large amount of photography and sculpture are purchased. The results are in line with some gallery owners indicated in another research (de Jong & Wolters, 2017). It seems that sculpture, photography, audiovisual, digital and media art, and graphics and (digital) prints are exhibited more often than sold.

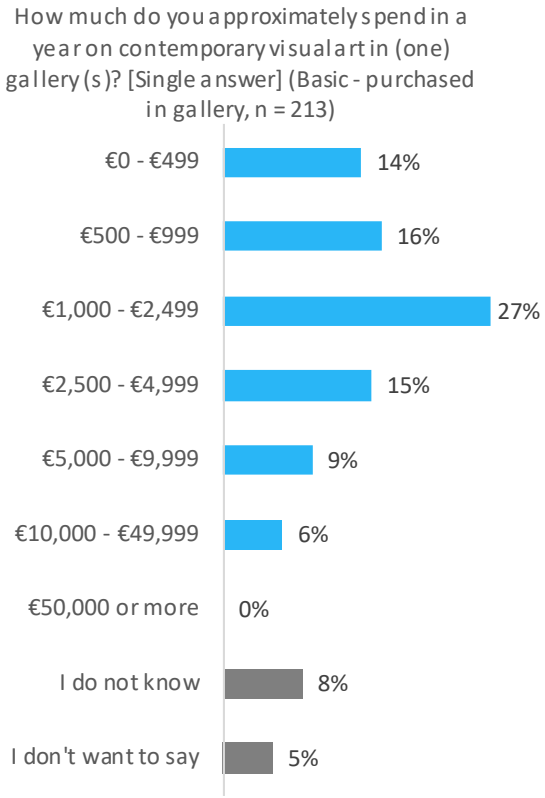


Figure 6. Amount spent by respondents in galleries in one year

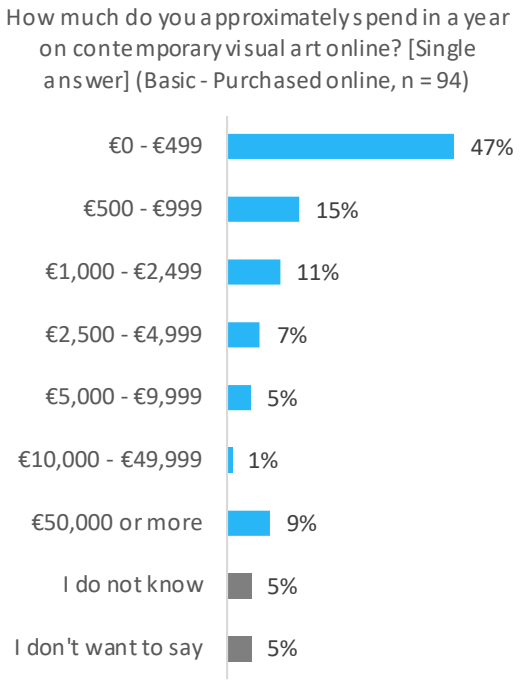


Figure 7. Amount spent by respondents online in one year

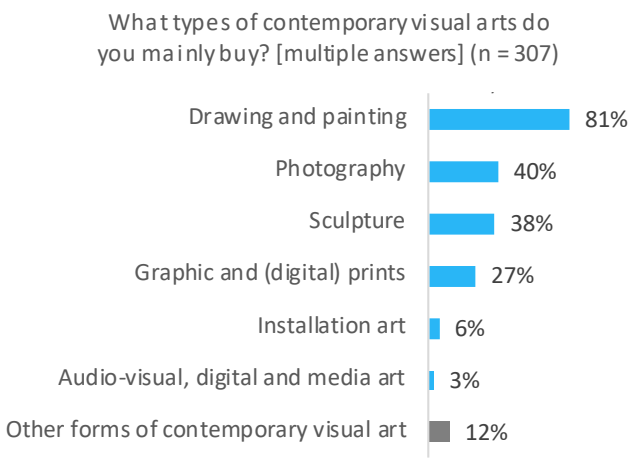


Figure 8. Types of artwork purchased

1.1.4 Reasons for purchasing art

When buying or borrowing art, the main reasons are following the instinct (27%), aesthetic reasons (26%), pleasure (25%) and enrichment of the interior (24%) (*Figure 9*).

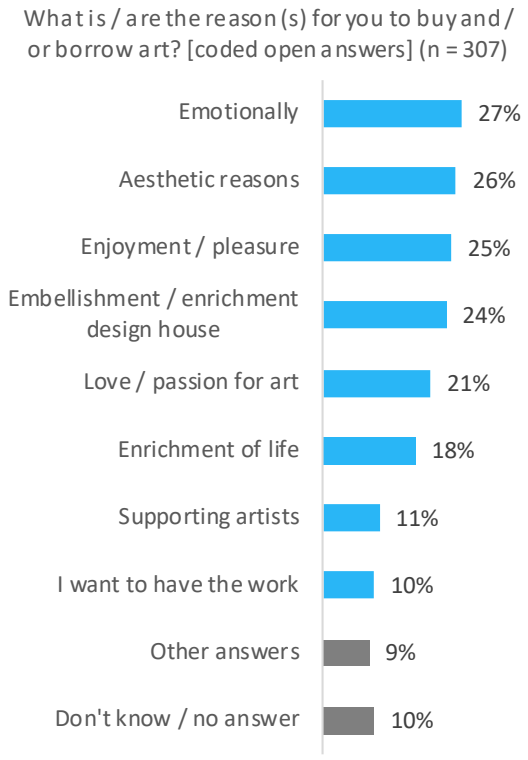


Figure 9. Reasons of purchasing/borrowing art

1.1.5 Sales channel

People were asked where they had purchased art in the three years (2015 - 2017). Majority purchased in a gallery (69%). Besides, a large number of respondents purchased through artists' studios (54%) and at art fairs (46%). Over the year 2015 to 2017, 25% customers had occasionally purchased art through an online channel. It's worth noting that art buyers younger than 40 years old bought art more often via online channels (40% compared to 25% on average).

1.1.6 Changes in the art market

Art buyers were asked whether they have noticed any changes in the art market from 2014 to 2017. Two thirds (68%) of the art buyers indicated to have noticed a change. The explanation of the change varied widely, the most frequently mentioned and most valuable answers to this project are:

- Some art buyers noticed the shift from offline sales channels to online sales channels. They didn't especially indicate that they themselves participated in it, but more like an observation of the general market.
- In terms of pricing, some said the prices of artworks seemed to be rising, while others said that there appeared more supplies in the most affordable segment.
- Commercialization in the art market is mentioned by a number of art buyers. Galleries, art fairs and artists seemed to be increasingly motivated by turnover and profits.
- A few art buyers stated that they now experience the art market as more accessible than before. Both art fairs and online initiatives seem to contribute to an accessible way to buy art.

1.1.7 What makes it attractive to buy art at galleries

Since the gallery was indicated above as the place where most art was purchased, the aspects which make a gallery attractive for people to buy art was studied. The quality of the artworks is said to be the most important aspect (61%) (*Figure 10*). Other frequently mentioned aspects are: a good selection of artworks (51%), meeting the artists (49%), appealing offers (48%) and freely accessible (48%).

1.1.8 Orientation

When considering purchasing artworks, people gather information for orientation. In the process of orientation, both physical sources (galleries, gallery owners, art fairs, etc.) and online sources play an important role.

- A majority indicates that the internet has become an increasingly important information channel for contemporary visual arts (65%). Art buyers first look at galleries' websites and then travel to the gallery for a specific work of art (60%). The other way around is also common: art buyers continue searching the internet after visiting a gallery (55%).
- Over the years there has been a downward trend in the number of people who would rather not buy art via the internet because they first want to see it in real life. In the most recent research, 78% agree with this, while it was 85% in 2014 (Cachet & Kroesemeijer, 2014) and 89% in 2010 (Cachet, van der Linden, Tepaske, & Rooker, 2010).

1.1.9 Expectations for improvement in future purchasing behaviours

People were asked what a gallery can do so that they would more often purchase art there. The result (*Figure 11*) showed that lower price played an important role in the purchase (27%). Followed by a clearer price listing on the website (26%) and in the gallery (25%). Making the appearance of galleries more accessible (26%) was mentioned very often as well. Art buyers would like to see more artworks from young artists (26%). Besides, more interest in the customers (25%) and a personal approach (23%) are desired. These aspects potentially provide some design opportunities for this project.

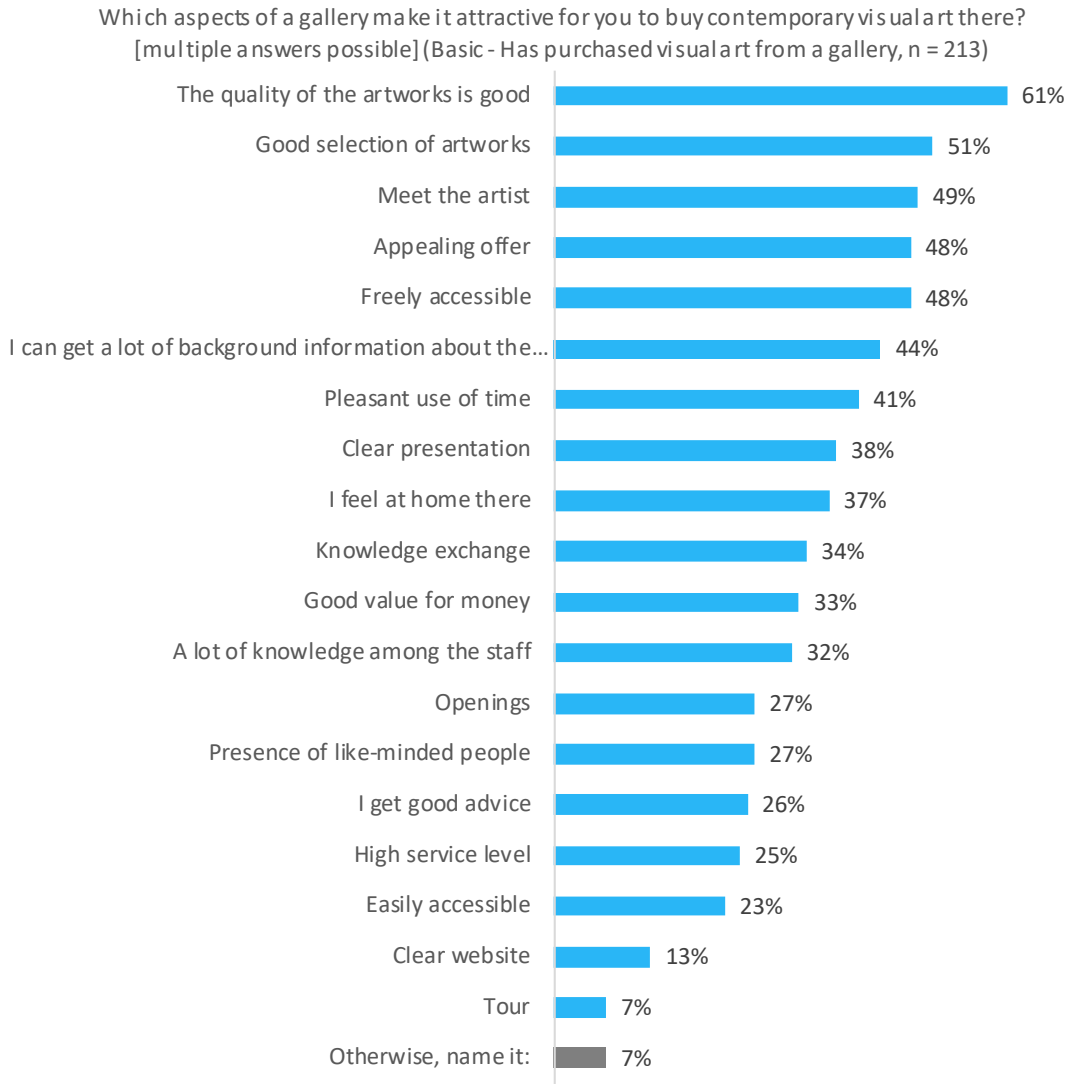


Figure 10. What attracts people to buy in the gallery

1.1.10 Conclusion

A majority (60%) of the current buyers are highly educated and aged above 51 years old. Galleries are still an important source of information and are still the most important sales channel for contemporary visual art. However, the youngest group of art buyers (20 to 40 years old) gathered information and purchased online more often than older buyers. They seemed more comfortable with online (digital) channels. From this, we might hypothesize that their acceptance of new digital technologies, related to art viewing and buying, is also higher. A research (Fernandez, 2006, pp. 57-63) indicated that younger individuals have high self-efficacy, and when individuals have high self-efficacy for a particular task, they will be accepting of technological changes that occur within the realm of that task activity. In addition, they are expected to spend more money on art in the future, while art buyers of 60 and older are expected to spend less. Therefore, this youngest group is chosen to be the target group in this project. Drawing and painting are the most purchased art forms, followed by photography and sculpture. This largely corresponds to the art forms exhibited by galleries (de Jong & Wolters, 2017). So the primary considerations of the form of artworks will be used for testing in this project will be painting, drawing and photography. The mentioned aspects in section 1.1.8 and 1.1.9 can potentially be the guideline and be addressed with the design of this project.

1.2 Target User

The clients have a preference to attract a broader audience and young artists. The analysis above showed that the youngest group (20 – 40 years old) of art buyers are more suitable to be the target group in this project because they are potential to have higher acceptance of new technologies, less represented and intended to buy more art in the future. Compared to the average:

- They find the internet an increasingly important source of information for contemporary visual arts (86% compared to 65%).
- They have fewer problems with buying art that they have not yet seen in real life via the inter-net (16% compared to 9%). However, this difference is relative, a majority of this group would still rather see art in real life before they purchase it.

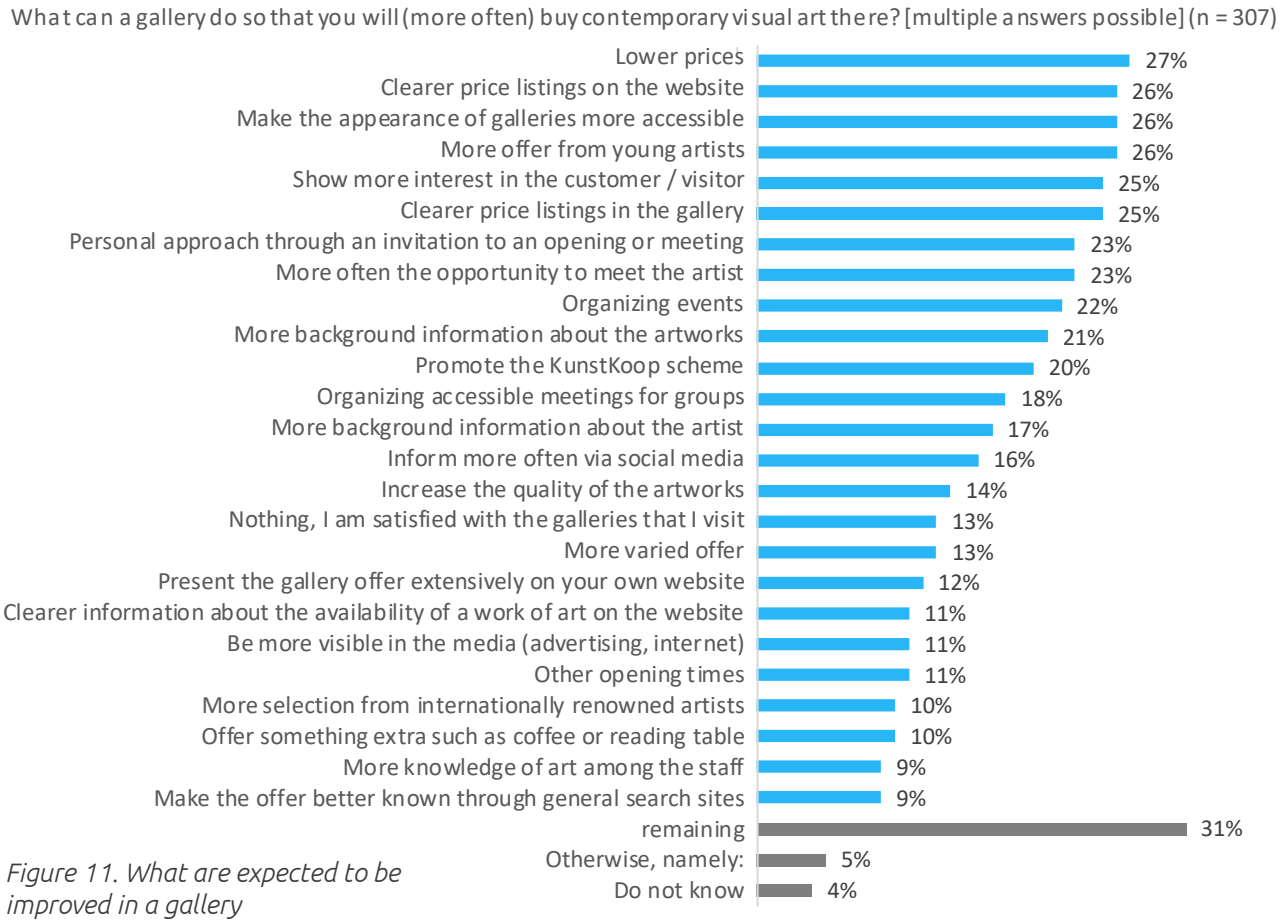


Figure 11. What are expected to be improved in a gallery

- They visit a gallery more often after they have researched on the internet (49% compared to 27%). 60+ people do this less often (15% compared to 27%).
- They are more often prepared to travel for a work of art that they first saw on the website of a gallery (68% compared to 60%).
- They search further on the internet after a visit to a gallery (70% compared to 55%). Art buyers of 70 years and older do this less often (35% compared to 55%).
- They would more often purchase a work of art online after they have seen it in real life (52% compared to 29%).
- They more often indicate that galleries play an important role in a high-quality selection of con-temporary visual arts (68% compared to 58%).
- They contact the artist more often for a possible purchase after seeing a work of art (24% compared to 17%).

The group of age between 20 and 40 years old consists people in different social status and carry diverse basic values, Sinus-Milieus (SINUS, 2018) categorized people based on these criterions (*Figure 12*). This project will focus on the middle classes which are categorized as "Modern Mainstreamers" and "Adaptive Navigators". During the early stage, the Adaptive Navigators, who are open for changes and go the galleries occasionally or have relatively more knowledge on art, will be focused. After the early adopters experience the new gallery, the Modern Mainstreamers, who have interests in art, will be focused.

In the other hand, the focus for the younger artists will be attracting them for exhibition rather than selling artworks to them. Based on the research (Damen & Cachet, 2017), art buyers who work in the cultural sector (among them 48% are artists) bought less art than average. This was also revealed by two short interviews carried out with two young artists (22 and 24 years old) (Appendix 1). They both indicated that they have lower income compared to other art buyers and they have a lot of opportunities to see different art, so they have less desired to purchase them. If they want to buy a piece, they would more often buy it from an artist privately, which was also in line with the research (Damen & Cachet, 2017) (65% compared to 47%). Furthermore, they have their own artworks that need to sell, "My stuff is still waiting for people to buy!", as one said during the interview.

1.2.1 Barriers to purchase

Two interviews were carried with people who are interested in art but are not working in the cultural sector (Appendix 2). The aim is to find potential barriers to purchase art and possibil-

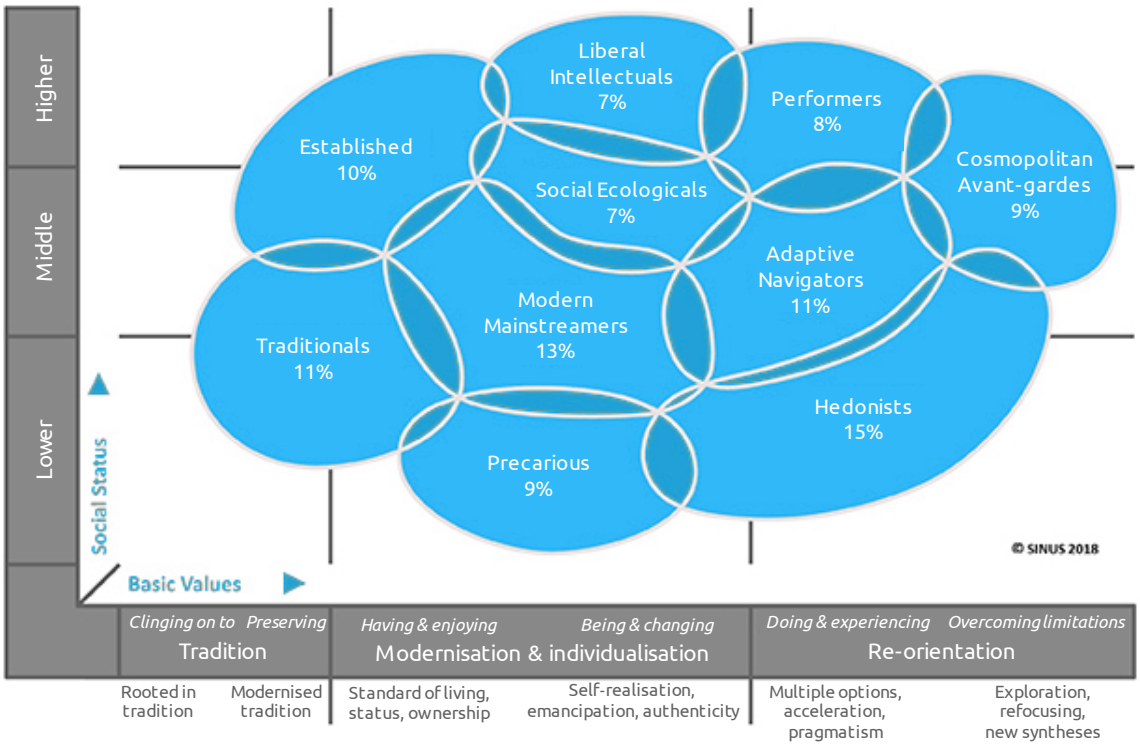


Figure 12. The Sinus-Milieus in Germany 2018

ities to increase the chance to purchase. One interviewee was 24 years old and the other one was 38 years old.

The first barrier was that they both found few suitable channels to buy. They have never attended any art auction because they didn't have deep knowledge of art, the price is very volatile at the art auction. They also have limited contacts with artists, so they couldn't buy art directly through artists. Hence, the option left to buy art relatively easily was going to a gallery. The second barrier, galleries are not easily accessible, both physically and emotionally. Not many galleries are in the city centers and the appearance of a gallery seemed not so welcoming. One participant indicated she was afraid to be the first one entering the gallery, which was also shown in the research (Damen & Cachet, 2017) that youngest group orient less often as the first in a gallery (19% compared to 33%). Furthermore, another barrier was the price. The artworks sell in the galleries are often much more expensive than their expected price. They would choose to buy a duplicate artwork if the original one was too expensive, since they are not buying for investment, but buying for pleasure and fondness of the piece, or just for decoration.

They mentioned that nowadays they sometimes would choose to make their own artworks because that would be more meaningful to them. If they are possible to see or even try how the artist makes the specific artwork, they would feel more willing to spend on the experience.

1.3 Experience in galleries

Research (de Jong & Wolters, 2017) indicated that 43% of galleries had less than 26 visitors a week in 2014, yet more galleries (58%) fell in this category in 2017. 43% of the galleries had up to 15 visitors on average per week in 2017 (*Table 1*). Besides, 80% of galleries regarded attracting a new audience as a problem, among them 37.5% regard it as a big problem. 74% of the galleries experience the turnover as a major (33%) or minor (41%) problem.

In order to learn about the process of the current experience of visiting a gallery, several observations were carried in Noordeinde street in Den Haag, the Netherlands, where several galleries are located close together. The detailed notes can be found in Appendix 3. The observation results showed that:

- People tended to enter the galleries where there are already some visitors inside.
- Like in *Figure 13,* people often glanced through windows before they decided to enter the gallery.
- Visitors are mostly in a group; individual visitors are less than group visitors.
- People normally stay for less than four minutes.
- Most people didn't chat with the gallery owners.
- The owner normally wouldn't chat with visitors unless visitors started talking with them first, or if a visitor has stayed for a longer period of time.
- No one made a purchase during the observation.
- Overall, it was observed that much fewer people visited galleries than other shops on that street.

	All galleries in 2017	In 2014
Up to 15	43%	23%
16 to 25	15%	23%
26 to 50	23%	34%
51 to 75	4%	4%
More than 75	14%	16%
Total	100%	100%
Median	20	30

Table 1. Average number of visitors in a gallery per week

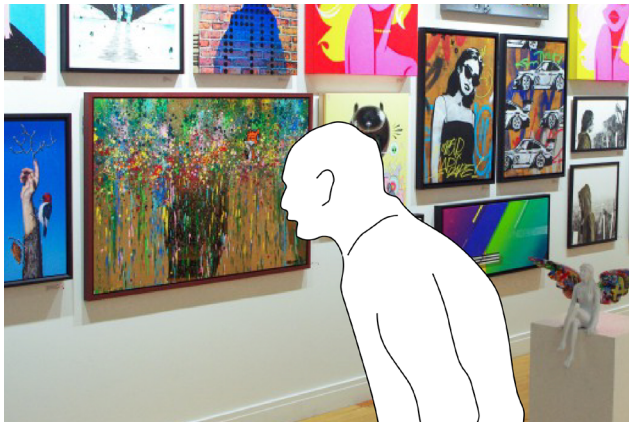
Figure 13. People looking through the window

A storyboard (*Figure 14*) illustrates the current experience for an average person visiting a gallery. (First 2 only apply on a visit on schedule)

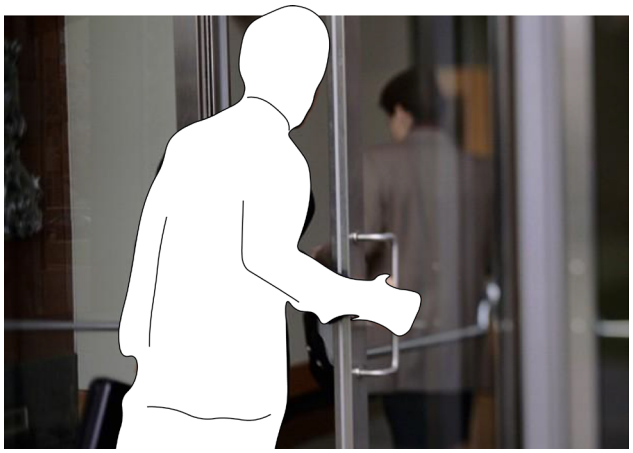
1. Search on the internet to explore interesting occasions.

2. Travelling to the desired gallery.

3. Glancing through the windows.



4. Go inside and browsing around to see different artworks.



5. Leave the gallery.

From the storyboard, it is noticed that people don't have many things to do in the gallery, so they stay quite a short time in the gallery. Most of the time, they will not purchase any artworks. The desired design should help them to spend more meaningful time in the "gallery" to increase successful sales.

Figure 14. Storyboard on visiting a gallery

In order to know the 'micro-emotions' happen during the experience (Ozkaramanli, Fokkinga, Desmet, Balkan & George, 2013). The method Emotion Capture Cards (ECC) was used to find the underlying concerns and potential design opportunities throughout the experience of visiting an art gallery. The chosen participant was a 25-year-old male who had interests in art but not working in an art-related field. In the first stage, the researcher went to one chosen gallery in Den Haag (*Figure 15*) with the participant. The participant reported his emotions as they arise, and the researcher observed and noted down all emotions on separated cards. In the second stage, the cards were taken as the starting point to probe for the underlying concern using a laddering-type interview technique (Reynolds & Gutman, 1988). One concern was distilled from each capture card, these concerns were clusters under the Thirteen Fundamental Needs (Desmet & Fokkinga, 2018). The whole notes from the emotion cards can be found in Appendix 4.

Figure 15. The chosen gallery in Den Haag

From the results, the positive emotions appeared often under stimulation. For example, in card 1 and 13 (Figure 16&17), the participant was triggered by some stimulations, and he was excited to explore the things he hadn't seen or didn't know. The desired experience can try to find ways to increase or extend the positive emotions. On the other side, the negative emotion happened when the participant saw the price (card 7), he mentioned he would prefer to save his money for better use. He didn't agree on the price, therefore, the desired experience should decrease the negative emotion possibly either by lower the price or showing more evidence to prove the value of the artwork. Furthermore, the participant showed negative emotions when he wanted to seek belonging and security. Hence the new experience can explore to improve the negative emotions based on the underlying concerns in order to make the whole experience into a positive experience. These results are also in line with previous findings that improvements can be made in approachability, price, and stimulation.

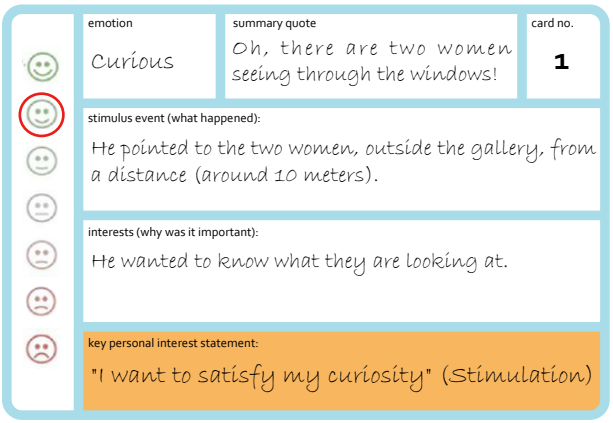


Figure 16. Emotion capture card no.1

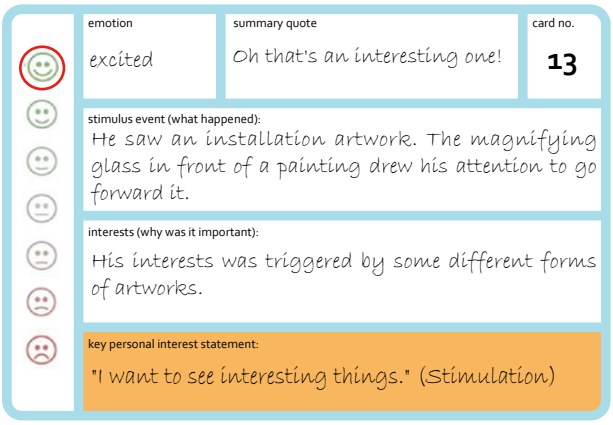


Figure 17. Emotion capture card no.13

1.4 Artists

This project is associated with the artists' collective, GSA. The type of art forms varies a lot including painting, drawing, photography, sculpture, etching, linocut, etc. In theory everything can be in VR, but there is a difference in the easiness to digitize them. Therefore only a selection of artworks is suitable to be input in a virtual environment for further evaluation.

Moreover, interviews were carried out with four artists of GSA. The goal was to better understand their feelings towards their work, their preference for exhibiting artworks, current sales channels for their artworks and their vision of the future. The interviews were audio recorded and photos were taken with permission, the transcription of the 4 interviews can be found in Appendix 5.

The artists were at the age between 50 and 90 (*Figure 18*). Overall, all artists expressed that making art only have positive impacts on their life, they enjoyed making art and if they stop, they would feel upset. All artists showed preference on only creating art, rather than managing activities related to selling it. They usually only check the information of a gallery where they wanted to exhibit their artworks. The detailed work on decorating (e.g. lighting, location) were usually handled by the gallery. They didn't have much control on how these galleries exhibit their work.

Figure 18. Interviewing an artist

When talking about their opinions on sharing stories behind the artworks, like sharing photos, videos or talking to their audience, one interviewee said he enjoyed that, and he shared several online videos about himself painting in the studio. The other two expressed positive attitudes towards it, but they haven't done anything. The other one said she wouldn't be direct contact with her audience because she didn't know what to say, the artworks spoke for themselves. She would prefer to secretly listen to others' opinions while they are viewing.

The main sales channel for them was through galleries. However, they mentioned the galleries never shared the information of the customers with them, so they seldom know who buys their artworks. They expressed a positive attitude to know their audience better. They also have websites, but people almost never purchased their artworks online. Usually, people would contact them first to see the real work. They all mentioned that the gallery would charge around 50% of the transaction price for the commission, besides they need to pay various tax, so the money they eventually got was not much.

When talking about the future, they all agreed that the art market would shift towards online. However, they didn't have a envision of the future of the gallery. Buying an artwork was not like buying a dress which you can return if you are not satisfied with it, so the strategies on online art market still needed to be refined a lot.

When designing the final product, the artists can be involved in some part to have indirect communication with their audience. However, the efforts should be as low as possible since two artists expressed difficulties on using digital products and they don't want to be disturbed a lot from creating their art.

1.5 Conclusions

The table below (*Table 2*) briefs the conclusion from the human aspects, elaborations can be found in corresponding sections.

Category	Conclusion	Section
H-A	The youngest group of art buyers (20 – 40 years old) and people who are categorized as 'Adaptive Navigators' (SINUS, 2018) are defined as the target user for the new gallery.	1.1 – 1.2 (parts before 1.2.1)
H-B	Gallery is the main sales channel for art, yet the imagine is not purely positive. Art buyers indicated a few aspects that the galleries can possibly improve, these aspects are potential design opportunities.	1.1.8, 1.1.9, 1.2.1, 1.3
H-C	To achieve a positive user experience, positive emotions (e.g. curious, amazement) can be enhanced and negative emotions (e.g. lack of security, lack of sense of belongings) can be improved.	1.3
H-D	Artists show a positive attitude in sharing their process of creation, yet the approach should be low effort since they don't want to be disturbed from creating art.	1.4

Table 2. Conclusions on human aspects

02 TECHNOLOGY ASPECTS

After analyzing the human aspects, the next step is to see how the envisioned experience can be made. The technology aspects of the envisioned gallery explore three parts: the different methods of digitizing cultural heritage, the different ways of exhibiting art virtually, and the technologies available to make a virtual gallery.

2.1 Heritage Digitization Methods

3D digitization is a complex process that consists of mainly three phases: preparation, digital recording, and data processing (Pavlidis, Koutsoudis, Arnaoutoglou, Tsioukas, & Chamzas, 2007). The process of data collecting, and processing can be further subdivided into 3D data capturing, 3D registration, geometric modelling and texture mapping (Li, Luo, & Zha, 2010).

For capturing 3D data, we can use different methods to obtain the range data from several views. Then the multi-view 3D raw data need to be registered and merged. The geometric modelling process includes polygonising the point cloud, filling the holes, decimating the mesh and some other postprocessing procedures. The output of the geometric modelling process is a mesh which can represent the geometric property of the object. For realistic rendering, texture mapping is needed to map high-resolution photos onto the geometric models.

A 3D scanner can be based on many different technologies, while each with its own limitations, advantages and costs. In order to pre-select some artworks from the artists of collective GSA, a diagram (*Figure 19*) of selection was made based on the easiness of 3d scanning and likelihood of purchase. From the results, paintings, drawings and prints are prior to be 3D scanned, artworks which have relatively flat and smooth surface is easier to be restored after digitizing than those have complicated details.

A research (Pintus et al., 2015) provided a taxonomy of methods for geometric analysis in cultural heritage by considering three axes of classification, which is, *Geometric Scale*, *CH Application*, and *# Object* (number of objects involved) (*Figure 20*). This research draws a parallel to this project, as it is quite similar in types and diversity of objects. The 3D scanning techniques that will probably be used in this project fall in the categories of Meso Geometry and single object analysis for perception enhancement. Besides, the most suitable techniques and scanners depends on the specific case. The Nine-Criteria-Table (Table 3) (Pavlidis et al., 2007) also provides a guideline for choosing an appropriate digitization system.

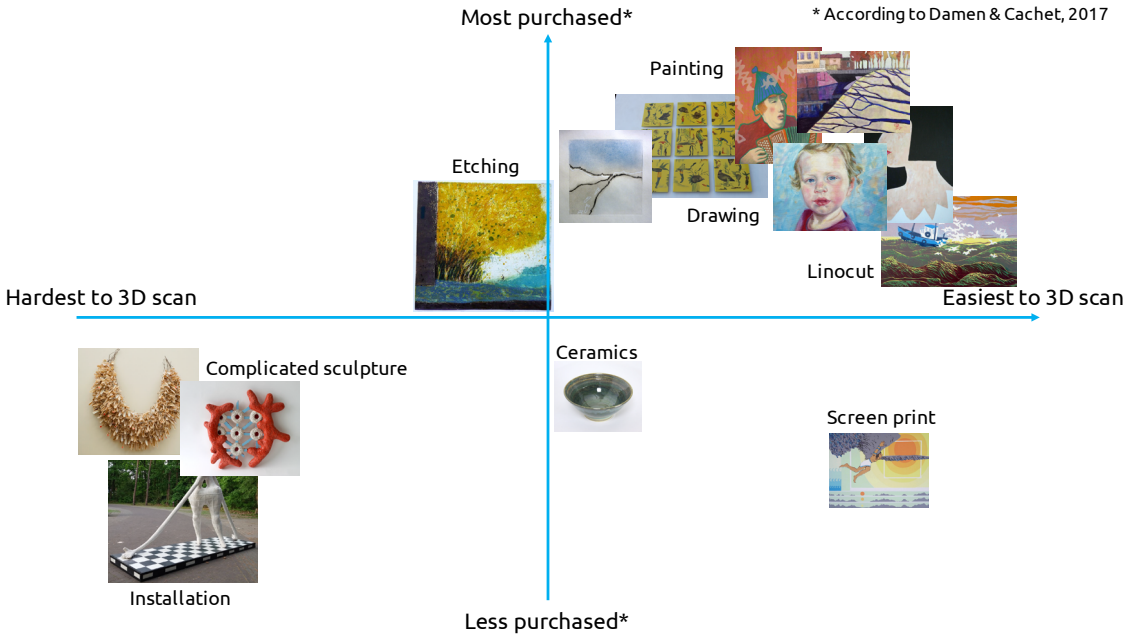


Figure 19. Selection of possible artworks for 3D scan

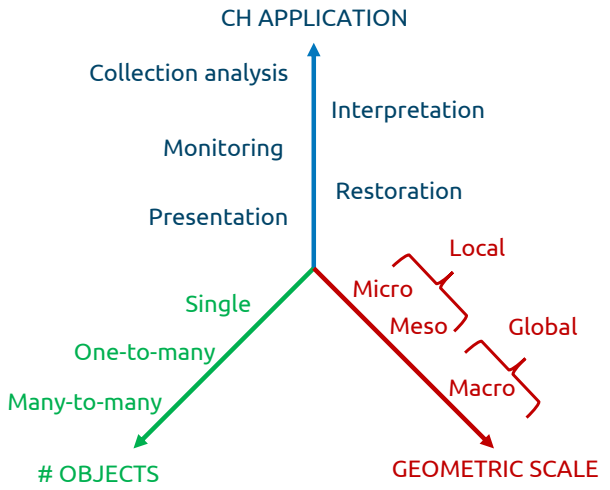


Figure 20. This taxonomy is based on three classification axes: Geometric Scale at which the analysis is performed, Number of Objects involved and CH application.

No.	Criterion
1	Cost
2	Material of digitization subject
3	Size of digitization subject
4	Portability of equipment
5	Accuracy of the system
6	Texture acquisition
7	Productivity of the technique
8	Skill requirements
9	Compliance of produced data with standards

Table 3. The Nine-Criteria-Table for choosing an appropriate digitization system

2.2 Existing Virtual Exhibition / Gallery

Virtual Reality (VR) is the use of computer technology to create a simulated and immersive environment (Bardi, 2019). It can be immediately recognized by the head-mounted display (HMD) component. Major players in VR include HTC Vive (HTC Vive, n.d.), Oculus Rift (Oculus, n.d.) and PlayStation VR (PSVR) (Sony, n.d.). Augmented reality (AR) overlays virtual objects on the real-world environment with spatial registration that enables geometric persistence concerning placement and orientation within the real world (Aschenbrenner, 2017, p. 48). Google glass (Google, n.d.) is a use of AR technology. Mixed Reality (MR) not just overlays, but anchors virtual objects to real-world objects and allows the user to interact with combined virtual/real objects. Microsoft HoloLens (Microsoft, n.d.) is an example of MR applications.

Quite a number of virtual galleries already exist online or on platforms like Steam (Steam, n.d.). There are mainly four categories:

- **Online presence of artworks**: Showing overview images or frontal images of paintings, incapable with VR or AR devices.
- **Virtual gallery**: The virtual version of a physical gallery or museum, similar environments to the real gallery or museum. For example, panoramic photography or 360-degree video like experience Rijksmuseum using Google Street View ("Rijksmuseum - first floor — Google Arts & Culture," n.d.). Experience can be viewed in simple VR device, like Google Cardboard (Google, n.d.-b), but limited interactions can be performed.
- **VR gallery**: Require VR HMD devices to experience, the environment is simulated so it can be similar to the real gallery or totally different. Various interaction can be performed using the hand controllers.
- **AR gallery**: Enhancement of the physical experience in a gallery / exhibition / museum. Often using a smartphone as a displayed device for virtual contents.

Existing virtual-related galleries only focus in showing artworks. To our knowledge no VR gallery has been made yet with the purpose of selling art. Therefore, we study other examples of virtual-related galleries, based on different categories discussed above.

Online presence of artworks

Occupy White Walls (OWW, 2018)

This is a sandbox-gallery-building game. Players can build their own place from a large choice of components and put art anywhere they want. People can open their virtual gallery to other players and earn money from visiting (*Figure 21*). Players can also communicate in text when they are in the same gallery or through the world channel. Although they are limited to text, players seemed to enjoy the communication through the chat channel, they liked to show their appreciation and exchange opinions. Therefore, some communication channels can be considered in the desired experience for this project.

Curat10n (Curat10n, 2019)

This company offers service on creating virtual

Figure 21. Game play scene in Occupy White Walls

art galleries & immersive 3D exhibitions. They focus on visualizing a real space, build and re-design accurate 3d modelling (*Figure 22*). Both Curat10n and Occupy White Walls visualize the art (mainly paintings and drawings) using 2D pictures.

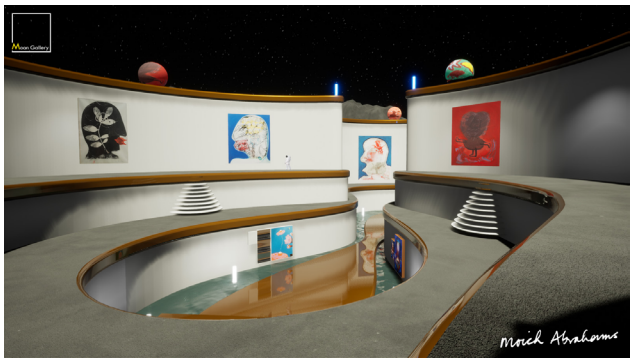


Figure 22. A virtual exhibition created by Curat10n.

Virtual Gallery

VR3D (VR3D, 2019)

A Vietnamese company which focused on digitizing cultural heritage. They 3d scanned many antique art pieces and build an interactive 3D museum using their self-developed software that people can visit (*Figure 23*). However, the interaction is limited, and the information provided is limited. People experience it like using Google Street View.

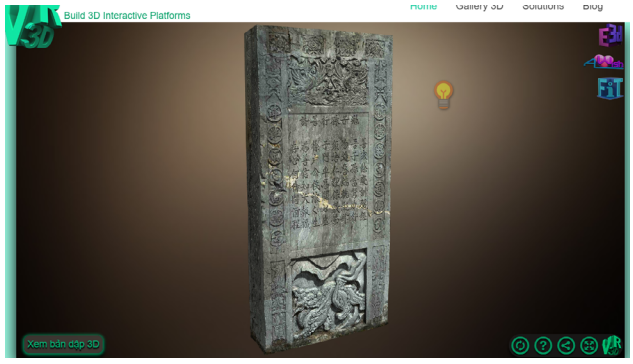


Figure 23. A 3D scanned model showed in VR3D

VR Gallery

Art Plunge in Oculus (Space Plunge, 2018)

Art Plunge (*Figure 24*)is a gallery where you can get the feeling of being inside famous paintings. This is a short but interesting experience featuring five VR interpretations of five famous artworks. The perspective of the experience is special, but it is time-consuming on building each experience.

Figure 24. Exploring the surroundings inside Mona Lisa

Slime Engine (Slime Engine, 2018)

This is a Chinese startup which makes different virtual spaces for exhibition modern and digital art. Each space has its own theme (*Figure 25*) and can be experienced in VR using a head mount for a smartphone (e.g. Google Cardboard). This was a cheap solution for general users to get in touch with VR. Viewers can leave their footprints in different spaces by leaving a comment. One of the exhibitions can be experienced through a virtual roller coaster, which is very different from other existing experience.

Figure 25. A Jurassic themed exhibition space in Slime Engine, art related to nature is exhibited here

AR Gallery

Artivive (Artivive, 2018)

Using AR in phones/tablets allows artists to create new dimensions of art by linking classical with digital art. Artists can take visitors on a journey in time and explain what lies behind,

enhance the artwork to tell a story (*Figure 26*). Using this kind of AR can possibly help the potential buyers to easily try to put artworks at home to see whether they suit the decoration. Hence this option will be a recommendation for this project but not the focus.

Figure 26. A viewer using a smartphone to reveal the message behind an artwork.

Petersen Automotive Museum in HoloLens (Microsoft, 2018)

Using HoloLens helps on storytelling the beauty of automotive. This museum shows how HoloLens helps in presenting the information rather than a static car. However, HoloLens is very expensive and more complicated than VR, hence this project will not consider using HoloLens.

2.3 Prototyping Techniques

The new virtual gallery will be built in a VR HMD device, final platform between HTC or Oculus depends on the availability and usability of the device. If HTC Vive is chosen, the room scale needs to be at least 2 meters by 1.5 meters, except seated and standing VR experience. In order to prototype the final product, there are two mainstream platforms to build the virtual gallery: Unity (Unity, 2019) and Unreal Engine (Unreal Eingine, 2019). Both are capable to produce amazing graphics and good performance. Yet Unity is easier to learn for beginners, and better supports can be acquired from experts. Therefore, Unity would preferably to be used to build the final product in this project.

During the earlier stage of prototyping, some rapid prototyping tools can be used to try a different concept. For example, Panoramas and 360 photos, Google Blocks or Cinema 4D. These rapid prototyping tools can save time and validate specific interactions quickly before implementing into the final product.

2.4 Conclusions

The table below (*Table 4*) briefs the conclusion from technology aspects, elaborations can be found in corresponding sections.

Category	Conclusion	Section
T-A	The types of artworks from GSA has been categorized, paintings, drawings and photography which have relatively flat and smooth surface are prior to be 3D scanned.	2.1
T-B	The most suitable techniques and scanners depends on the specific case. The taxonomy (Pintus et al., 2015) and Nine-Criteria-Table (Pavlidis et al., 2007) can be used to choose the most suitable approach.	2.1
T-C	Four types of existing virtual-related gallery were cate-gorized: Online presence of artworks, virtual gallery, VR gallery, and AR gallery.	2.2
T-D	By studying existing virtual galleries, no galleries are focusing on selling art. Strengths should be extracted from each product that to be considered in the con-ceptualization.	2.2
T-E	The chosen device to prototype depends on the availability and usabilty of it.	2.3
T-F	Unity is chosen to be used to build the final prototype. For quick prototyping, various tools can be used.	2.3

Table 4. Conclusions on technology aspects

03 BUSINESS ASPECTS

After analyzing what the envisioned experience should offer and how this can be made. It is important to explore whether this is a viable idea, since the goal is to help the small art collective to achieve broader audience and encourage purchases. The business aspects of the new gallery are analyzed by creating a business model canvas, and what benefits it can bring to the clients and the society in general.

3.1 Business Model Canvas

It is concluded that there is no direct competition on the existing market. To our knowledge, no virtual gallery has a focus on selling art. Therefore, a business model canvas (Osterwalder & Pigneur, 2010) is created to help define the unique offering of the new VR gallery. Business Model Canvas is a strategic management and lean startup template for developing new or documenting existing business models (Barquet, Ana Paula B., et al., 2011).

In order to gain a competitive advantage over current galleries, special value propositions are determined in *Figure 27*. These values can be concluded in one value proposition: The new combined physical & virtual reality gallery allows young art buyers to explore artworks with different experience and easily purchase them through a VR platform.

As the goal is to help the collective GSA get in touch with broader audience, it is important to make use of online channels to keep good customer relationships and spread announcement. As indicated in previous section (1.2), younger customers orientate via online channels more often than the average buyers. Therefore, using of social networks for advertisement can probably results in more customers visiting the store. Furthermore, the price of the artwork is always a big barrier to purchasing. Hence, from the business model, we are possible to explore more revenue streams to increase revenue, including charge for special events and fees for food.

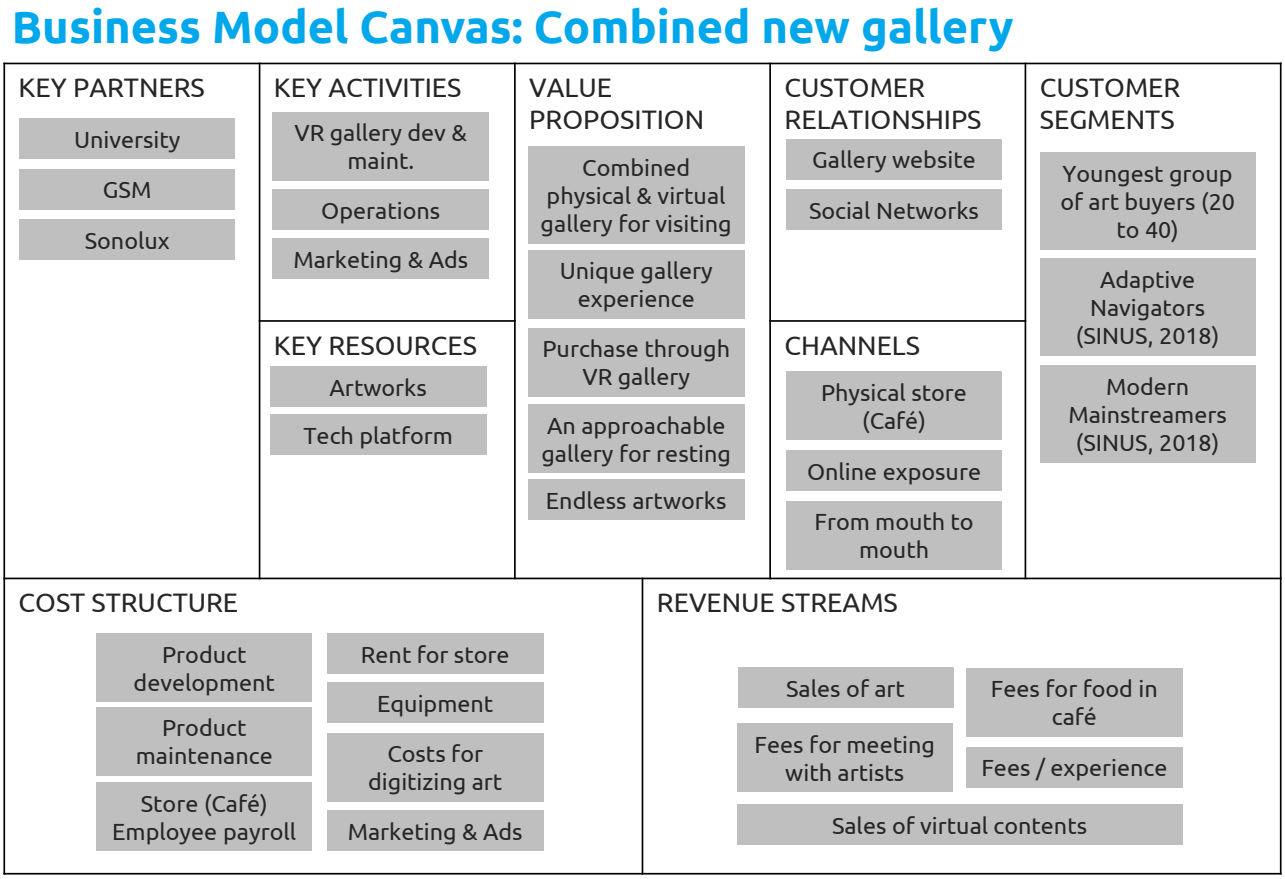


Figure 27. Business model canvas for the new gallery

Modern Customer Journey

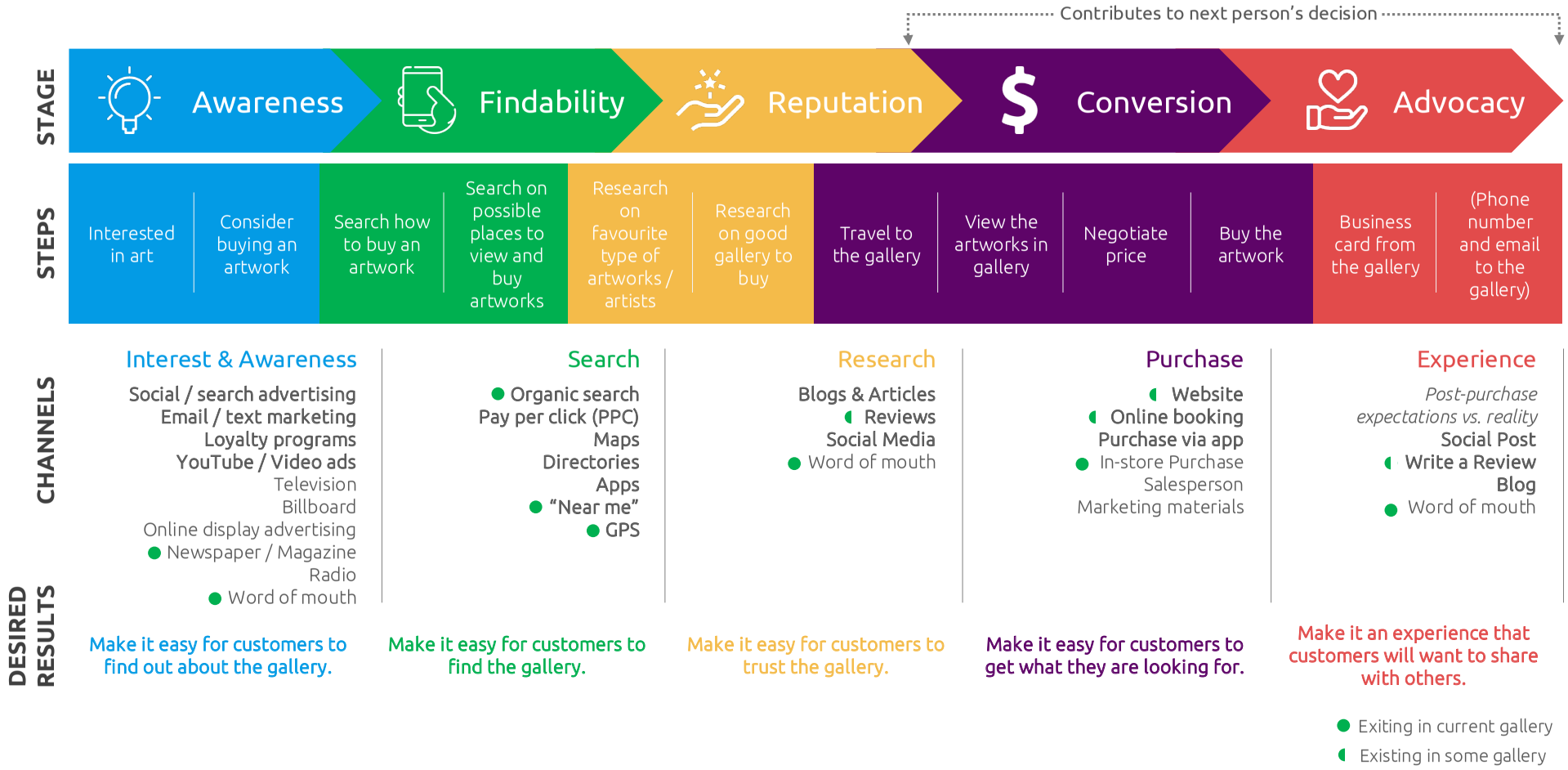


Figure 28. A customer journey map to understand pain points of the current experience

3.2 Customer Journey Map

In order to understand the pain point of the current experience, a customer journey map was drawn. In *Figure 28*, the most used and most efficient methods to get a desired result for each phase are in bold. We can see that the current galleries are lack of using varies channels in each phase. From the beginning, there are limited ways to encourage novice art lovers to know more about buying artworks through gallery. It is also hard to choose where to buy and there's a high threshold to learn how to buy an artwork in a gallery. Moreover, the post-purchase experience is often limited to calling the gallery if the artwork is not satisfied. It is very hard to spread the activity to a broader audience based on current business flow. Therefore, possible improvements should be addressed in the given channels in the map.

3.3 Social benefits & Client Benefits

Besides the benefits gained from having a successful new gallery in the market, developing the envisioned solution has benefits for the society as well. These benefits can roughly be divided into benefits for the research industry and benefits for the art industry.

VR technology has been out for years but has not been broadly used for galleries or in such context. Some museums use VR HMD sets to tell stories, yet most of the applications are designed for viewing artworks, rather than encouraging the purchase of them. This project would, especially focusing on broadening the audience and encourage purchases. This would not only benefit the research community of VR technology but also helps the art industry to explore a different way to adapt in the digital era.

3.4 Conclusions

This chapter has analysed the business aspects that play a role in the development of the envisioned gallery, resulting in the following findings in Table 5:

Category	Conclusion	Section
B-A	The unique value proposition of the new gallery is combining physical & virtual reality gallery allows young art buyers to explore artworks with different experi-ence and easily purchase them through VR platform.	3.1
B-B	It will be helpful to use online channels to reach and communicate with the target customers.	3.1
B-C	The customer journey map showed the current experience is lack of using varies channels in each phase. The current business flow is too old to adapt the modern world.	3.2
B-D	The unique focus of this project which is to help broaden audience and encourage purchasing will ben-efit both research and art industry if it is successful.	3.3
B-E	If the price of artworks cannot be reduced, there are more options to acquire revenues for the gallery.	3.1

Table 5. Conclusions on business aspects

04 DESIGN REQUIREMENTS

The next step is to bring the knowledge fields of human, technology and business aspects together, defining the desired user experience and the design requirements for the envisioned new gallery. These design requirements provide a frame and a direction that can be considered during the conceptualization phase.

4.1 Desired user experience

Creating a positive experience for the user is the goal of the envisioned new gallery. It is difficult to specify what the exact user experience should be. However, what can be defined is the desired impact, which has been touched upon section 01 – Human aspects. This impact can be communicated in the form of a value proposition:

> *The envisioned new gallery will offer a **more approachable** way of visiting a gallery. The novice art buyers should feel **comfortable to enter** the café-like gallery, where they can **explore** different forms of interactions with **VR HMD devices** to have continuous stimulation. Furthermore, after the experience, they should be motivated to **spread the word**. A competitive price may be offered to **encourage the purchase** of artworks. They should be offered possibilities to schedule **next visit** or glancing desired artworks **online**.*

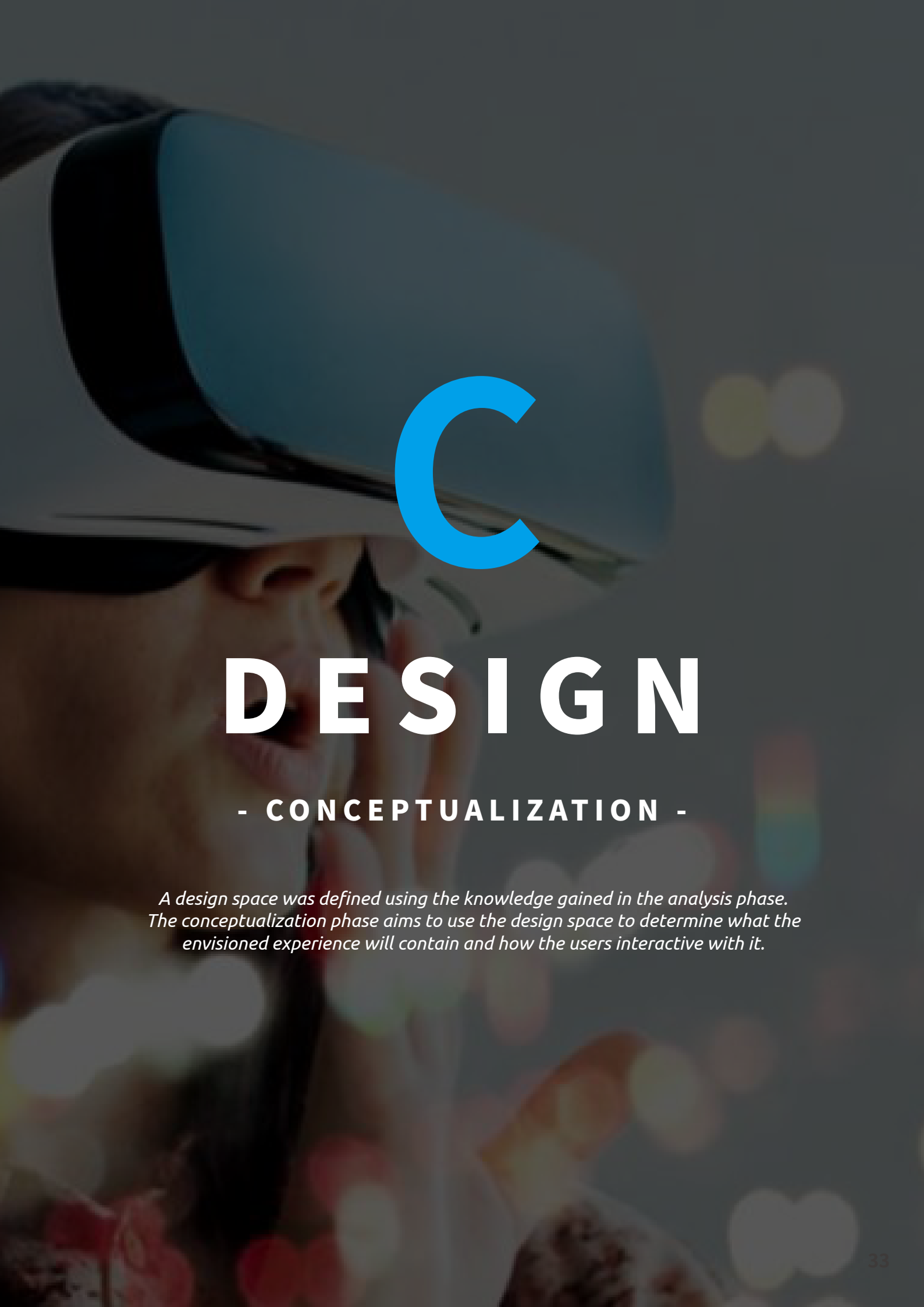
If the development of the envisioned gallery is successful, the qualities discussed above should become visible during the final evaluation. Successfully making the gallery more approachable will be visible in the new gallery encourage initiative to visit. Successfully providing explorable contents will be visible in users having fun using it.

4.2 Program of requirements

The desired user experience is a qualitative value, which can hardly be used to start the conceptualization. Therefore, a program of requirements is necessary, combining all the knowledge gained during the analysis.

Requirements	Related Conclusion	Sections
The user experience should be more appealing to people from 20 to 40, which means novel, unique, creative.	H-A	1.1 – 1.2 (before 1.2.1)
The following aspects about the gallery should potentially be addressed with the design: • more accessible appearance of the gallery, • more opportunity to meet / communicate with the artists, • more background information about the artworks and artists, • offer extra services like coffee or reading table, • more varied offers, present the offers & price clearer offline and online	H-B	1.1.9

The new experience should also be inclusive for the existing customers, which means current elements of the gallery should present in the new gallery.	H-A	1.2
To achieve a positive user experience, three emotions should be evoked: amazement, curiosity, and sense of belonging.	H-C	1.3
The experience should be a sharing experience, other people (e.g. gallery owner, visitors) can see the interactions performed via a screen.	H-B, H-C	1.1, 1.3
The user interface for artists should be easy and intuitive, possibly in line with existing approaches. Preference to be flexible for different characters.	H-D	1.4
The level of fidelity of digitization of the artworks should be suitable for the interactions.	T-A	2.1
The chosen digitization techniques should consider following aspects: geometric scale, objects involved, and the application.	T-B	2.1
A group of employees should be trained to digitize the artworks.	T-B	2.1
The VR gallery is possible to have extended platforms, the experience should be extended to an online presence.	T-C, H-A, H-B, B-B	2.2, 3.1
The system should be portable, and easy to be set up in new locations.	T-D	2.2
The design should be usable of commercially available hardware (e.g. HTC Vive, Oculus), with minimizing the requirements of computing power.	T-E	2.3
The calibration of the system should be straightforward. The new "gallery owner" should be trained to calibrate.	T-F	2.3
The new gallery should combine physical & virtual reality gallery allowing art buyers to explore artworks with different experience.	B-A	3.1
Customers are able to easily purchase the artworks through VR platform.	B-A	3.1
The physical, VR and online gallery should be comparable with each other.	B-A, B-B	3.1
Users are provided information to access the gallery via online channels.	B-B, B-C	3.1, 3.2
More channels should be involved in the new customer journey, so that they can easily: • find out the gallery • find the gallery • trust the gallery • get what they are looking for • (want to) share the experience with others.	B-C	3.2
Additional contents (e.g. buying virtual contents) are available to extend revenue streams.	B-E	3.1



C

DESIGN

- CONCEPTUALIZATION -

A design space was defined using the knowledge gained in the analysis phase. The conceptualization phase aims to use the design space to determine what the envisioned experience will contain and how the users interactive with it.

CHAPTER SUMMARY

The conceptualization phase focused on using the insights gained from the analysis phase to materialize the ideas into three concepts which focusing three aspects (approachable, emotions, purchase). The first step in doing so was to create a morphological chart (Roozenburg & Eekels, 1995). This framework helped in generating ideas in an analytical and systematic manner. In order to fill in the morphological chart, a co-creation session was conducted with three other designers.

By combining solutions from each function that should appear in the experience, ideas were developed further into three concepts, visualized with storyboards. These concepts were distinctive in three aspects (*approachable*, *emotions*, *purchase*) in order to get distinctive feedbacks on each aspect. The three concepts which varies on different design directions were explored through more user tests using paper prototypes (Snyder, 2003).

Finally, the results of the test led us towards one final design proposal, combining aspects from the three concepts. The conceptualization strategy is illustrated in *Figure 29*.

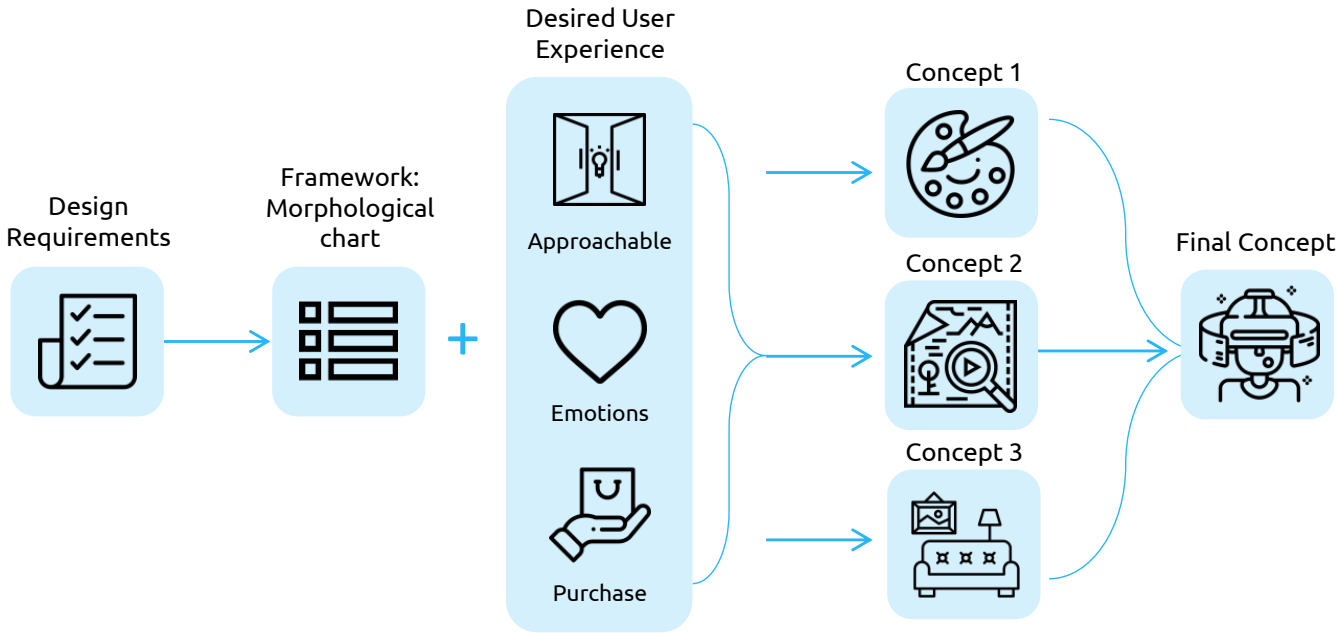


Figure 29. Conceptualization strategy

01 APPROACH

The analysis phase has concluded with various requirements for the envisioned experience. Guidances were required in order to develop a solution in a systematic manner. Co-creation (Sanders & Stappers, 2008) was chosen to use as an approach to gain different insights from potential customers. A morphological chart was used as a tool to structure the process of ideation.

1.1 Co-Creation

Goal

The co-creation session aimed to generate kinds of ideas in different directions that could encourage people to purchase more artworks in the new gallery.

Setup (Morphological Chart)

In order to make this session more efficient, a morphological chart was made prior to the session. The morphological chart is a method to generate ideas in an analytical and systematic manner (Roozenburg & Eekels, 1995). As in *Figure 30*, the required "functions" were listed on the left side of the chart based on the design requirements from analysis phase. On the right side are possible "solutions" that can be used to perform the functions. Apart from that, pens and sticky notes were provided to write or draw for the participants.

Participants

Three young designers who are also potential users of the new gallery, together with the researcher.

Procedure

The session consists of two main parts: fill in the morphological chart, select components for three diverse concepts. In the beginning, the researcher introduced the topic of this project and

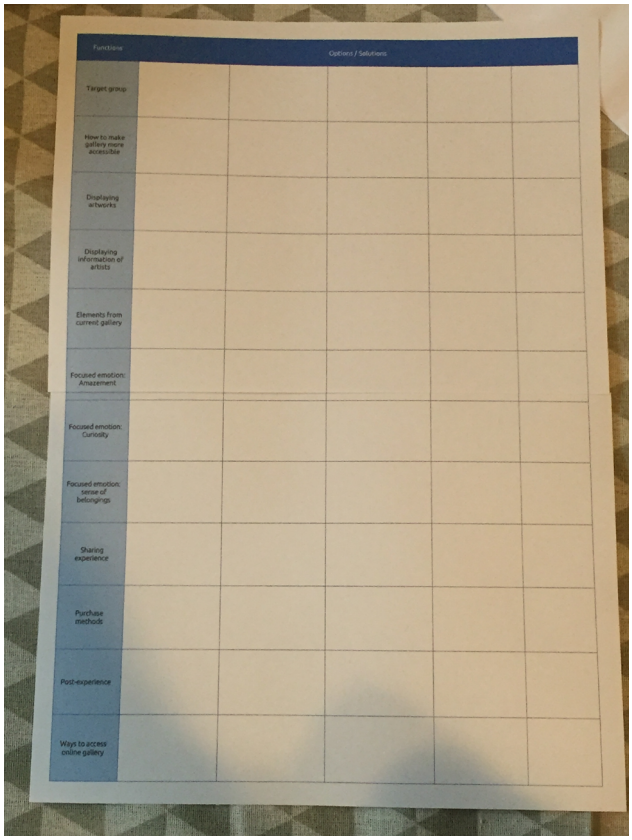


Figure 30. A printout of morphological chart used for co-creation

the main outcomes from the analysis phase, including the scenarios, target group (using persona card, *Figure 31*) and design requirements. After a short introduction of the morphological chart, participants started generating ideas for each "function". Then everyone could post their ideas under the "solution" columns in the chart.

In order to inspire extreme ideas, a sub-brainstorming was carried out on the three emotions (*amazement, curiosity, sense of belongings*) that the desired experience want to trigger. Participants

were asked to think related activities that involved each emotion. After that, the activities were clustered (*Figure 33*), and several common characteristics were concluded for each emotion. These common characteristics were used to fill in the morphological chart.

After finishing the morphological chart, the components for three diverse concepts were selected. The direction of the concepts was determined by the three key elements that the desired experience should consist (see *Figure 1*, and *Chapter B - section 4.1*), which were *approachable*, *emotions*, and *purchase*.

Figure 31. A persona card used to help participants know the target group quickly.

Figure 32. During co-creation

Results

The random combination of design elements opened the mind and led to various design directions. After discussion, three ideas were selected for further development because they were distinctive to each other in different aspects and logically narrative. In this way the pros and cons of each aspect can be tested ultimately and combined into one final concept after evaluation.

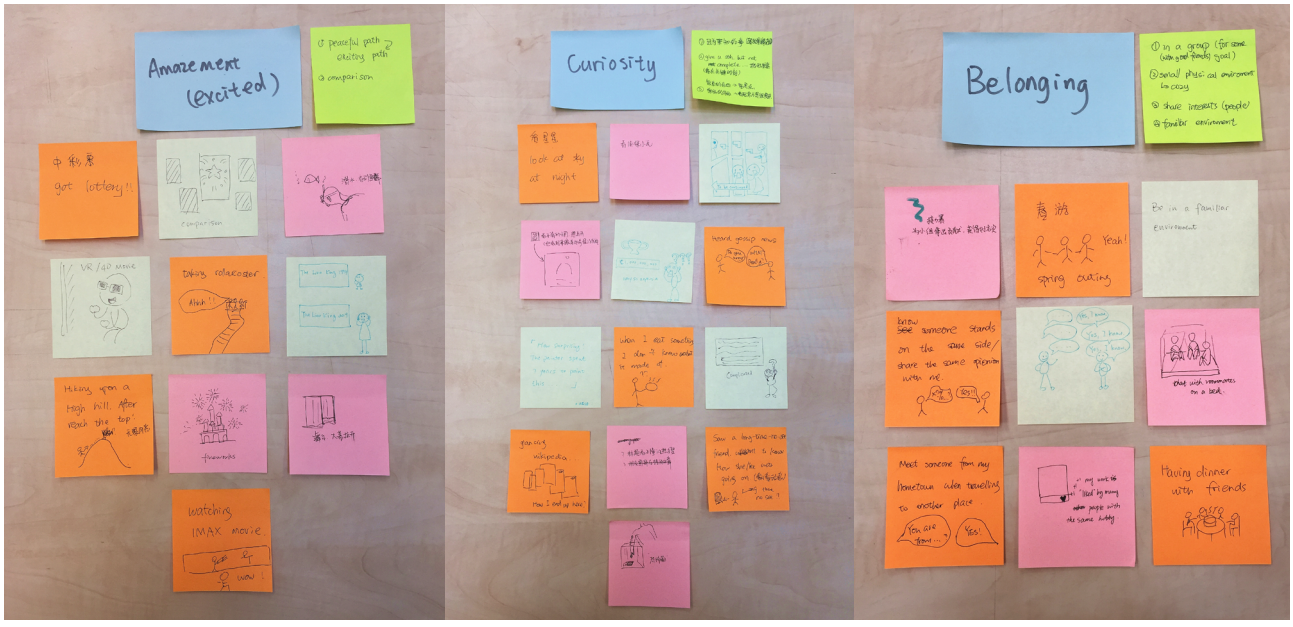


Figure 33. Clustered activities under three emotions

02 THREE CONCEPTS

By combining elements on each function in the morphological chart, three concepts were developed.

2.1 Concept 1: Stories behind the paintings

Focused direction: Approachable

– making the gallery more approachable doesn't only mean to make the appearance more approachable, but also should include getting know more about the artists who create the artworks. As gallery visitors often indicated they would like to get more contacts with the artists (*Chapter B - section 1.1.9*). Helping the visitors to feel closer to the artists should be an important way to lessen the distance between art and them. Therefore, this concept focuses on making the gallery, art and artists more approachable for the visitors. *Figure 34* showed how this concept was developed from a morphological chart.

Description

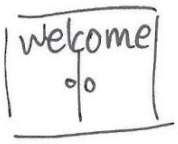
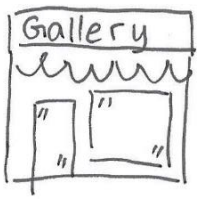
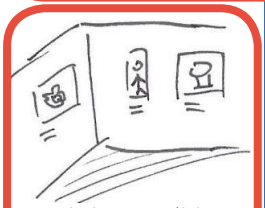
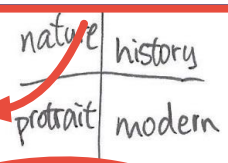
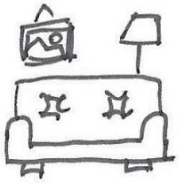
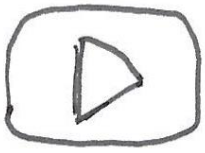
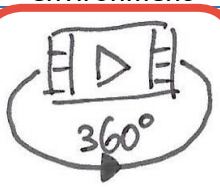
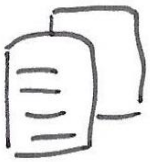
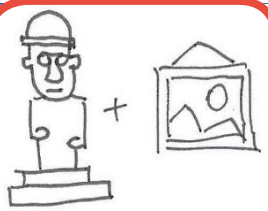
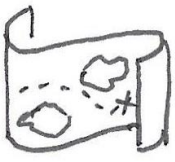
[text in brackets are the design reasons]

As a user wears the VR HMD device, he will enter a similar space like in the physical gallery *[elements from current gallery]*. He is free to look around, indications will suggest him to walk closer to an art piece. If he walks close to an art piece, a flat video showing the artist working on the art piece will start playing automatically. As he presses the video, he will enter an environment in a 360-degree video, watching the artists doing their works *[getting closer with the artists, knowing the stories behind one artwork]*.

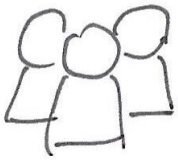
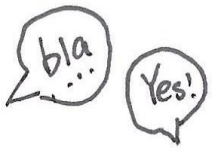
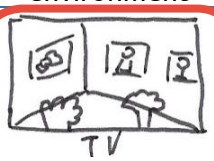
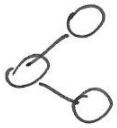
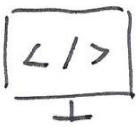
After he exits the video, he can touch the art piece to open the information window of the art piece. Under the art piece, he can see a "like" button, indicating how many people have liked this artwork *[creating sense of belongings]*. There is also another button called "show all artwork from this artist", by pressing this, the whole gallery will be redecorated with artworks only from this artist *[getting closer with the artist]*. Another button "default gallery" will change the gallery into default decoration.

He will notice that he is carrying a basket for shopping at all time *[reminding purchase behavior]*. As indicated in the information window, he can grab the art piece and put it into the basket to show purchasing intention. As he opens his shopping basket, he will see the details of the art pieces he has chosen. He can choose to continue viewing or buy all in the shopping cart. A third option is available to "save all in a postcard". In this way, he will get a freshly printed postcard after the experience, with all the information from his shopping cart and indicating he can continue buying online *[offer options for post-experience actions]*.

The experience flow is shown in *Figure 35*.

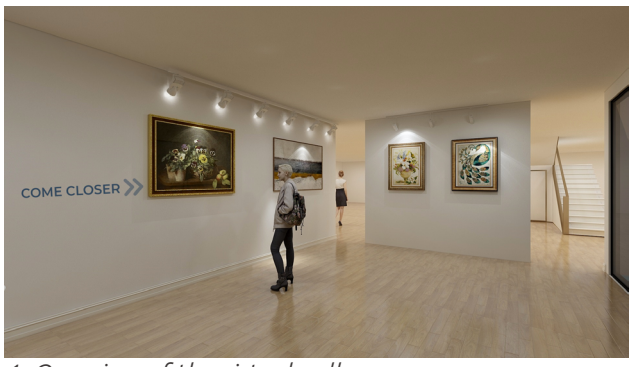
Functions	Options / Solutions				
Target group	 20-40, looking for unique and creative lifestyles				
How to make gallery more accessible	 Welcoming entrance	 Coffee & relaxing area	 Transparent to see		
Displaying artworks	 Exhibition (like current gallery)	 Exhibiting in different themes (categories)	 Presenting in home environment		
Displaying information of artists	 Photos	 Videos	 Immersive 360° videos	 Texts	 Not much information
Elements from current gallery	 Gallery owners	 Physical paintings & sculptures			
Focused emotion: Amazement	 Need efforts of exploring	 Offer surprise during experience	 Showing comparison of improvements		
Focused emotion: Curiosity	 Adventurous	 Giving clues but not complete result	 Seeing something you don't understand		

next page

Focused emotion: sense of belongings	 Present in a group	 Be in a familiar environment	 Shared interests / opinions		
Sharing experience	 Multi-person interaction	 Share the experience in a big TV that everyone can see	 Share experience online (broadcasting)	 Share experience on social medias	
Purchase methods	 Physical purchase	 Virtual shopping basket	 Shopping via computers in store		
Post-experience	 Sending business card	 Sending a postcard with artworks in shopping cart			
Ways to access online gallery	 QR code printed	 Website	 Accessible via computers in the store		

Concept 1

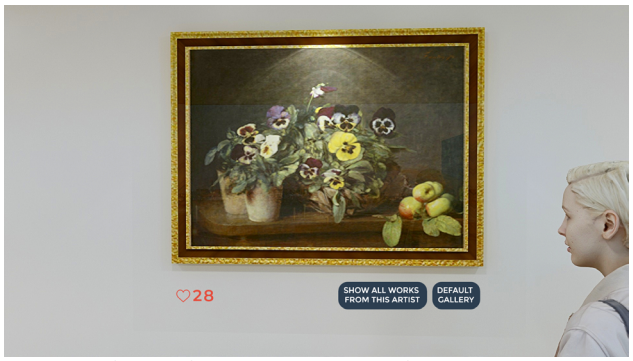
Figure 34. Morphological chart for concept 1



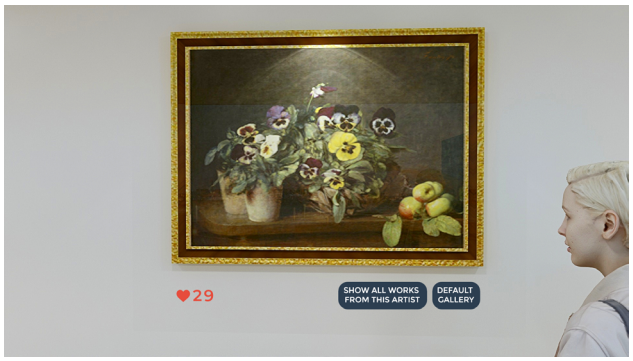
1. Overview of the virtual gallery

2. Video starts playing when close to an artwork

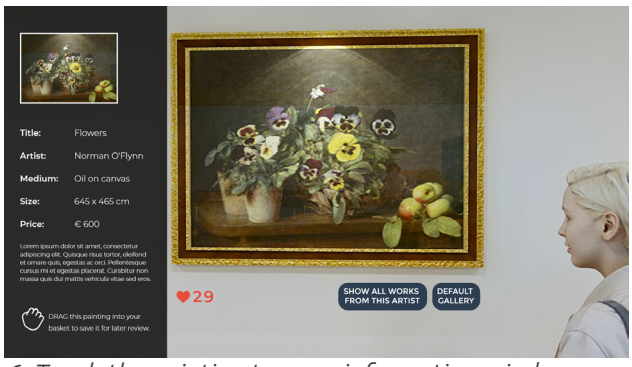
3. Enter the 360-degree video in the artist's studio



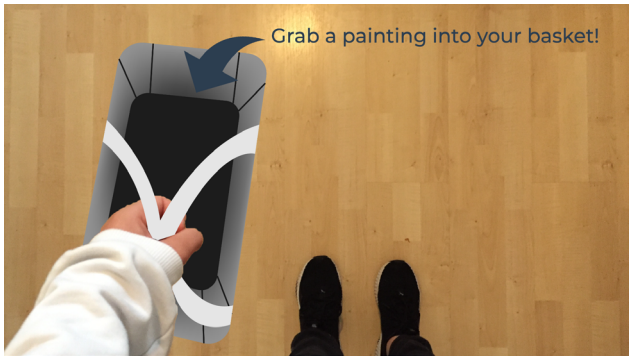
4. Exit video and seeing options under the painting



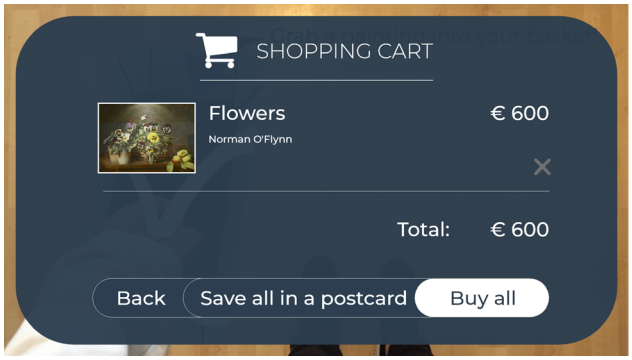
5. A user can press "like" button



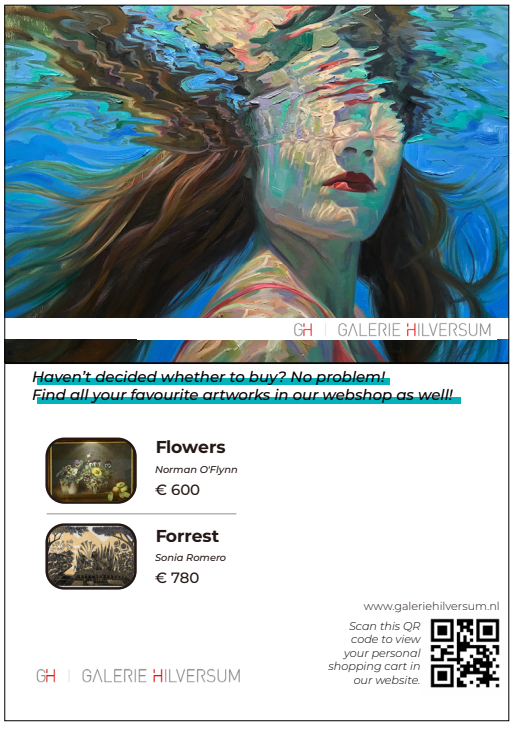
6. Touch the painting to open information window



7. Grab the painting to put into shopping basket



8. Open the basket to see shopping cart



9. Option to save all information in a freshly printed postcard

Figure 35. Experience flow for concept 1

2.2 Concept 2: Adventurous Collection (Themed room)

Focused direction: Emotions

– one of the big barriers that many galleries can hardly attract visitors is their lack of interesting stimulations. Visitors couldn't find many things that can stimulate their interests to explore in the current gallery for a longer time (see *Chapter B - section 1.3)*. Therefore, they always leave the gallery within five minutes, which lower the chance they will purchase. Hence this concept intensifies the emotions (amazement & curiosity) to continuing stimulates users' interests to explore the virtual gallery. *Figure 37* showed how this concept was developed from a morphological chart.

Description

[text in brackets are the design reasons]

As a user wears the VR HMD device, he will enter a room similar to the physical gallery, but with different tunnels direct to different themed room *[giving hints for exploration, triggers curiosity]*. If he chooses one themed room to enter, for example, the "nature" themed room, he will be transferred to a wild scene in a forest *[distinctive scenes triggers amazement]*. He is free to walk around and explore. Several art works are scattered here and there. He can hear the sound of birds and winds just like in the wild *[stimulation of different sensations improves amazement]*. He can see indications of where the previous visitors have standing on [creates sense of belongings].

There's a backpack on his hand, and indicating he can collect the artworks by putting them into his backpack. As he gets closer to the artwork, he can touch the artwork to show the basic information of it. After he left the themed room and back to the central gallery, the artworks he collected will be displayed in the gallery *[displaying artworks in a relatively real environment helps to see them clearly]*.

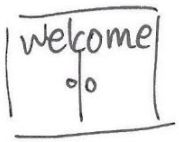
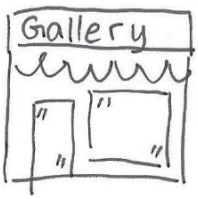
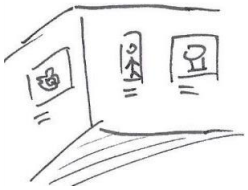
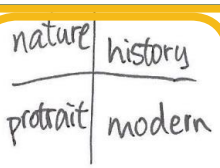
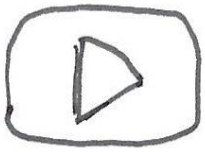
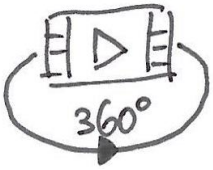
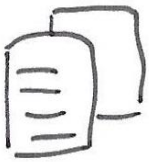
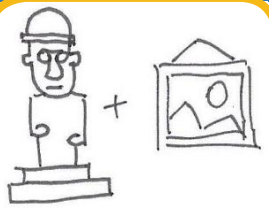
There's also an exit door in the virtual gallery, as he enters the door, the shopping cart will be shown asking whether he wants to buy the artworks. He also has the option to save all information to a postcard *[offering post-experience service]*.

The experience flow is shown in *Figure 36-1 & 36-2*.

1. A tunnel to the nature themed room

2. An overview in the nature themed room, indications remind you to collect artworks

Figure 36-1. Experience flow of concept 2

Functions	Options / Solutions				
Target group	 20-40, looking for unique and creative lifestyles				
How to make gallery more accessible	 Welcoming entrance	 Coffee & relaxing area	 Transparent to see		
Displaying artworks	 Exhibition (like current gallery)	 Exhibiting in different themes (categories)	 Presenting in home environment		
Displaying information of artists	 Photos	 Videos	 Immersive 360° videos	 Texts	 Not much information
Elements from current gallery	 Gallery owners	 Physical paintings & sculptures			
Focused emotion: Amazement	 Need efforts of exploring	 Offer surprise during experience	 Showing comparison of improvements		
Focused emotion: Curiosity	 Adventurous	 Giving clues but not complete result	 Seeing something you don't understand		

next page

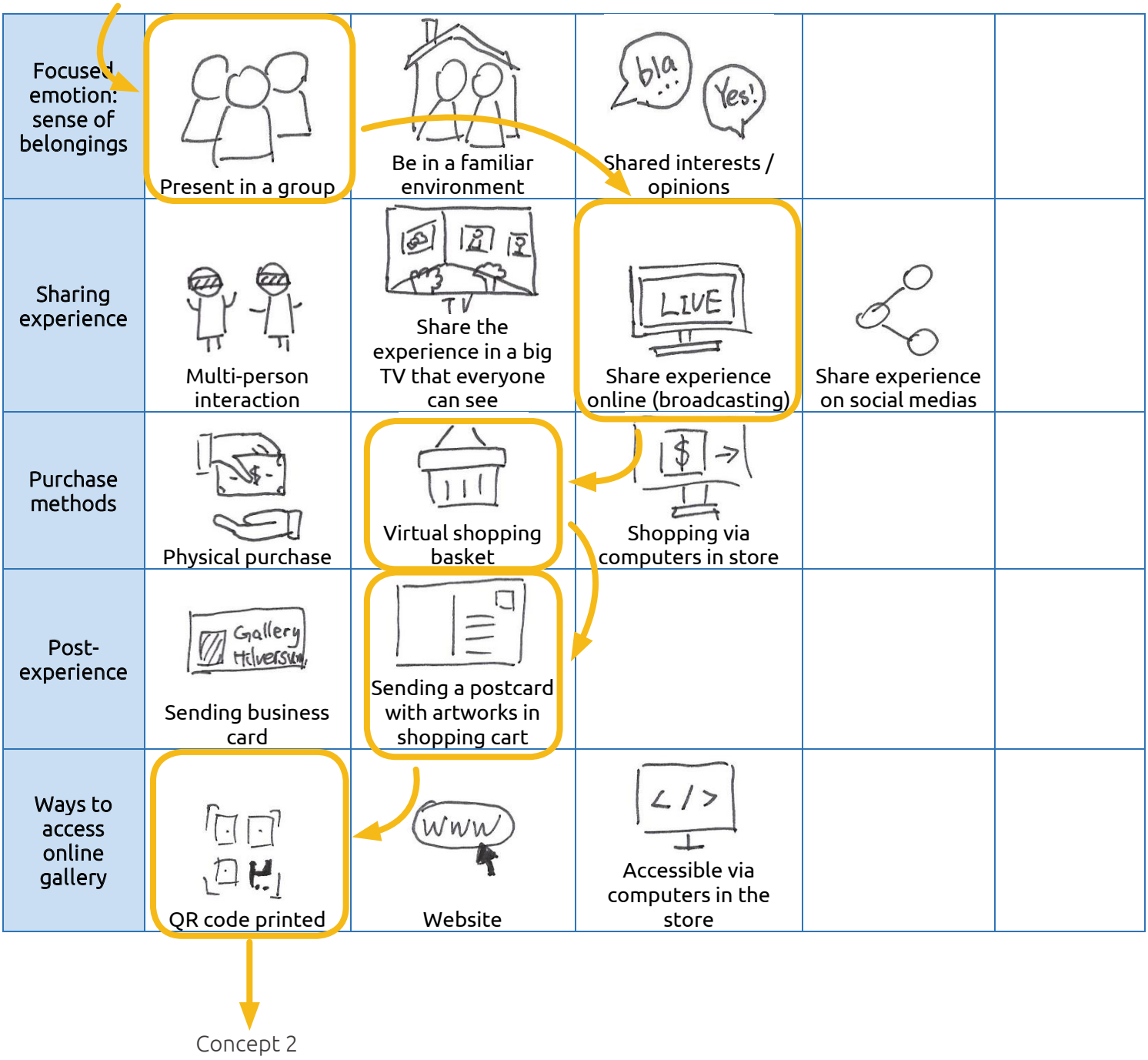
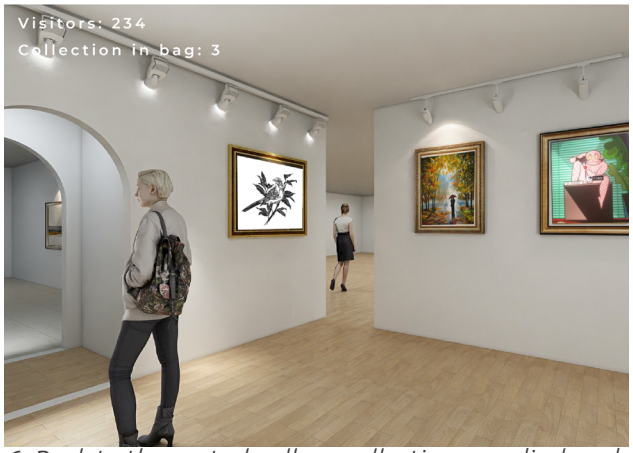


Figure 37. Morphological chart for concept 2

3. see the backparck on your hand

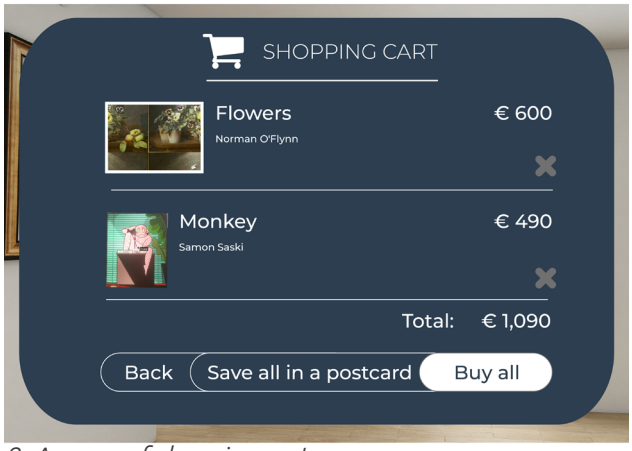
4. Walk closer to a painting

5. Grab and collect it to your backpack

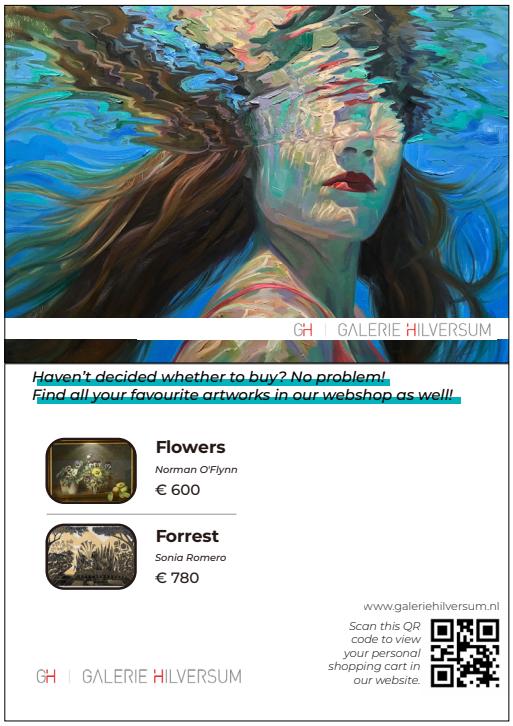


6. Back to the central gallery, collections are displayed in the gallery

7. Go to exit door to leave / enter shopping cart



8. A scene of shopping cart



9. Option to save all information in a freshly printed postcard

Figure 36-2. Experience flow of concept 2

2.3 Concept 3: Find your perfect art piece for your home!

Focused direction: Purchase

– another important problem for current gallery is the low conversion rate. This was caused by various reasons: vague price, too high price, doesn't know how to buy, doesn't know whether the art piece suits, etc. (*Chapter B - section 1.2.1*) Many visitors visit the gallery without having intention to buy anything. Some of them may have the confusion on whether a gallery is a place to exhibit or to sell artworks. In this concept, it focuses on helping customers to find their suitable art piece for their home and encourage purchases. It is designed into an obvious commercial space that sells artworks, so that customers have the feeling that they are here to purchase. *Figure 39* showed how this concept was developed from a morphological chart.

Description

[text in brackets are the design reasons]

As a user wears the VR HMD device, an interface will be shown letting him to choose the most similar interior style of his taste *[direct selection]*. After he chooses the desired interior design, he will be guided in a normal living room that decorated with various artworks. He is free to walk around the apartment to see different decoration.

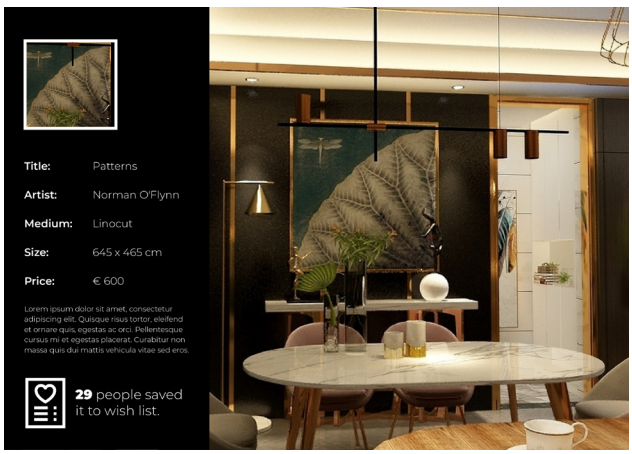
If he walks closer to a selling artwork, the detailed information will be shown automatically in the screen. He can see how many people have saved the art piece to wish list *[create sense of belongings, and also creates urgent feeling that he should buy it fast if many people have indicated interests]*. He can also add the art piece to wish list by posting the stickers that in his hand on the art piece.

He can see the button to open his wish list by standing in a distance to the artworks. The wish list also offers three options including saving in postcards or buy all *[offering post-experience service]*.

The experience flow is shown in *Figure 38-1 & 38-2.*

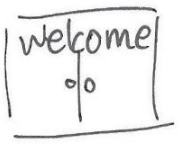
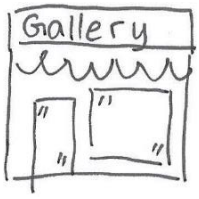
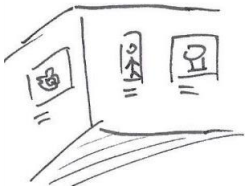
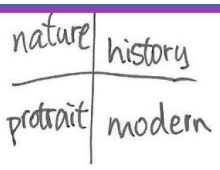
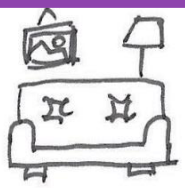
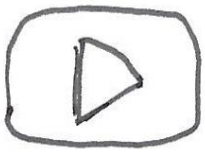
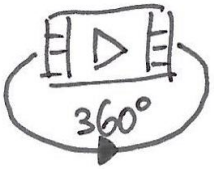
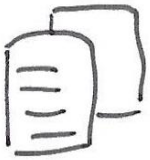
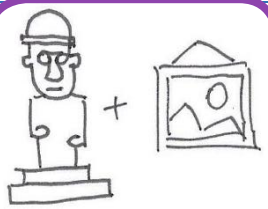
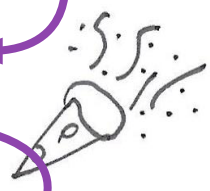
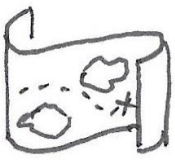
1. choosing desired interior style

2. Entering an appartment that is free to explore



3. Getting closer to an art piece will trigger information interface.

Figure 38-1. Experience flow of concept 3

Functions	Options / Solutions				
Target group	 20-40, looking for unique and creative lifestyles				
How to make gallery more accessible	 Welcoming entrance	 Coffee & relaxing area	 Transparent to see		
Displaying artworks	 Exhibition (like current gallery)	 Exhibiting in different themes (categories)	 Presenting in home environment		
Displaying information of artists	 Photos	 Videos	 Immersive 360° videos	 Texts	 Not much information
Elements from current gallery	 Gallery owners	 Physical paintings & sculptures			
Focused emotion: Amazement	 Need efforts of exploring	 Offer surprise during experience	 Showing comparison of improvements		
Focused emotion: Curiosity	 Adventurous	 Giving clues but not complete result	 Seeing something you don't understand		

next page

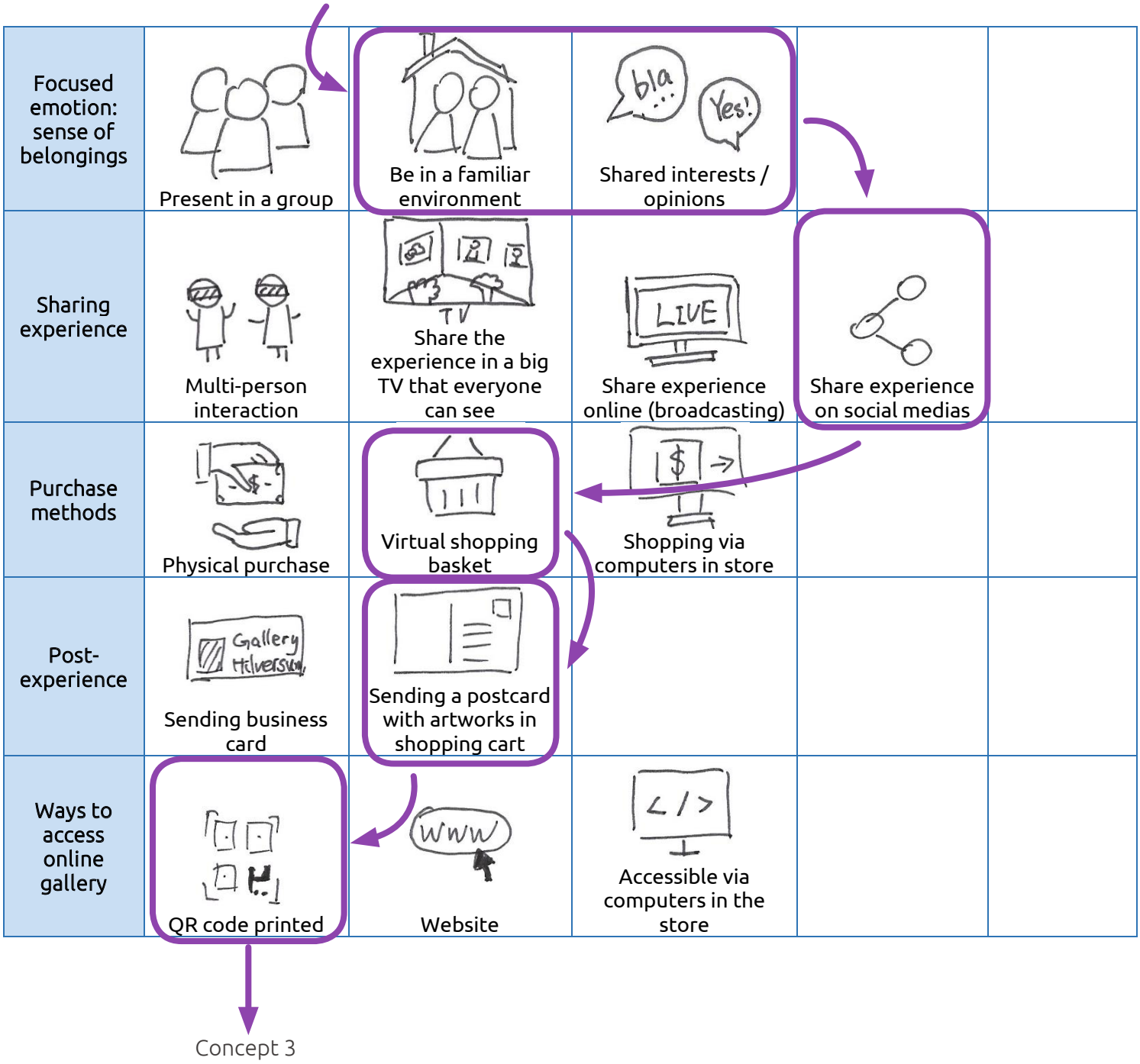
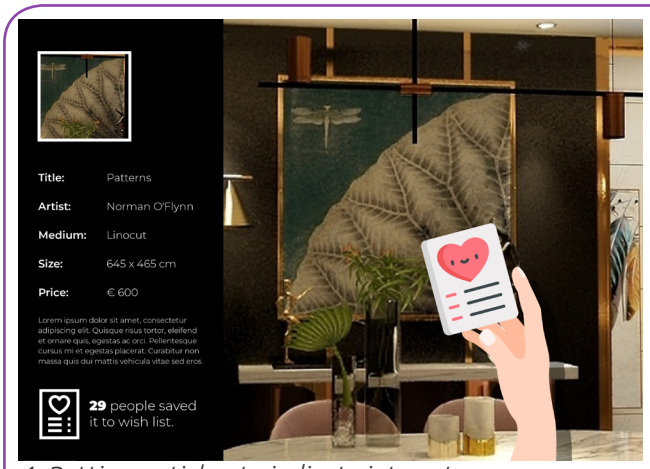
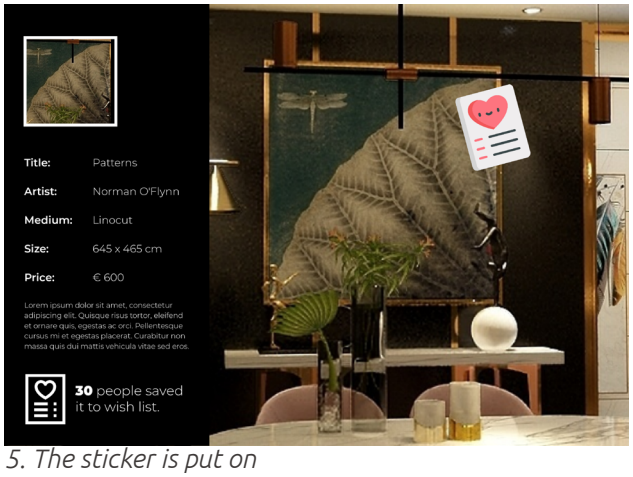


Figure 39. Morphological chart for concept 3

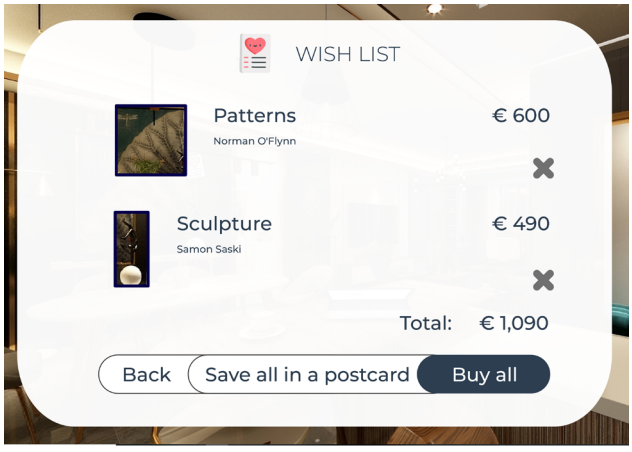


4. Putting a sticker to indicate interest

6. Back to the middle of the room to overview the room



5. The sticker is put on



7. Opening wish list to do different actions

Figure 38-2. Experience flow of concept 3

03 USER TEST

The three concepts above were used in user testing in order to get more insights from the users and further iterate to the final concept. The user tests were evaluative session to make sure the storylines of the concepts are clear to understand, and the interactions were intuitive and logical. In this session, the user test process will be elaborated.

For this user test the choice was made to execute a within-subject (Charness, Gneezy & Kuhn, 2012) comparative analysis between the concepts. This enabled a direct comparison that could effectively communicate the influence of the different elements.

Setup

Paper prototypes (Snyder, 2003) were made and printed (*Figure 40*), supported by multimedia contents. A VR Cardboard and a mobile phone was provided to experience the basic environments and 360-degree video. A miniature model of the new physical gallery was made to help the participants immersive to the scenario (*Figure 41*).

A questionnaire was designed to collect general information from the participants and assessed based on ease of use, interests to use and helpfulness of each concept. The complete version is in Appendix 6.

Figure 40. Paper prototypes

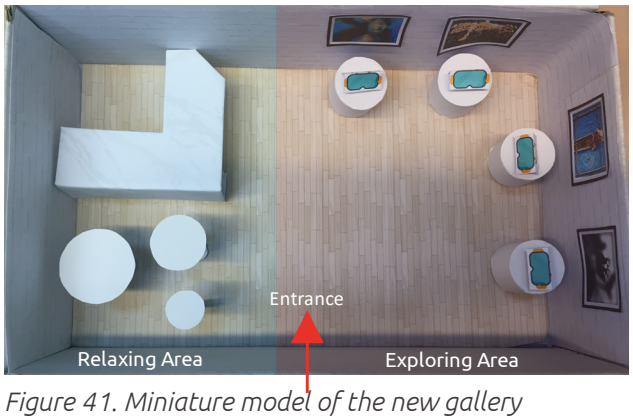


Figure 41. Miniature model of the new gallery

Participants

10 participants, 4 males and 6 females, aged from 24 to 31 years old.

Duration

Around 30 minutes for each participant.

Scenario

Visiting a gallery without purchasing plans.

Goal

To understand how intuitive each of the concepts are and what users like and dislike about them, in order to compare the three concepts.

Procedure

Participants were asked to imagine they were going to visit a gallery without purchasing plans. The storyboard of visiting a gallery and the miniature model of the new physical gallery was shown as an instruction to let people immersive the whole user journey.

When participants picked up the VR device in the miniature model, they were started being presented with one concept. Here they could start interacting with the paper prototypes and the researcher would make changes to the interface of the paper prototypes corresponding to their actions (*Figure 42*). Following the instructions, participants would go through every function.

After finishing going through the user journey of one concept, the steps were repeated for the other concept. The order of showing the three concepts was changed for different participants

Figure 42. Participant interacts with paper prototypes

Figure 43. Participant experiences an immersive video

to avoid the influence of order.

During the test, participants were encouraged to think out loud. After trying all the concepts, they were asked

to fill in the questionnaire and rank for the three concepts (*Figure 44*).

In the end, the participants were interviewed by the researcher to talk about what they liked and what they didn't like for each concept and explain the reasons behind their choice.

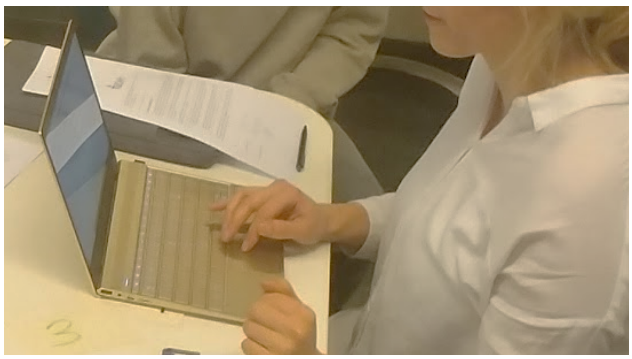


Figure 44. Participant filling a questionnaire afterwards

04 RESULTS

Each concept was assessed through a combination of judgement-based and performance-based analysis methods. The data was gathered through the use of observation, questioning and questionnaire.

From the questionnaire, we can know that most of the participants feel comfortable using digital products and all of them have some experience with either simple VR or advanced VR devices (*Figure 45 & 46*). The results from the questionnaire (Appendix 7) can be seen in *Figure 47*.

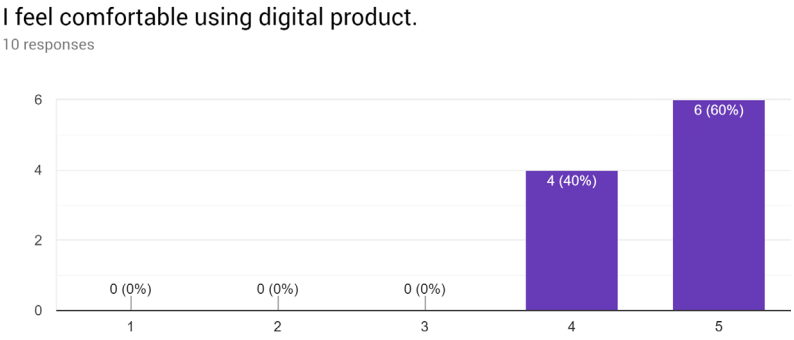


Figure 45. Results of participants' attitutes towards digital product

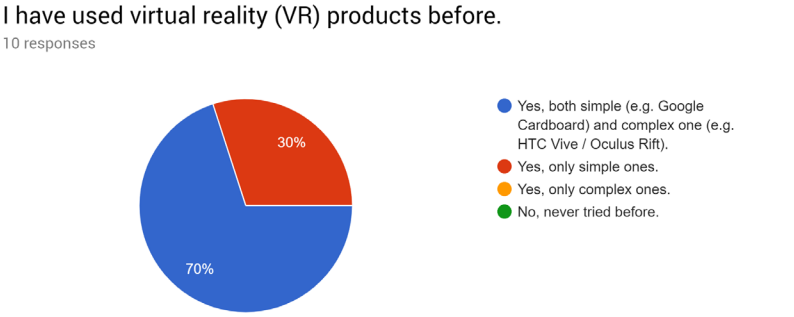


Figure 46. Results of participants' experience with VR products.

The results (*Figure 47*) from the questionnaire showed that concept 3 scored highest on average, however, concept 2 scored much higher than the other two concepts in triggering curiosity during the experience (question 2 & 5).

Participants were asked to give two ranks based on their liking and usefulness. 5 out of 10 participants chose concept 2 to be their favorite concept (*Figure 48*), yet 9 out of 10 scored concept 3 to be the most useful concept. (*Figure 49*)

Since there were limited amounts of participants in this test, the results may bias due to the small quantity. Therefore, we should pay more attention to the qualitative results from observation and interviewing with the participants, and get to know the deeper reasons under their choice. The pros and cons for each concept were concluded after analysis.

Figure 47. Overall results from questionnaire

10. Please give a rank to the three concepts from most favorite to least favorite.

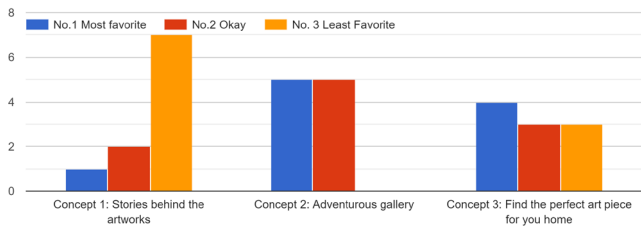


Figure 48. Ranking based on liking

14. Please give a rank to the three concepts from most useful to least useful.

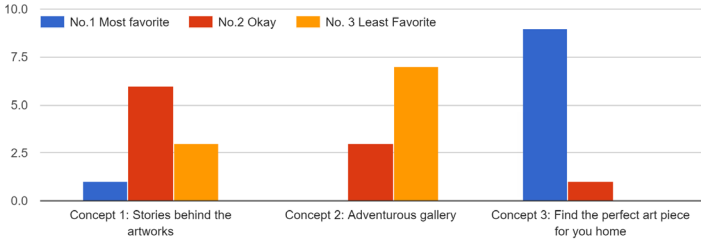


Figure 49. Ranking based on usefulness

Concept 1: Stories behind the paintings

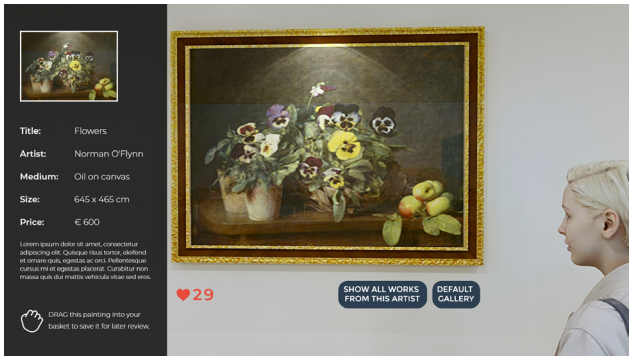


Figure 50. A scene in concept 1

Positive

- The storyline is clear and easy to understand.
- Similar virtual environment to the physical gallery decrease discomfort.
- Video of artists is attractive to watch.
- The information interface is informative.
- The way of grabbing a painting is intuitive.
- It has the most guidance among the three concepts which was appreciated.
- Love the postcard.

Negative

- Participants prefer to only look at what the artist is doing (no talking).
- Video should not be too long.
- Video should be presented next to the artwork, rather than covering the artwork.
- Basket can be designed better.
- The info page should be popped up by itself, instead of touching.
- Button "Show all from an artist": users prefer popping all works in front of them immediately rather than change the whole gallery.

Concept 2: Adventurous Collection (Themed room)

Figure 51. A scene in concept 2

Positive

- Very appealing and different environment gave great visual stimulation.
- Interesting interaction of collecting things.
- Different sensations (natural sounds) escalated the experience.
- It increases impulsive purchasing, but they may regret after they are back home.
- A transition between themed room and the central gallery

Negative

- Participants seemed to focus more in the environment than the artworks, attention was distracted.
- Categorized by themes may cause aesthetic fatigue of one type of artwork.
- Need more guidance throughout the process (how to interact, what can they interact).
- The bag seems too small for the artwork, requiring some transforming of artworks when putting them into the bag.

Concept 3: Find your perfect art piece for your home!

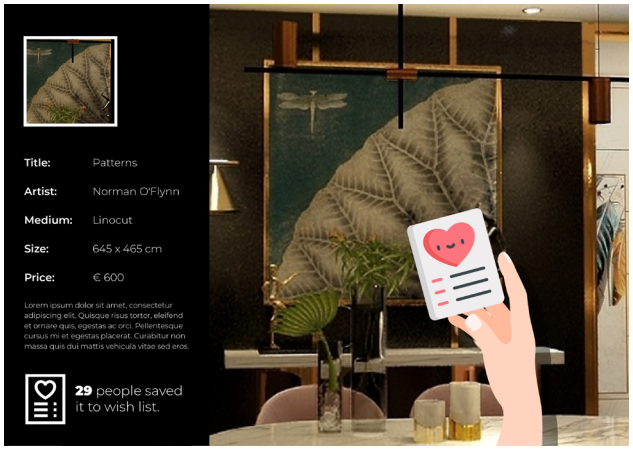


Figure 52. A scene in concept 3

Positive

- Easy, direct and most useful.
- Always know you are here to buy art.
- Experience only need short time.
- Intuitive and easy-to-learn interactions.
- Seeing people putting one painting into Wishlist makes user feel the painting is popular. There was an urgent feeling to buy their desired artworks.

Negative

- Less interactions compared to the first two concepts.
- Less interesting than the first two concepts.
- Feels more like an IKEA than a gallery, may need to increase the amounts of artworks.
- How many styles is suitable? Not sure whether five style is a too much or more than enough.
- The styles were too ideal, should find some example that were more common.
- Lack of guidance

Conclusion

Concept 1 and concept 3 both have a clear and logical narrative, and they are most related to purchasing artworks in virtual environment. They have different directions and focus points, which are both considered to be in line with the design goal. Therefore, most elements from these two concepts will be considered integrating into the final concept.

Although concept 2 were the most favorable concept, mainly because its interesting setting and attractive virtual environments. Users would pay more attention to enjoy the virtual environment and interactions, forgetting they were here to purchase some artworks.

So some interesting elements may exist in different forms in the final concept, we should pay more attention not to blur the prior focus for the desired experience, which were making the gallery more approachable, triggers emotions, and eventually leading to encourage purchasing.

05 FINAL CONCEPT

Using the conclusions from the last session, a converging concept proposal was designed and iterated upon. In this part, we will introduce the key elements that should be included in the final concept, and present the converging design proposal.

Key elements

- **Instructions and simple training session:** During the user tests, several users express the need of some guidance on where and what to interact. Simple training session on the controllers of the VR devices will also be needed since VR devices are not a common device that everyone is familiar with.
- **360-degree video:** This was affirmed during the user tests. People appreciate some contacts with artists behind the artworks. They do not need much interaction with the artists, just observing quietly on what the artists are doing is more than enough for them. This is also feasible for the artists, since they do not want much disturbance during their creation, a quietly recorded 360-degree video will be suitable in this situation.
- **Gallery-like environment:** Most users prefer a gallery-like space in the virtual environment, since then they feel less insecurity during the experience, and it helps reminding them the intention is to purchase something.
- **Explorative elements:** Since customers need some explorative elements to trigger their interests to stay longer in the gallery. The experience shouldn't be completely plain. Customers should have a certain freedom to explore or stop at any time. The whole experience should be a moderate time-consuming, not too short that still lack of attractions to the customers, but also not too long that will fatigue the users and make the gallery inconvenient during peak hours.
- **A way they can see how the artworks look in home environment rather than in the gallery:** Customers of the gallery often said they don't buy artworks because they are unsure about how it looks at home. Some regrets may occur after seeing the difference when displaying the purchased artworks at home. Therefore, there should be some ways that can help them to view the artworks in a home environment, preferably at their home environment. It helps the customers to judge artworks in different settings.
- **The postcard including shopping information (post-experience service):** The postcard idea should be kept since everyone liked it. Although there is no guarantee that customers will purchase more after getting this postcard. It can be presented as a small present from the gallery and help them getting more audience. Ideally, the front side of the postcard should be printed with one of the artworks the customer selected into the shopping basket. Yet it

may cost a fair amount of time to print a good qualitied picture in real situation. Therefore, the postcard may better be pre-printed in one side with several selected artworks to decrease the waiting time at the gallery.

Description

The final concept should consist of three scenes: training scene, gallery scene, home scene.

Training scene: (*Figure 53, 54*) Users will first enter this scene after they wear the VR HMD devices. One statue will be presented in the middle of the room. Guidance will show that user can walk closer to it. The information box will be shown automatically on the left side of the screen. A play button will appear on top of the artwork, user can touch the play button to play the 360-degree video. User will be indicated to put the sticker on the statue, to save the artwork into wish list.

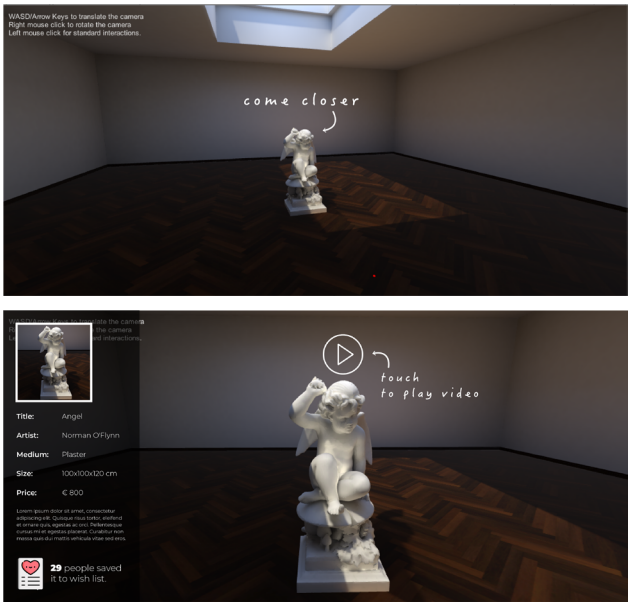


Figure 53 & 54. training scene

Gallery scene: (*Figure 55*) After the user finished the first task, the gallery will be decorated with various artworks, user can interact with various artworks, using the interaction he learned from the short training session.

Figure 55. gallery scene

Home scene: (*Figure 56*) There will be a teleporting point present in the gallery scene. If the user standing on the teleporting point for five seconds, he will be transferred to a home environment, which will be a living room in this concept. He can then open his wish list, and carries out the saved artwork, and put it into the scene to see. He can always assess the Wishlist from a button in the left controller. He can adjust the Wishlist whenever he wants.

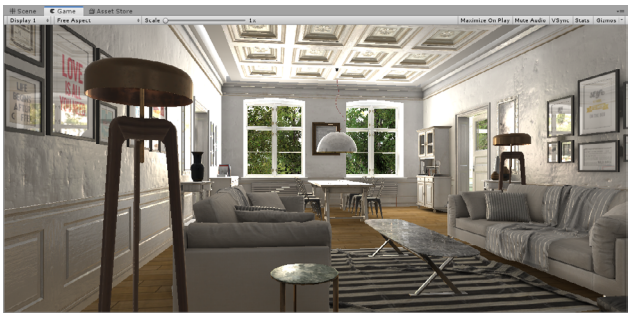


Figure 56. home scene

If he finished glancing, he can open the wish list to choose to buy all or save all in a postcard. If he chooses to save all in a postcard, a postcard will be printed with the saved artworks from his Wishlist.

D

DESIGN

- PROTOTYPING -

Design explorations were done, and it is time to put the theoretical knowledge into a practical prototype.

CHAPTER SUMMARY

In order to develop the concept into a virtual gallery prototype, four steps were carried out:

• *Building the virtual environment*

The company Sonolux provided a virtual gallery frame only including a room, and a statue in the middle of the room. The researcher adjusted the frame and decorating the room using some exiting models from the Unity assets store.

• *Implementing 3D scanned artworks*

The art collective GSA provided three sculptures and sent them to the university for the researcher to 3D scan. The researcher carried out the whole 3D scanning process and post-processed the scanned models into 3D models that can be rendered and used in virtual environments afterwards.

• *Recording 360-degree videos of artists*

The researcher carried out experiments on the possibilities to record a desired 360-degree video for revealing the creating process of an artist. Yet an existing 360-degree video (https://youtu.be/nluot_Jeef0) will be used for evaluation in this prototype due to the time limits.

• *Developing interactions in virtual space*

The researcher defined the user interaction flows in prior. Key interactions were determined and developed in virtual space using the software Unity.

This process can be used as a guideline for researchers or designers who want to develop a virtual gallery, decisions were made by certain reasons which would be explained in the following articles.

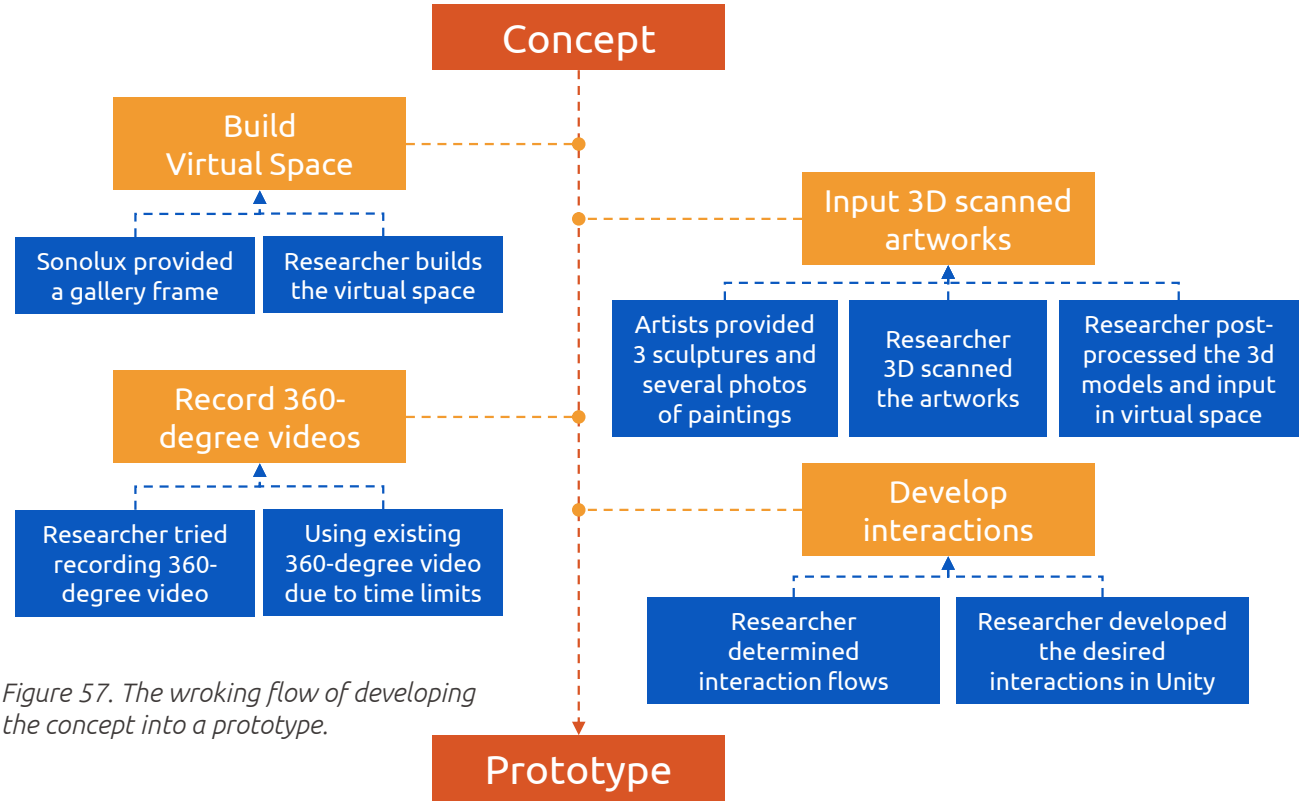


Figure 57. The wroking flow of developing the concept into a prototype.

01 CONSTRUCTING VIRTUAL GALLERY

Before implementing everything into the virtual gallery, we need a virtual space of the gallery. The construction of the virtual gallery meant to build a 3D model of the space of the gallery excluding any interactions.

The company Sonolux provided a virtual space of a room similar to a gallery room (*Figure 60*) in Unity. This room only includes a model of a room and a statue put in the middle of the room. Besides, the Unity package was made for Oculus Quest. Therefore, the researcher needed to transform the Unity file suitable for HTC Vive since this device is available in the university for further user tests.

1.1 Adaptability for different platforms

There are two types of mainstream VR platforms: PC VR and Portable built-in VR.

Oculus Rift and HTC Vive are the representations of a PC VR headset, they require connections to a powerful PC. The visual contents are calculated by the PC and transmit to the headsets.

On the other hands, Oculus Quest and HTC Vive Focus are the representations of a built-in VR headset. At its most basic, it is an Android phone, you plug it into your computer like one, you deploy to it like one and you can access like one (with the Android SDK (software development kit) 's Android Debug Bridge (adb) tool).

Unity offers different platforms to build the programme, for example on PC or on Android. Therefore when developing in Unity, it's needed to switch the platforms for HTC Vive or Oculus Quest. In this project, the platform was switched from Android to PC since the researcher will build the prototype for HTC Vive (*Figure 58*). Unity transformed most of the codes automatically, yet some configurations needed to be made to run the programme perfectly.

Furthermore, the HTC Vive is based on Steam VR, it is needed to install Steam and its VR plugins to run the project. If you want to run the project for Oculus Rift in Unity, it is needed to download the Oculus Integration plugins from the Unity Assets Store. Besides, the Oculus SDK should be added in the Player Settings in Unity. The VR SDK list works as a first-come, first-served list of VR devices. If you have OpenVR (for HTC Vive) as the first SDK and Oculus as the second SDK then the VR system will try them in that order, see *Figure 59*.

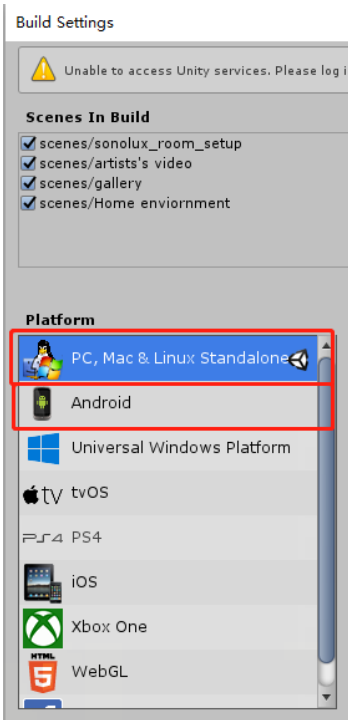


Figure 58. Swtiching different platforms in Unity

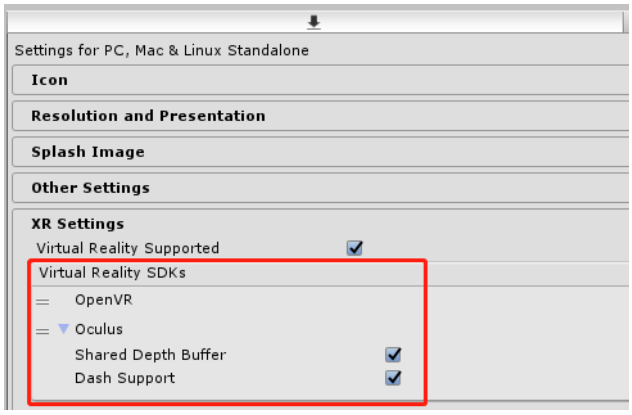
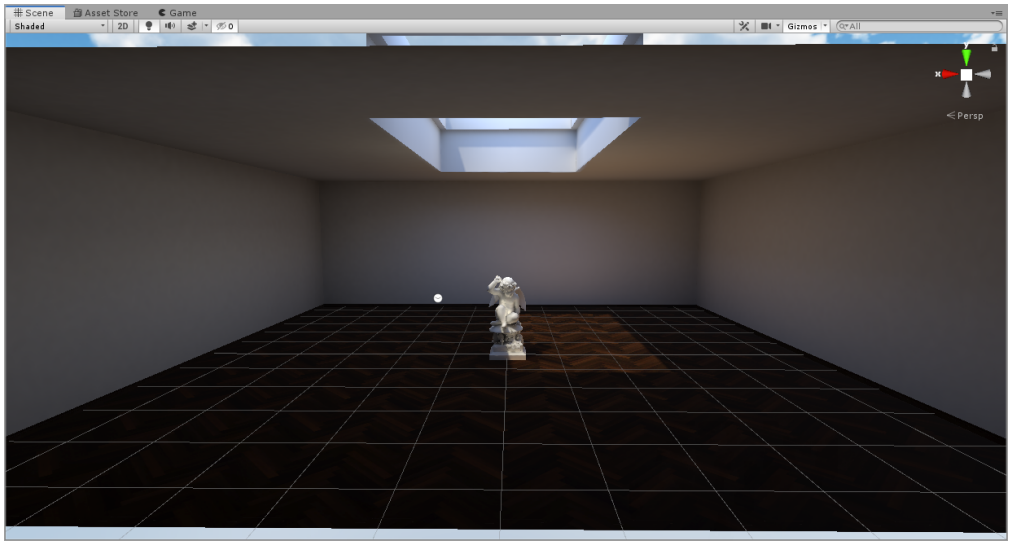


Figure 59. The player setting in Unity. In this order, the programme will try HTC Vive first, then Oculus.

1.2 Constructing virtual gallery

The first step was to set the gallery in a suitable size so that the artworks are displayed similar to real size even when they were in a virtual environment. This required some tests to find the best size. Eventually, the room was enlarged 1.5 times to the original file, while the statue remained the same size.

The second step was to construct the gallery. Since there would be two scenes of the experience, the training scene, and the main gallery scene. The training scene remained as the scene the company provided. Yet the main gallery scene was filled with more elements: including 3D models of ceiling lamps, wall lamps, exhibiting stands, painting frames and doors. These models were downloaded from the Unity Assets Store, and being put in the scene to simulate a real feeling of a gallery. The gallery scene after constructing can be seen in *Figure 61*.



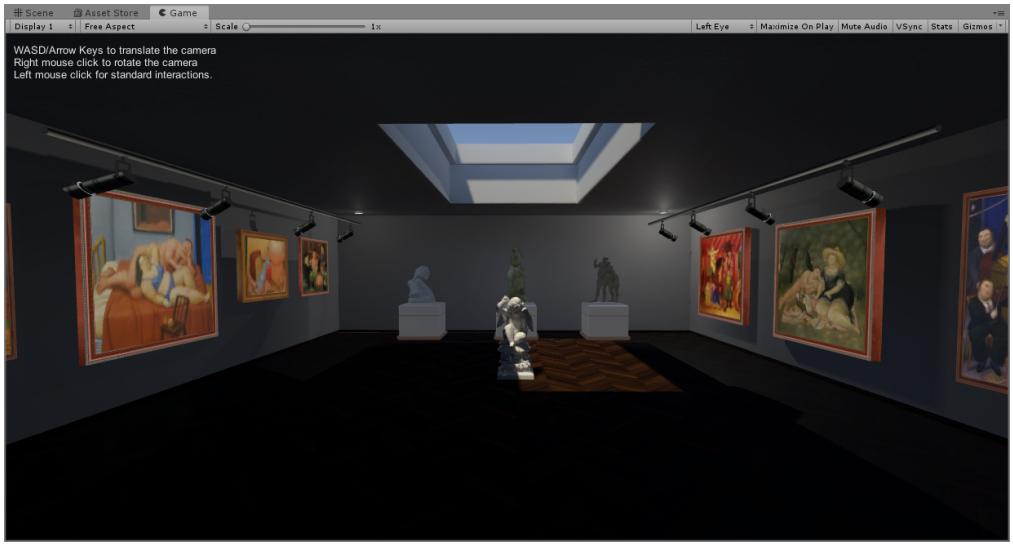


Figure 60 (Above). The scene company Sonolux provided
Figure 61(Below). The gallery scene after constructing by the researcher

02 INTEGRATING ARTWORKS

After constructing the virtual space for the gallery, we need to integrate some artworks into the gallery. There would be two types of artworks in the virtual gallery: photos and sculptures. The photos would be integrated as pictures and the sculptures would be integrated as 3D models from 3D scanning.

2.1 3D scanning for three statues

In order to integrate some digital models of the artworks from the artist Hetty Kook from GSA, three statues were selected for 3D scanning. They were sent to the university for 3D scanning by the company. The 3D scanning process was carried out by the researcher, after some guidance and teaching from the supportive staff.

The three statues were shown in *Figure 62*, *Figure 63* and *Figure 64*. The 3D scanner the researcher used for 3D scanning is Artec Eva. It is a photogrammetric scanner that recording, measuring and interpreting photographic images and patterns to compose a 3D model. Since the principle for a photogrammetric 3D scanner to scan is to take photos of the objects that are in the same certain distance to the scanner. There will be some difficulties to scan parts that have different distance or parts have small gaps that the scanners cannot see. The difficulties of scanning each statue and corresponding solutions would be explained in the following texts.

Statue 1: Upper part of a woman, head leaning against her right hand.

Size: 50 x 30 x 24 cm

This statue was made of clay. Although it is hollowed inside, which would be different for 3D scanner to scan, it is not necessary to scan a perfect inside of the statue since the viewer would not see it. The main difficulties would be parts that have small distance in between. For example, on the front side, the area between under the head and the right hand, and the area between under her left breast and the left hand. (red arrows in *Figure 62*) To solve the problem, the statue was scanned in different angles. It was scanned first as its standing position, and then scanned in laying down positions. The models were post-processed together to make up a final one.

Figure 62. Statue 1

Statue 2: Upper part of a woman, head leaning to the left side

Size: 49x36x32 cm

This statue was also hollowed inside

and not need to be seen by the viewer, so only a general model of inside structure was scanned. The main difficulties of scanning this statue were under her hair, and the area between under her breasts and her left hand (red arrows in *Figure 63*). The sighting area under her hair was blocked by the half bottom of the statue, therefore, it is very hard for the scanner to scan under required distance to the part. The distance between under her breast and inside of her left palm was too small, and the sight was also blocked for the scanner to scan. After scanning from different directions and angles, there were still some holes remained in those areas. Therefore, the researcher used the filling-hole function during post-processing, the holes were filled with similar surface calculated by the programme.

Figure 63. Statue 2

Statue 3: Two women looking at a phone, the right one holding a phone on her right hand

Size:60x35x23 cm

This statue was in patina colour. The main difficulties to scan were the contact areas between the two women, and the area between their leg (red arrows in *Figure 64*). The contact areas between the two women have different distance to the scanner, so does the area between their legs. Therefore, it was necessary to scan in many different directions to fill the missing parts. Besides, the sight view was blocked in some angles that some areas remained holes even after many scans. This way the researcher needed to fill the hole when post-processing the model.

Figure 64. Statue 3

The procedure of 3D scanning

The components used during the 3D scanning included: a 3D scanner, a computer, a corresponding post-process software (Artec Studio), a rotating platform and the statue. The 3D scanner

Figure 65. Set up of the 3D scanning.

was connected to the power and the computer to transfer data it acquired. The scanning setting can be seen in *Figure 65*.

After setting the basic components, the statue was put on the rotating platform. It was the best to scan the statue without moving too much of the scanner while the statue rotated itself. In this way the scanner could keep a constant distance to the object it was scanning, errors could be reduced.

However, it was always not perfect to scan only from one angle. The distance between the scanner and the scanned object were not always the same, some details would not be captured for the first time. Therefore, the statue was put in different positions and the researcher moved the scanner to scan it from different angles (*Figure 66*). This needed to be repeated several times until every side of the statue was scanned.

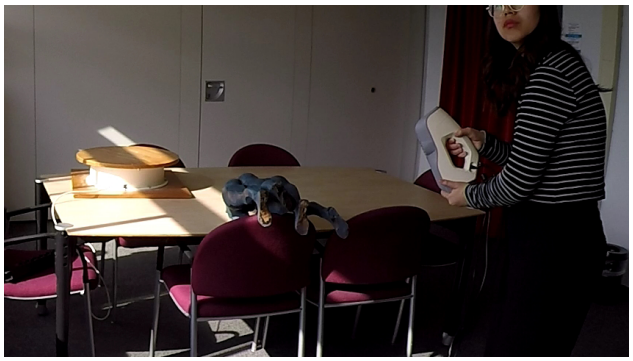


Figure 66. Scanning from different positions

After scanning several times, the raw data were post-processed into 3D models in the Artec Studio software. The point cloud needed to be registered and the surface of each part was edited smoothly. After that, several parts from different scans were integrated together into one model. If there were still holes in the model, the researcher would conduct further scanning in certain directions. If the holes could not be filled by scanning, the researcher used the filling-hole function to create a similar surface of the surrounding for the holes.

Compromise

In order to see how the texture would look like, the researcher generated a preview of adding the texture (*Figure 67*), the result was okay on the front

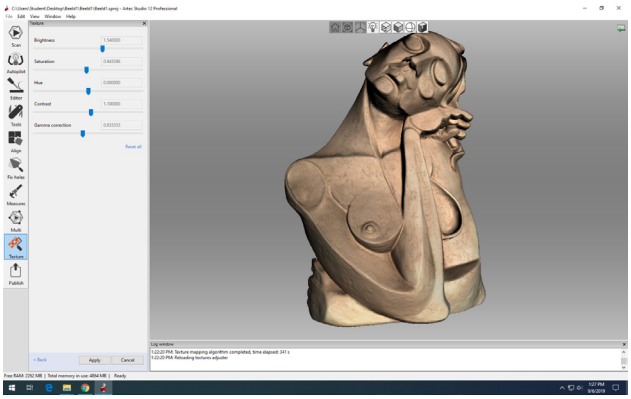


Figure 67. Previewed model with scanned texture

side, but uneven on the backside. This may occur because of the uneven lighting, shades were produced when scanning, so there were black shades on the backside of the model if texture was added. Due to the big capacity of one scanned file (around 2GB), and lack of powerful computer. It was extremely slow to add scanned texture on the model. Therefore, the researcher decided to export all 3D models without scanned textures. The downside was that the small details of the crafting traces (*Figure 68*) would be hard to notice in the 3D models. However, it allowed rendering a smoother and more even texture on the models using other post-processed software.

2.2 Photos

Some photos were provided by the company from the artists (*Figure 69*), therefore would be used in the virtual gallery prototype. The photos would

be framed using the frame models downloaded from the Unity Assets Store.

Figure 68. The uneven surface shows the traces of handcrafting

Figure 69. Going home from Nannita van Veen

2.3 Integration of the artworks

The 3D models of the statues needed to be post-processed before putting into the virtual gallery. Since the format exported from the 3D scanning was .stl file, which only contained the 3D structure of a model. Unity requires formats that contain texture file, so the models were rendered with some texture using other programmes, in this case the researcher used Keyshot for doing that. A .obj file was exported from Keyshot, and can be input into Unity. (*Figure 70*)

When inputting 2D images of the

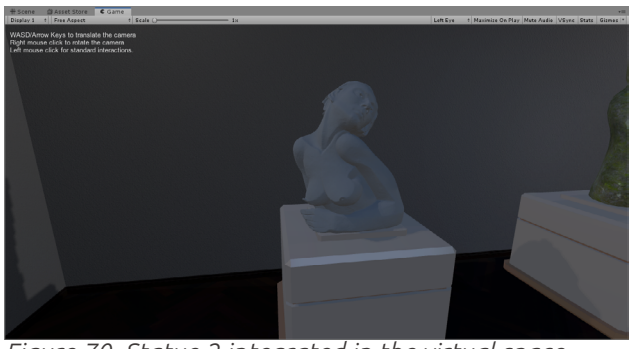


Figure 70. Statue 2 integrated in the virtual space

photos in Unity, the image would be input as a texture file. It is necessary to change the *Texture Type* of the image to *Sprite (2D and UI)*, see *Figure 71*. Otherwise, it could not be input in the 3D space.

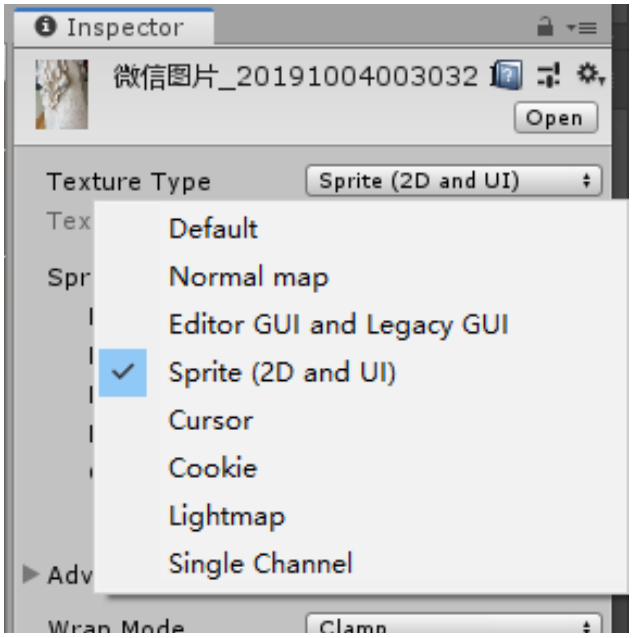


Figure 71. Changing format of a picture

03 INTEGRATING 360-DEGREE VIDEO

One of the key elements in the desired experience was to watch 360-degree videos of the artists doing their creation. To realize the concept, the researcher did research and experiments on recording 360-degree videos by herself. Besides, the researcher found a way to integrate the video in virtual space since it cannot be integrated directly to Unity.

3.1 Recording 360-Degree Video

A 360-degree video helps to immerse the viewer into the scene in the video. Just like recording a normal video using a camera, a 360-degree camera was needed to record a 360-degree video. With virtual reality headsets becoming more popular and more video platforms supporting 360-degree photos and videos, a lot of different brands of 360-degree cameras came to the market. The researcher borrowed an Insta360 One X (*Figure 72*) to do some tryouts and research on the possibilities of recording the 360 videos of the artists by themselves.

The researcher first tried to record 360 videos by putting the 360 camera at a fixed point in the room (*Figure 73*). The camera would record what the researcher did in the room, and viewers can move 360-degree around the viewing point. By testing, it was the best for viewing by putting the camera at an eye-level height when recording. The position of the camera in the room didn't influence much of the quality of the video. Where the camera was put would be where the viewer would stand and view the video. So you want to record some detailed work of a creation process, it may be better to put the camera closer to the creation point. Otherwise, it would be too far away from the area that the viewer could not move towards it when viewing in VR.

Figure 72. Insta360 One X from https://www.insta360.com/product/insta360-onex

Figure 73. Doing experinment by recording at a fixed point

After trying on recording at a fixed point, the researcher tried to record

the video in a designated route. Since a participant mentioned to design a guided tour of visiting an artist's studio, it may be interesting to explore the feasibility of recording a guided tour. The research tried three ideas to record a guided tour (*Figure 74*).

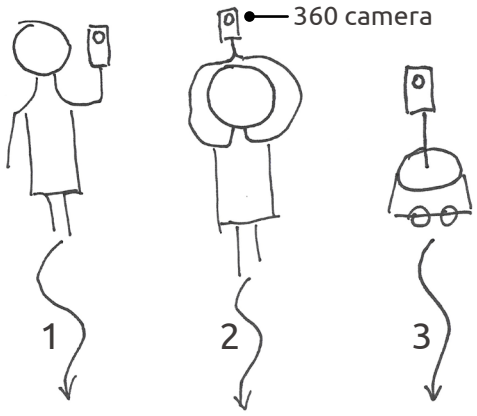


Figure 74. Three ideas of recording a guided tour

The first one was holding the camera next to her face and walking in a designated route when recording, simulating a scenario that you are walking with someone else. However, the result was not desired, because it could be seen that there was someone holding the camera, and the small distance to the person besides sometimes cause distortions, see *Figure 75*.

Figure 75. Doing experiment of first method

The second one was holding the camera above her head and walked in a designated route when recording. However, although the camera would automatically erase itself and tripod down below it, it is not possible to erase a person down below it. The person down below still could be seen in the video, and the height of the viewing point was too high.

The third one was fixing the camera above a movable small object (for example, a toy car), then drag the object to move, or if it was a remote control car, control it to move. It was a possible solution to move. Yet the movable object can still be seen on the video, it would not be a big influence on the desired experience. The movement speed then would be an influence on the experience. Since during the experiment, the researcher dragged the object to move, the speed was hard to keep constant or walk as fast as a person. Using a remote control car may be a solution to better move.

However, this concept would require a lot of time and effort to design the route, experience and edit the contents acquired afterwards. Therefore, this idea of designing a guided tour would not be adopted in the final concept. The results of the experiments may be useful for people who want to design this kind of experience in the future.

3.2 Editing 360-Degree Video

The raw files of the panoramic videos recorded by the Insta360 One X were in .insv format. These files could be edited by their own software Insta360 Studio on PC (*Figure 76*), or converted to .mp4 files which could be edited in Premier or other similar video editing software. The most convenient method to edit the video was to edit them on mobile devices (e.g. an iPad). The assorted software from Insta360 could edit

simple videos pretty easily. The basic functions would satisfy the need of a suitable 360 video for the artists. In this way, the artists would also be possible to edit the videos on their own, they do not need to deal with complex software and spend too much time to create a 360 video.

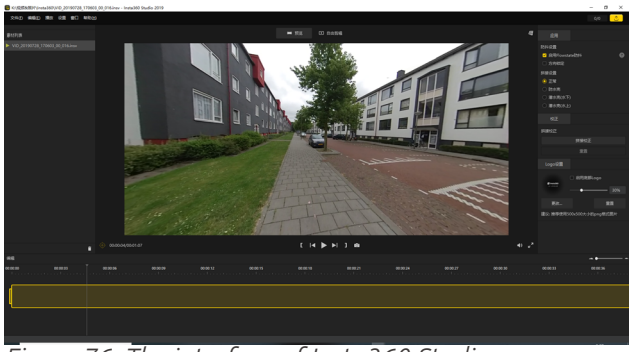


Figure 76. The interface of Insta360 Studio

3.3 Integrating 360 Video in Unity

Unity did not provide a straight-away component to input a 360-degree video, therefore we need to create the scene by ourselves. The researcher found a way including four steps in doing it.

Step 1: Build a sphere

First, a new scene was created because the 360-degree video would be integrated into the virtual gallery. We need to add a sphere object in the Scene, placing it at the centre (Position = 0, 0, 0), with a radius of 50 (Scale = 50, 50, 50). The camera should also be set to 0,0,0. Since the camera would be the viewer's eyes so we want it to be at the center. Placing it elsewhere would make the video look distorted.

Step 2: Flip the Sphere's Normals

If the video was input straight towards the sphere we just created, the video would play on the outside surface of the sphere (*Figure 77*). Yet in this case, we need to see our Sphere from the inside, so we needed to turn it inside-out.

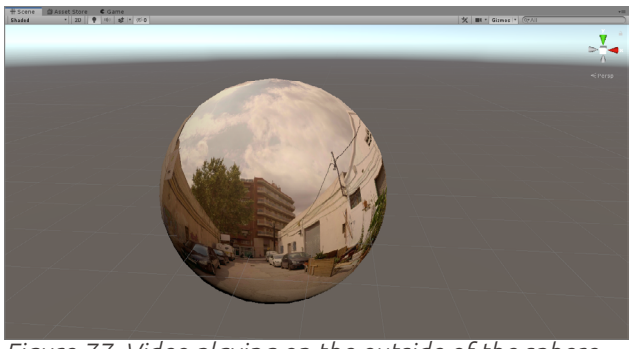


Figure 77. Video playing on the outside of the sphere

In Unity, spheres are not real sphere, they are polygons made with thousands of tiny facets. The external sides of the facets are visible, but not the internal ones. For that reason, we needed to flip these facets, in 3D geometry, this transformation is called 'reversing normals' or 'flipping normals'.

There are different methods to reverse the normal of a sphere. The researcher used 3DMAX to create a sphere and using the 'flipping normals' function to flip the normal of the sphere. Then the sphere was ready to be exported and inputted into Unity.

Step 3: Project the 360 video inside the Sphere

The video to be input needed to be a 360 .mp4 file. It was possible to just drag it onto the Sphere. Or adding a '*Video Player*' component to the Sphere and input the video under '*Video Clip*' (*Figure 78*). Some configuration of the video could be adjusted in this view.

Step 4: Adjust and Play

The final step was to make some adjustments to the size of the sphere and the position of the camera. Make

sure the camera was in a good height of the eye-level, otherwise the viewer would 'float' in the air or out of the sphere. It was also possible to walk for some distance in the sphere so the viewer would feel they could be closer to a point (*Figure 79*).

The video used for prototyping was a video from online, since there was no video recorded from the artists due to time limits. This should not be a key influence on the results of the evaluation.

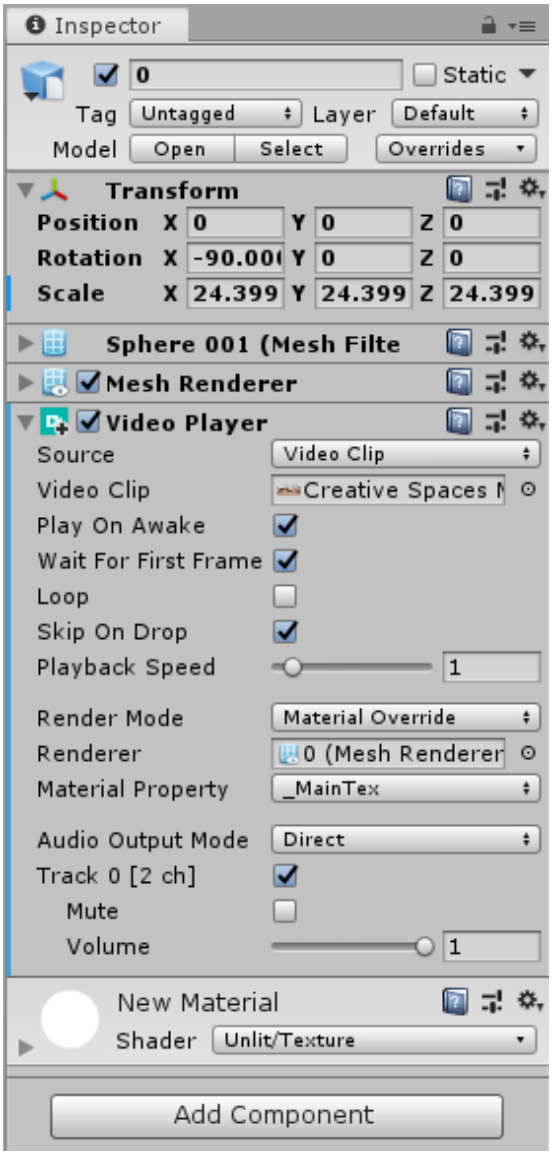


Figure 78. Adding video player component to Sphere

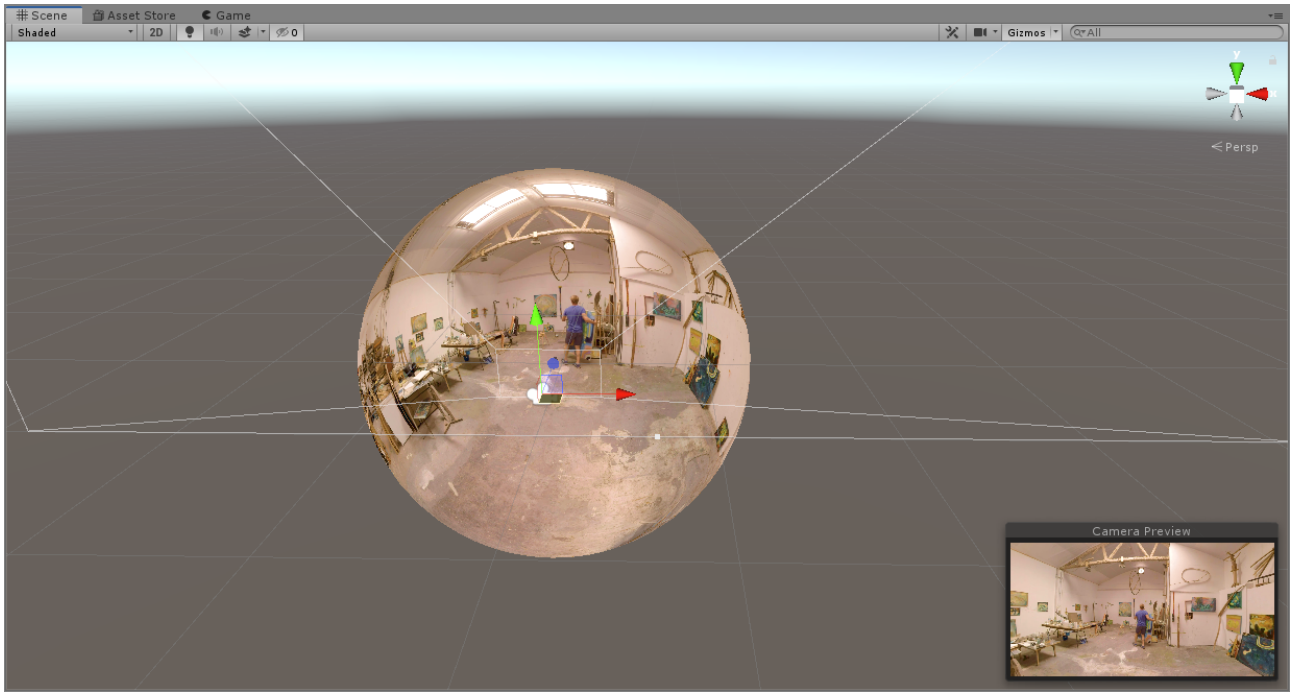


Figure 79. Video playing inside the sphere (see right bottom corner in camera view)

04 DEVELOPING INTERACTIONS

The final step of prototyping was to integrate interactions in the virtual gallery, so the viewers can actually experience it.

4.1 Interaction flow

In order to develop the interactions in Unity in a structural way, an interaction flow diagram was drawn (*Figure 80*). As you can see in the diagram, the interaction starts when a visitor enters the physical gallery (red). After wearing the VR headset (orange), he will enter the training scene of the VR gallery to learn the basic interaction methods in a virtual environment. After some tutoring, he will enter the main scene which is the VR gallery. In here he can explore the gallery to a full extent. The blue boxes are the interaction he can perform, and the text in blues are the ways to perform an interaction.

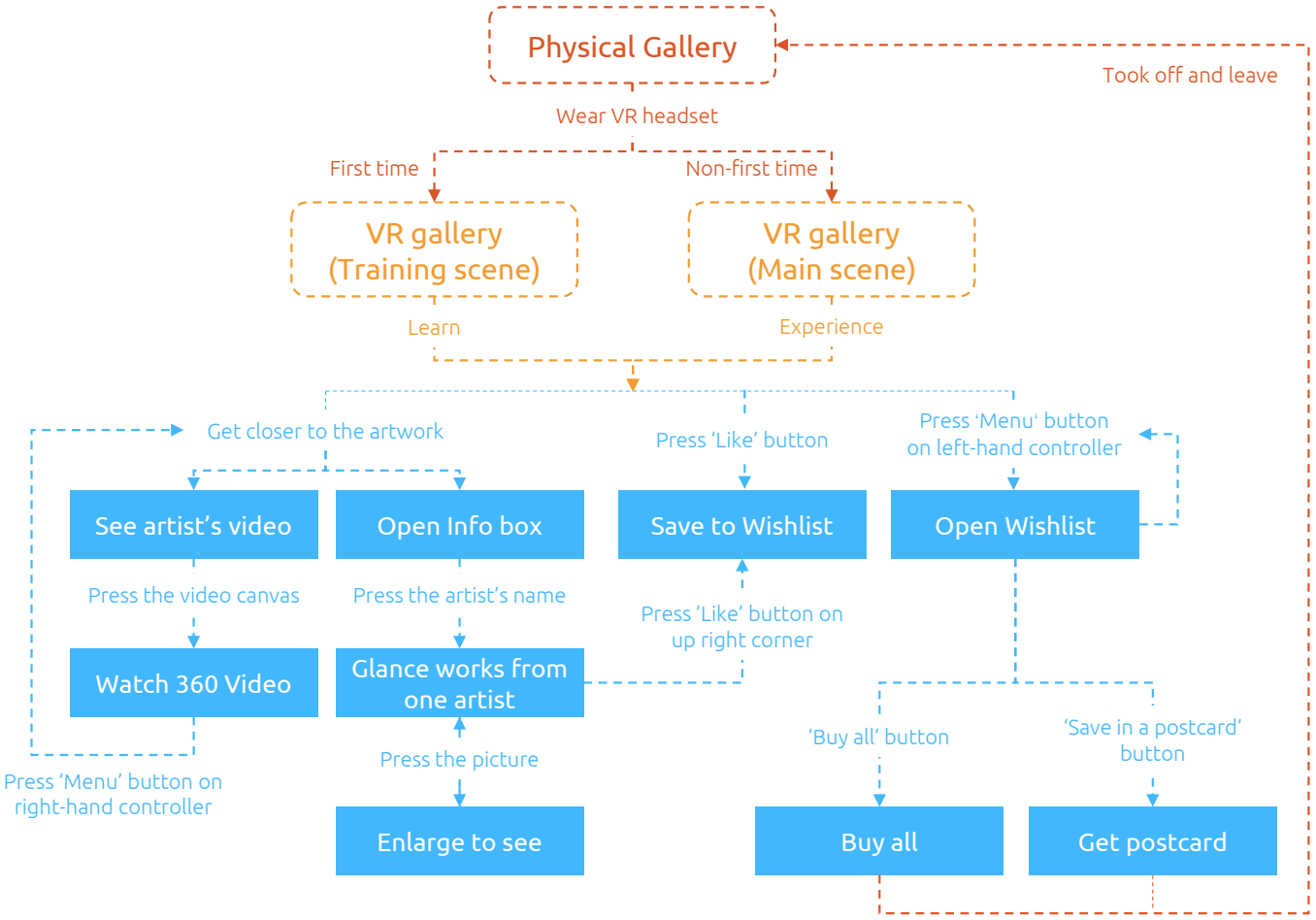


Figure 80. The interaction flow diagram of the VR gallery

4.2 Developing interactions for two gallery concepts

There are various ways to perform a function in Virtual Reality, yet no standards for certain interactions have been determined in the research area. In order to compare possible ways of interactions, two VR gallery concepts were developed. They were mostly identical in the appearance of the gallery but varies in the interactions.

- **Gallery 1**: The interactions were designed likely to the experience in a physical gallery. Users need to walk closer to interact with the objects and the interfaces.
- **Gallery 2**: The interactions were designed based on the use of touch screens. Users use teleporting to move and user laser pointer to interact with the objects and the interfaces.

Six functions / tasks were determined to be tested, so the interactions to perform these functions were different in the two concepts. The differences were shown in *Figure 81*, and will be explained in the following contents.

No.	Functions / Tasks	Gallery 1	Gallery 2
1	Guiding method	With training session	Only guiding tag on controller
2	Open info box & video	Walk closer to open	Laser point icon to open
3	See more works from an artist	Without	Open via clicking the name of the artist
4	Add to Wishlist	Hit “Like” button	Laser point icon to “like”
5	Wishlist displaying method	Wishlist attached to controller	Wishlist shown in front of eyesight
6	Checkout	Only “Buy all” option	“Save in postcard” option

Figure 81. The differences of Gallery 1 and Gallery 2

1. Guiding Method: Training session VS Tags on controllers

In gallery 1, a training session was integrated to help the users to get familiar with the VR gallery. A statue was put in the middle of the room (*Figure 82*). Basic guiding texts like a bouncing “come closer” could guide them where to start. The users can try all interactions in this session. The guiding tags (*Figure 83*) on controllers can only be seen in this session. No more guiding will be presented in the main gallery scene.

In gallery 2, no training session was integrated, the users will enter the main gallery scene immediately after they wear the VR HMD. Yet the guiding tags on controllers can always be seen in order to remind users about the main functions.

Figure 82. The training scene of guidance

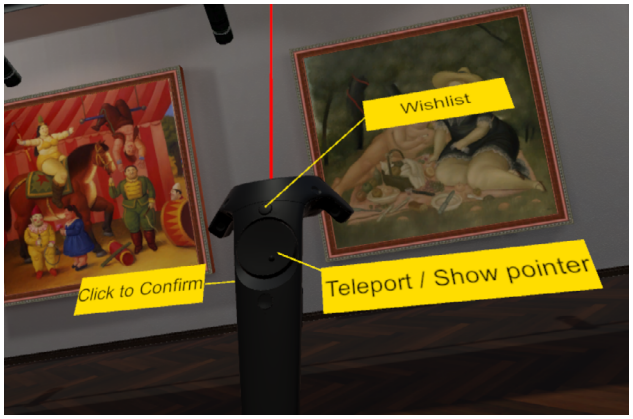


Figure 83. The guiding tags on controllers

Figure 84. The infobox and video canvas show when a user walk closer

2. Open Infobox: Walk closer VS Laser point icon

In gallery 1, when a user walks closer to the artwork, an information interface and a video canvas will pop up (*Figure 84*). The details of the artwork will be shown on the interface, including a thumbnail of the artwork, title, artist, medium, size, price and a small text describes the artwork. It also shows how many people have saved the art piece to wish list. This was included because it was proved during the conceptualization phase that people would feel an urge to buy the one art piece they really like. This indication could also give the user a feeling that he is not the only one viewing the gallery, feeling a sense of belongings.

In gallery 2, three icons were integrated in front of each artwork (*Figure 85 & 86*). By using the laser pointer triggered by the controllers, the user can interact with each icon to perform corresponding functions. The video canvas is shown after clicking the video button, and by pressing the 'watch' button using the laser pointer, users can enter the 360-degree video of the artists.

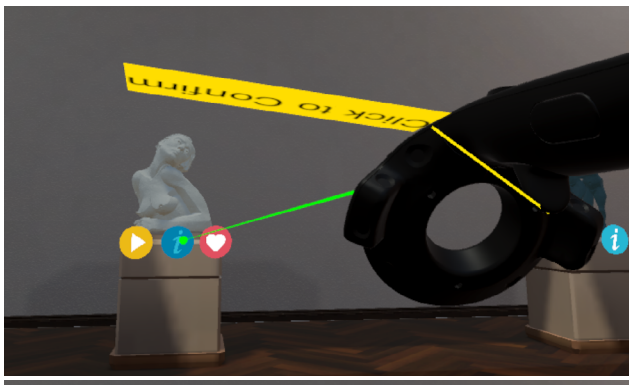


Figure 85 & 86. Using laser pointer to open infobox in gallery 2

3.Artist's works: N/A VS Laser point name

One of the shortages of a traditional gallery is that people can only see a limited amount of artwork. Therefore, VR gallery has the ability to satisfy their interests to see an oeuvre of artworks from each artist. In order to test whether this is a necessary function, this function was only integrated into gallery 2. The researcher wanted to see if the users aware of missing this function in gallery 1.

In gallery 2, the works of one artist can be accessed by pressing the name of the artist. This will lead to an interface with all digitized artworks from the artist (*Figure 87*). The pictures can be enlarged to see by pressing the picture, it will shrink by pressing again. The user can also save these artworks in wishlist by a long press for 3 seconds.

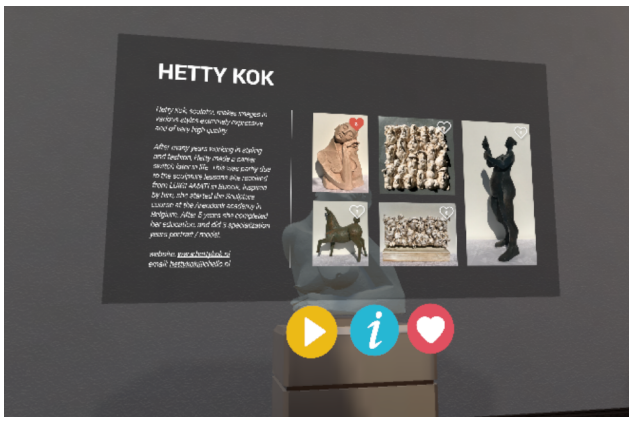


Figure 87. Interface of glancing one artist's artworks

4. Add to Wishlist: Hit 'like' VS Laser point 'like'

In gallery 1, a 3D 'like' button was integrated near each artwork. Users need to walk closer to the button, and use their controller to 'physically' press the button (*Figure 88*). After pressing the button, the button will become red and the artwork is saved to the Wishlist.

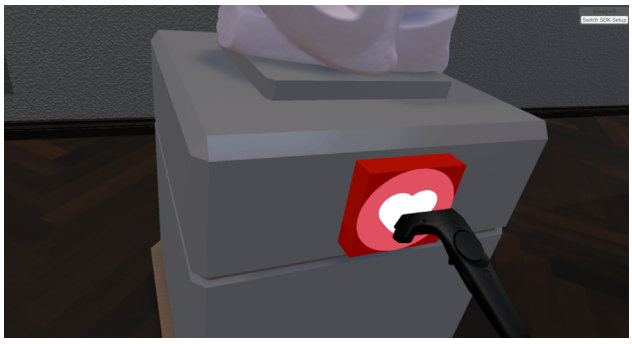


Figure 88. Physically hit the 'like' button in gallery 1

In gallery 2, a 'like' button was integrated next to the information button. Users can express their like by pressing the 'like' button using laser pointers (*Figure 89*). The icon will also become red after the press.

Figure 89. Laser point to 'like' in gallery 2

5. Wishlist displaying: Hold VS Float

In gallery 1, users can open the Wishlist by pressing the 'menu' button in one controller(*Figure 90*), and use the other hand to interact with the Wishlist interface. The Wishlist is attached to the controller so it will always follow the controller. It can be closed by pressing the 'menu' button again. The interaction is like holding a Wishlist paper physically. Users can choose to buy all in the wishlist, or make adjustments.

In gallery 2, users can also open the Wishlist by pressing the 'menu' button in one controller, then a floating interface will be shown in front of their eyes (*Figure 91*). The Wishlist will follow the movement of their head, so it will always be in front of their eyes. Users can use laser pointers to interact with the UI.

Figure 90. Interface of Wishlist in Gallery 1

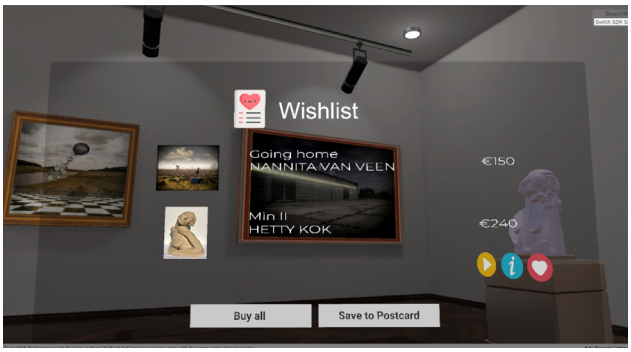


Figure 91. Interface of Wishlist in Gallery 2

6. Checkout: Buy all & Save in a postcard

In gallery 1, only 'buy all' function is available, users can press this button to buy all the artworks in the Wishlist.

In gallery 2, the 'save to postcard' function will be available (*Figure 92*). This allows users to have their Wishlist printed in a physical postcard (*Figure 93 & 94*). The gallery presents it as a gift to the users. Users can take it home and scan the QR code to use the AR app to try artworks at home.

Figure 92. Click 'save to postcard' in gallery 2

Figure 93 & 94. A printed postcard

4.3 Other Interactions

Artist's video

When the user gets closer to the artwork, the video of its creator artist will also start playing automatically (*Figure 95*). The video is muted to trigger the user to look inside it. The user can press the video to enter the 360-degree video scene (*Figure 96*). He can walk around for a small distance and look at how an artist works and know the stories behind all the artworks.

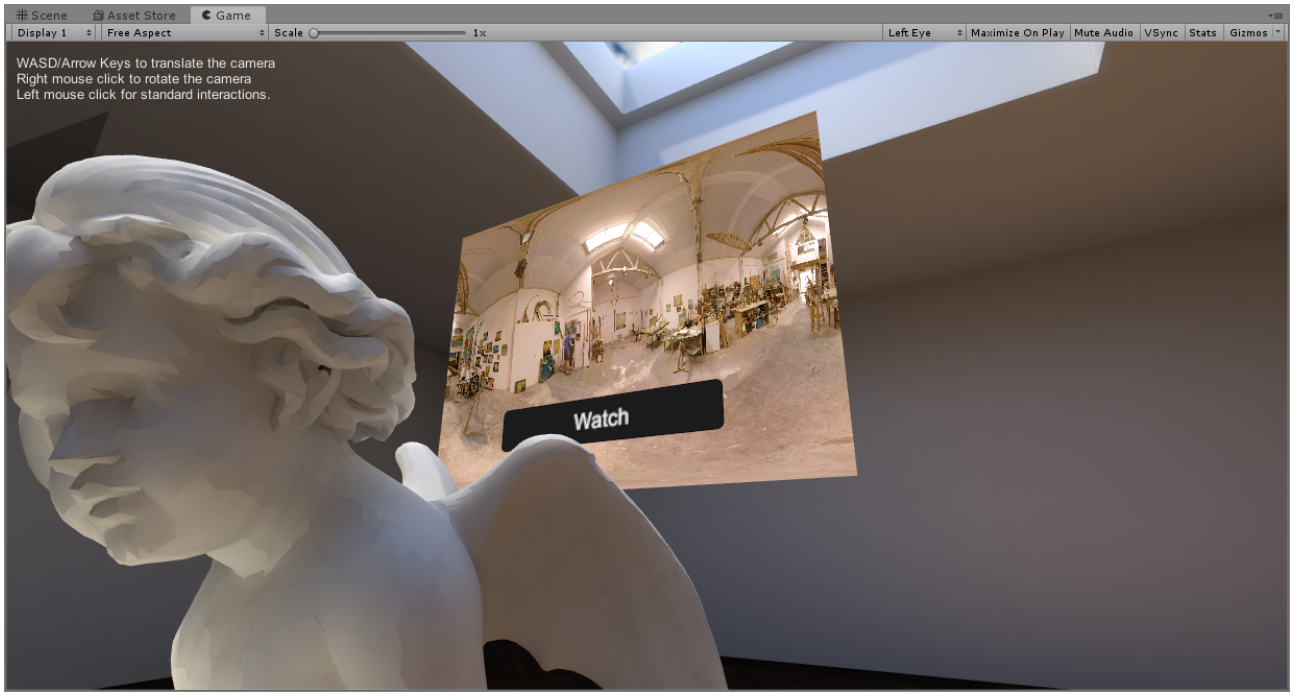


Figure 95. The video will starts playing next to the artwork, user can click the video to enter the 360 scene

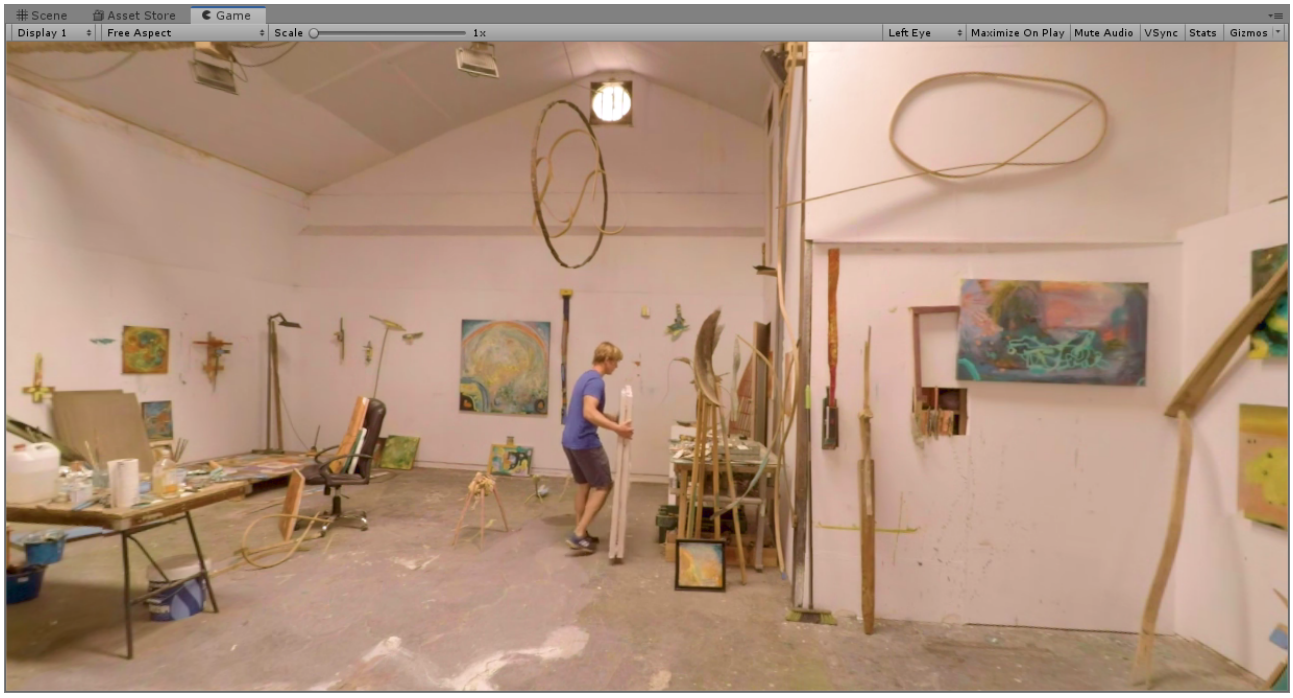


Figure 96. How it feels inside a 360-degree video, you can turn you head around to see the scene

Teleporting

The pop-up store for implementing the VR gallery is around 4 x 6 meters in size, then there will be enough space for users to walk around. However, space would be limited during testing for the prototype. Therefore, it was necessary to implement the teleporting function in the gallery. Instruction of teleporting would be given during the training scene as well. When pressing on the pad of the controllers could awake teleporting function, by pointing the pointer to the desired area and press trigger button under the second finger would teleport the user to the desired point (*Figure 97 & 98*).

Figure 97. Teleporting Guidance

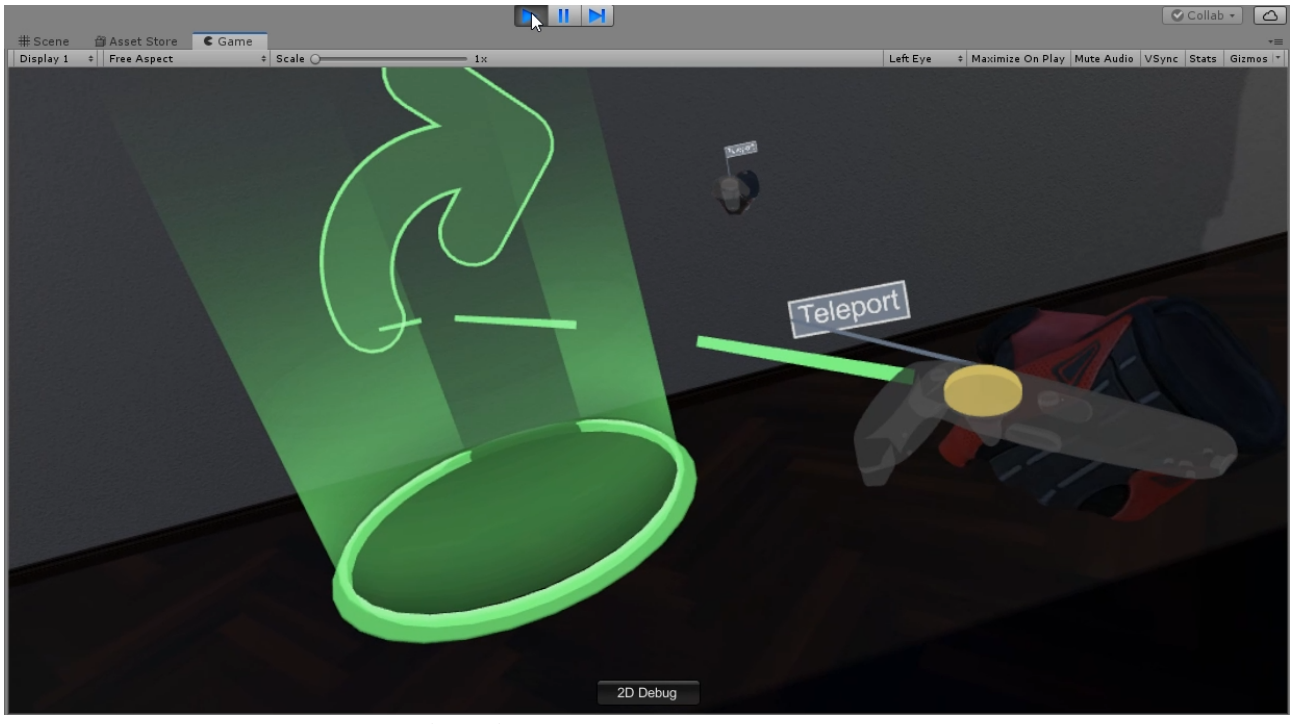


Figure 98. Use pointer to teleport to desired place.

E

EVALUATION

CHAPTER SUMMARY

This section will describe the user evaluation sessions and their corresponding results. The evaluation phase consisted of two parts:

The first one is evaluation on excluding the VR home scene from the final concept. This was done because of the doubt of whether a home scene in VR gallery would help users make decisions to buy artworks. The result showed that An AR application would be more helpful than using the VR gallery.

The second evaluation is the user tests on the functional prototype of VR gallery. Two gallery concepts were developed, which were identical in the environment, but different from the interactions on performing six certain functions. The order of the testing galleries was random to prevent bias on one gallery. There were four parts of the analysis of the results. From the results, the VR gallery achieved the requirements of the desired experience to some extent.

The evaluation process is illustrated in *Figure 99*.

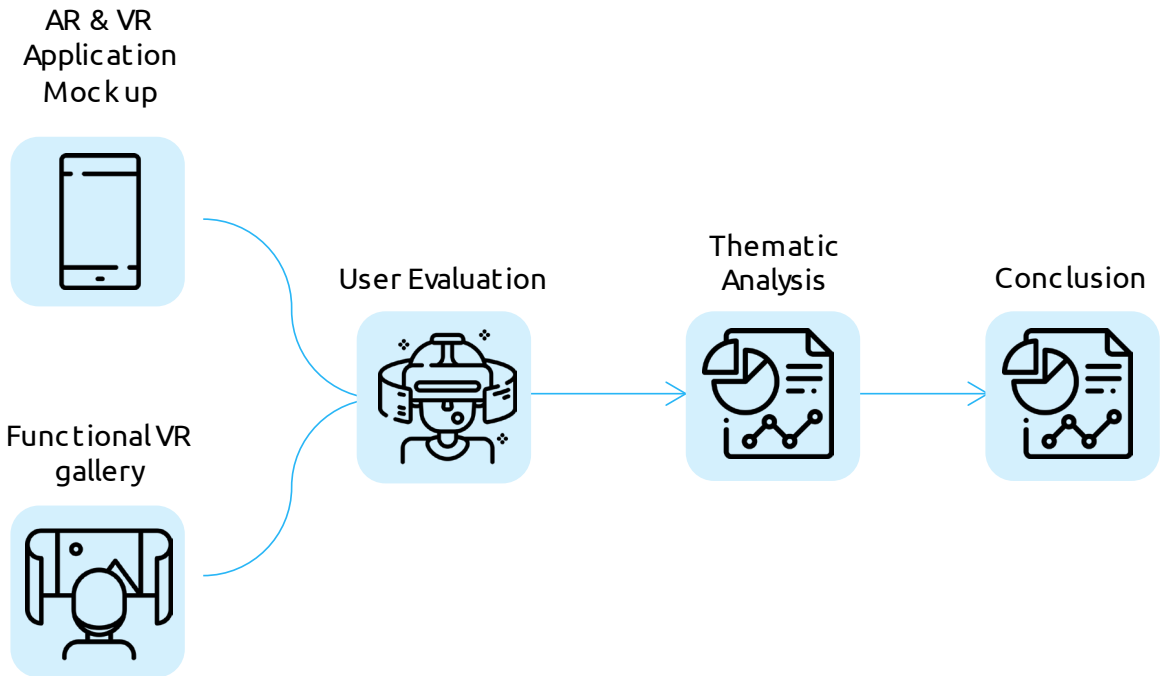


Figure 99. An overview of evaluation process

01 EXCLUDING VR HOME SCENE

1.1 Excluding VR home scene

In the final concept description in *Chapter C – 05*, a home scene was included in the concept. This scene was meant to help the consumers to view the artworks in a home scenario. Since it has been a big problem that consumers don't buy an artwork because they don't know what it will look like in their home.

However, during prototyping the concept, the researcher got feedback on the home scene. A few people indicated this solution cannot solve the consumers' problem directly. Using AR technology is a more straight and targeted solution for the problem. It seemed unnecessary to include this scene.

In order to approve the hypothesis of the unnecessaries of including this home scene in VR, the researcher decided to carry out a small test on the problem.

Two pictures were created to represent two different solutions: one is using AR technology to view paintings on the wall (*Figure 100*), another is putting paintings on the different walls in different home style on VR (*Figure 101*).

Figure 100. An illustration of using AR technology to view artworks at home.

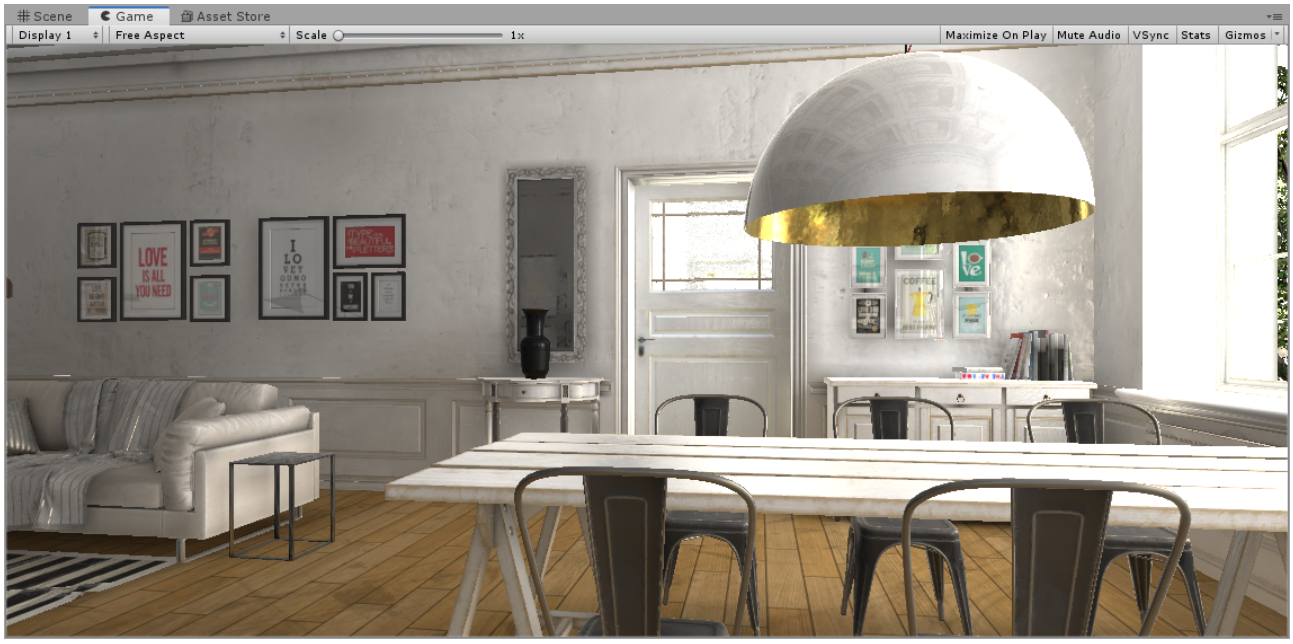


Figure 101. An illustration of viewing artworks in VR technology in a home scene.

After that, the researcher got in touch with 5 people. First describing the two ideas to them, then asked their opinions on the two ideas.

As expected, all of them prefered the AR idea rather than the VR idea, the reasons included:

- "AR is more convenient, I can view it anywhere at any time I want."
- "AR is cheaper to get touched with, everyone has a phone but not everyone has a VR headset."
- "No matter how real the scene is in VR, it is not my home."
- "The lighting and settings in VR are difficult to change, but in AR, I can just change my light switch."
- "The sizes of the artworks are still hard to tell whether it fits at your home, but with AR it's easy to see"

The results are obvious. This little evaluation helped the researcher to decide not to prototype the VR home scene of the virtual gallery. It was proved to be an unnecessary and inefficient idea. Using AR technology for the same purpose is a better idea to develop. Yet it would not be developed in this project since the scope of this project was on Virtual Reality. This would be a good idea to develop further AR applications for viewing artworks at home to improve the possibility of consumers to purchase artworks.

02 USER TEST

2.1 Process

Approach

Two gallery prototypes were developed to be tested. A within-subject design experiment (Charness, Gneezy & Kuhn, 2012) was carried out. All participants tried two VR galleries and all interactions. This method was chosen because of the relatively small pool of participants and can help reduce errors associated with individual differences. The test order of the two galleries was randomised to reduce the bias preference of one gallery.

The Immersive Tendencies Questionnaire (Witmer & Singer, September 1996) was used to check whether any individual participant differs from the average because of their immersive tendencies.

The evaluation of the interactions fo two galleries used a 5-scale Likert scale (Boone & Boone, 2012). Participants were asked to evaluate each function in four aspects: understandability, usefulness, ease of use and interests to use.

Moreover, the experiment leans largely on quality research due to the small number of participants, therefore interviews were conducted after the testing.

Setup

The tests were carried out in the VR zone in the Applied Lab of IDE faculty at the Delft University of Technology. The setup can be seen in *Figure 102*. The left side was the controller place, for researcher to run the prototypes and taking notes. A VR ready PC and a monitor was available for the researcher to monitor the performances of the participants. The right side was a platform for the participants to experience the VR prototypes. HTC Vive was used in this experiment.

A GoPro camera was used to record video and audio of the process. The screen was recorded during the experiments to review interesting interactions afterwards.

A consent form, pens and papers were provided to the participants.

Figure 102. A participant was conducting a user test.

Research questions

- Does the user feel this VR gallery more approachable to the traditional gallery?
  - Does the VR gallery empower the user compared to traditional gallery?
  - Does the user understand the functions?
  - Are the functions useful to the user?
  - Is the user able to perform the tasks fast and smoothly?
- Does the user feel interested to explore the VR gallery?
  - Are the functions attractive to explore?
  - Are the contents provided enough to explore?
- Does this VR gallery encourage their interests to know more about arts? In order to purchase more arts?
  - What are their opinions/ attitudes on art galleries before and after the tests?
- What functions could be developed further?
- How much time they would like to spend in the VR gallery?
- Which way of interactions do they prefer? Gallery 1 or Gallery 2?

Participants

8 participants from the Delft University of Technology, 4 males and 4 females, mainly aged from 20 to 29. Next to that one female pilot participant was invited to do the pilot test.

Procedure

The user test consisted of five parts, as illustrated in *Figure 103*:

1. The researcher introduced the project to the participant and the participant signed the consent form. The participants were introduced to the pop-up store of the new gallery and the miniature model (*Figure 104*) was used to help them understand better.

Figure 104. The Miniature Model

2. Participant fill in two preliminary questionnaires: ITQ - Immersive Tendencies Questionnaire (Witmer

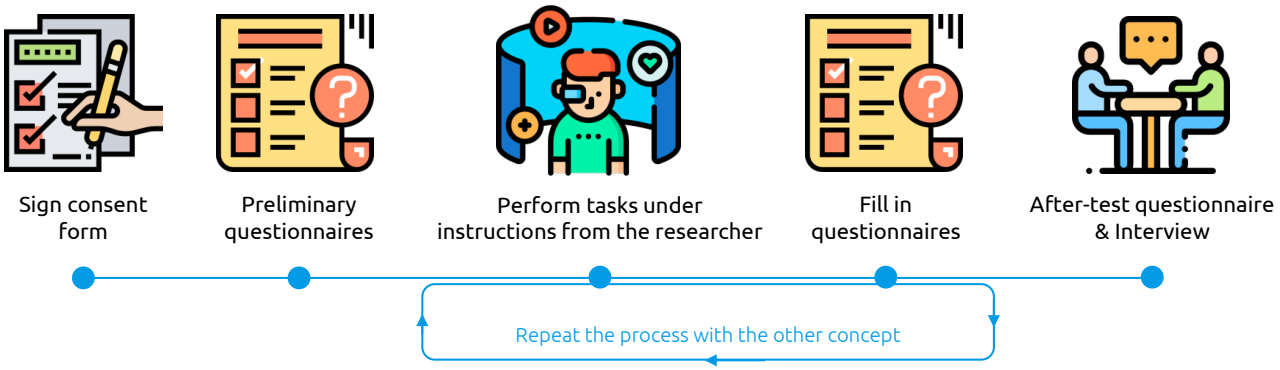


Figure 103. The user test procedure

& Singer, Version 3.01, September 1996), and a pre-test questionnaire on their past experience related to galleries. The questionnaires can be found in *Appendix 8*.

3. Participant started experience one VR gallery. Four people tested Gallery 1 first and four tested Gallery 2 first. They were allowed to freely explore the gallery for a while in order to familiar the virtual environment. Then they were asked to perform six tasks (*Figure 105*) under the instructions of the researcher. They were asked to assess each task in four aspects. The researcher asked the following questions and they needed to give a rank from -2 to +2 meaning very negative to very positive for each aspect.
   - To what extent you can understand the interaction in this function? (Understandability)
   - How useful do you think this function is? (Usefulness)
   - How easy is this function to use? (Ease of use)
   - How interested are you to perform this function? (Interests to use)

   The participants gave the scores verbally and the researcher recorded their answers. So that they didn't need to take off the VR headset, and more instant feedbacks can be given during the experience.
4. The participant repeated step 3 with another gallery concept. The order of experiencing the two galleries was changed for half of the participants to avoid the influence of the order.
5. After testing both galleries, the participant filled in an after-test questionnaire (*Appendix 8*). Interviews were conducted to talk about the experience, some open questions, and their preferences on the galleries.

No.	Functions / Tasks	Gallery 1	Gallery 2
1	Get familiar with the gallery	With training session	Only guiding tag on controller
2	Open info box & video canvas	Walk closer to open	Laser point icon to open
3	See more works from an artist	Without	Open via clicking the name of the artist
4	Add an artwork to Wishlist	Hit "Like" button	Laser point icon to "like"
5	Open the Wishlist	Wishlist attached to controller	Wishlist shown in front of eyesight
6	Checkout	Only "Buy all" option	"Save in postcard" option

Figure 105. The 6 tasks on 6 functions the participants need to perform

2.2 Results

ITQ

This test included testing on four aspects of a personal immersive tendency: Focus, Involvement, Emotion and Game. The result of the 8 participants is listed in *Figure 106*. To compare the group results with a larger sample, the data from Witmer, B.G. & Singer. M.J. (1998) was used, listed in *Figure 107*.

	N	Mean	Std. Deviation
Focus	8	21.75	6.296
Involvement	8	22.63	7.652
Emotion	8	18.38	4.749
Game	8	11.63	3.462
Total	8	78.50	19.581

Figure 106. Results of 8 participants of VR gallery

	N	Mean	Std. Deviation
Focus	94	24.81	7.54
Involvement	94	15.33	8.67
Emotion	94	14.25	6.70
Game	94	6.56	4.95
Total	94	64.11	13.11

Figure 107. Norms of 94 French-Canadian participants from Witmer, B.G. & Singer. M.J. (1998)

To check whether our samples are significantly different from the samples of the 94 Frech-Canadian participants, t-test was conducted for each aspect. The results can be seen in *Figure 108*. If the significance is lower than 0.05, we can say our samples are different from the compared samples.

As we can see, except the 'Focus' and 'Total' value, our participants scored significantly higher than the compared sample in 'Involvement' (*0.031*), 'Emotion' (*0.044*) and 'Game' (0.004). This means they are more easily involved in an activity, more emotional, and more gaming than the compare samples. This occurs may because of two reasons:

The compared samples are from research from 20 years ago, people may have been changed a lot during these years;

Besides, the age group in this research is between 20 to 29, a relatively young group, while the compared research conducted people from a bigger range of age group. Young people may show higher tendencies in those aspects.

Pre- & After-test Questionnaire

Pre-test questionnaire consists of two parts: personal data and prior experience. The personal question consists of age and gender. The prior experience questionnaire consists of 6 questions. Each question will be described with the results in the following paragraphs.

1. Which of the followings you have already used before? (multiple answers)

As shown in *Figure 109*, all of them have used tablet devices, 7 of 8 have used AR applications, 6 have tried mobile VR goggles and 5 of them have used PC based VR headsets before.

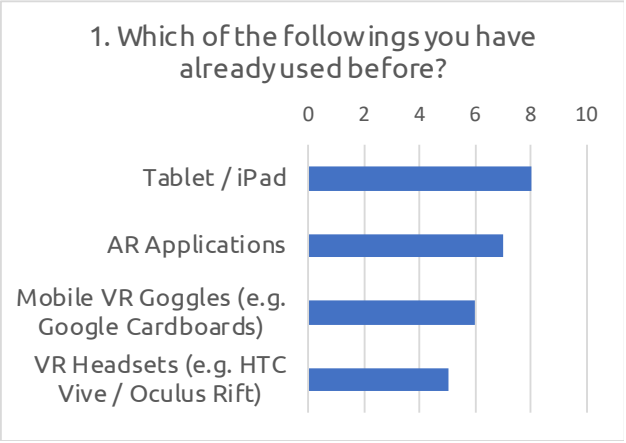


Figure 109. Result of question 1 of pre-test questionnarie

Test Value = 24.81

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Focus	-1.375	7	.212	-3.060	-8.32	2.20

Test Value = 15.33

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Involvement	2.696	7	.031	7.295	.90	13.69

Test Value = 14.25

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Emotion	2.457	7	.044	4.125	.15	8.10

Test Value = 6.56

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Game	4.139	7	.004	5.065	2.17	7.96

Test Value = 64.11

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Total	2.079	7	.076	14.390	-1.98	30.76

Figure 108. T-test of each aspect, compare to the sample value from 94 French-Canadian participants from Witmer, B.G. & Singer. M.J. (1998)

2. What is your attitude towards art in general?

As shown in *Figure 110*, all of them have some interests in art. A quarter of them respect it but not keen on it. Half of them really like it but didn't have many opportunities to do related activities. Two of them also often do related activities.

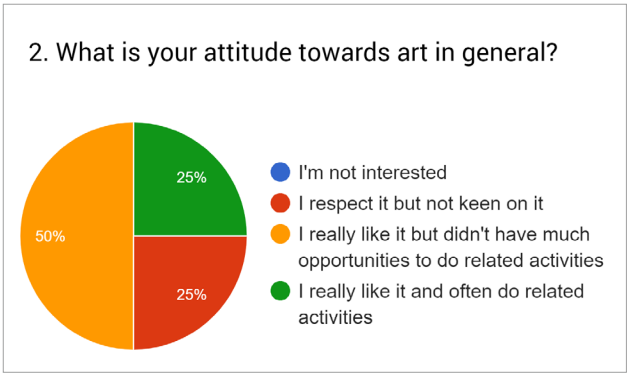


Figure 110. Result of question 2 of pre-test questionnarie

3. What is your experience on art-related activities?

As shown in *Figure 111*, 5 of 8 visited galleries they are interested in, while 3 of them even make arts by themselves.

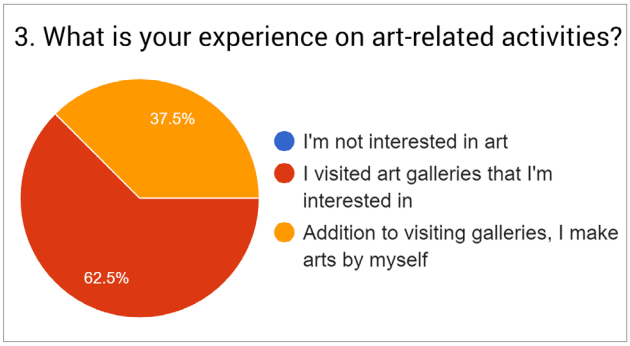


Figure 111. Result of question 3 of pre-test questionnarie

4. How often do you visit an art gallery?

As shown in *Figure 112*, majority of them visited a gallery once a year. 2 of them often visited galleries and 1 even visited galleries more than once a month.

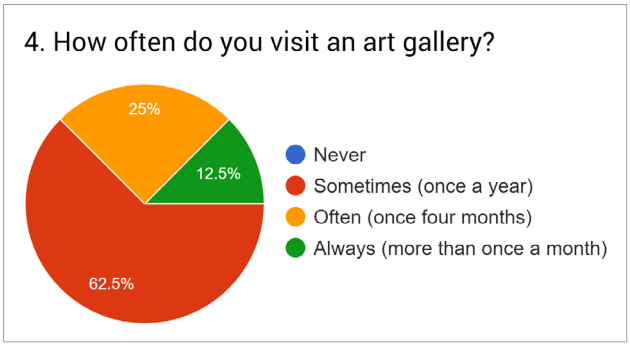


Figure 112. Result of question 4 of pre-test questionnarie

5. In your memory, when and where/ what was the gallery you visited last time?

The answers including:

- National Gallery (London)
- three weeks ago, Den Haag Art Museum
- the Rotterdam art museums /last month/ about hip-hop culture
- Van Gogh
- At the beginning of this year in Vienna.
- August, Delft, Pottery art gallery
- Beijing 798, JULY 2019, installation art exhibition
- Rijksmuseum

From the results we can see, many of them still confuse the museums or exhibition with a gallery, after some explanation from the researcher.

6. Mark corresponding score that best describes an art gallery you perceived.

The participants were asked to give scores on 8 pairs of adjectives on a 7 scale form. This result will be analysised with question 9. The adjectives are:

- UnApproachable - Approachable
- Exclusive - Public
- Uncomfortable - Comfortable
- Dull - Interesting
- Humble -Luxury
- Casual - Formal
- Calm - Excited
- Traditional - Futuristic

The after-test questionnaire consists of three questions.

7. What's your overall user experience on the VR gallery? (1 = very negative , 7 = very positive)

As shown in *Figure 113*, half people scored 6 and half people scored 7 for the VR gallery experience, which is a very high score. This showed that even though there were still imperfections in the prototypes, people were stimulated to use the VR gallery.

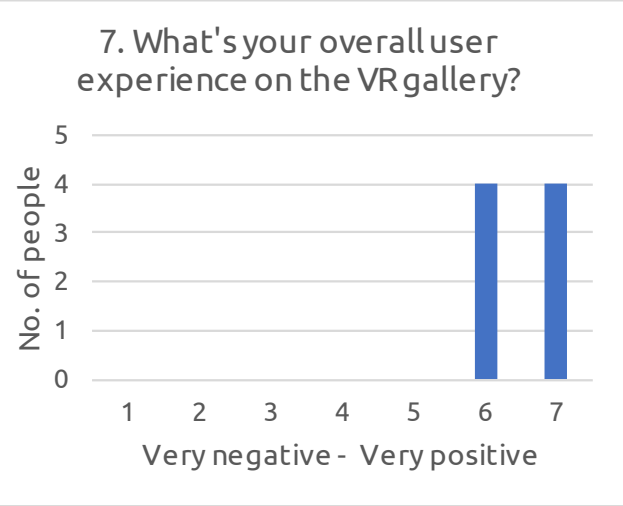


Figure 113. Result of question 7 of after-test questionnarie

8. Based on your experience, visiting the VR gallery again would be: (1 = very unlikely, 7 = very likely)

As shown in *Figure 114*, all of them were willing to visit the VR gallery again. 3 people scored 5, 4 people scored 6 and 1 people scored 7. This showed they were very motivated and interested to use the VR gallery via visiting the pop-up store.

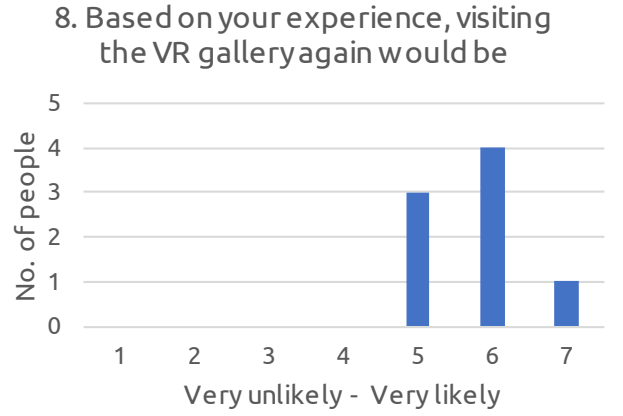


Figure 114. Result of question 8 of after-test questionnarie

9. Mark corresponding score that best describes the VR gallery you experienced.

The scales of this question are the same as in question 6. The goal is to compare the traditional gallery and the VR gallery. The result of the average scores is shown in *Figure 115*. From this diagram, we can see that people think:

- VR gallery is more approach than the traditional gallery.
- Yet they feel the VR gallery is more exclusive than the traditional gallery, mainly because they think the VR products are expensive.
- The comfort level of two forms of the gallery is the same. They feel uncomfortable on the VR gallery mainly because of the heavy headsets.
- VR gallery is more interesting than the traditional gallery.
- No difference in the luxury of the two galleries. They feel the VR gallery is luxury mainly because they think the headsets are expensive.
- VR gallery is more casual to them.
- They are way more excited about the VR gallery compared to the traditional gallery.
- VR gallery is more futuristic than the traditional gallery.

However, some scores differed a lot in some scales, using the mean to show the results was not convincing enough to draw the conclusion. Therefore, a boxplot in *Figure 116* tells better in the distribution of the scores on each scale.

From the boxplot diagram, we can confirm that:

- More people think VR gallery is more approachable than the traditional gallery.
- People feel VR gallery is a bit more exclusive than the traditional gallery.
- People don't feel much difference in the comfort level of the two galleries.

- A bit more people feel that VR gallery is more luxury than the traditional gallery.
- Most people feel that VR gallery is more casual than the traditional gallery.
- Majority of them feel very excited about the experience of the VR gallery.
- All of them think VR gallery is way more futuristic than the traditional gallery.

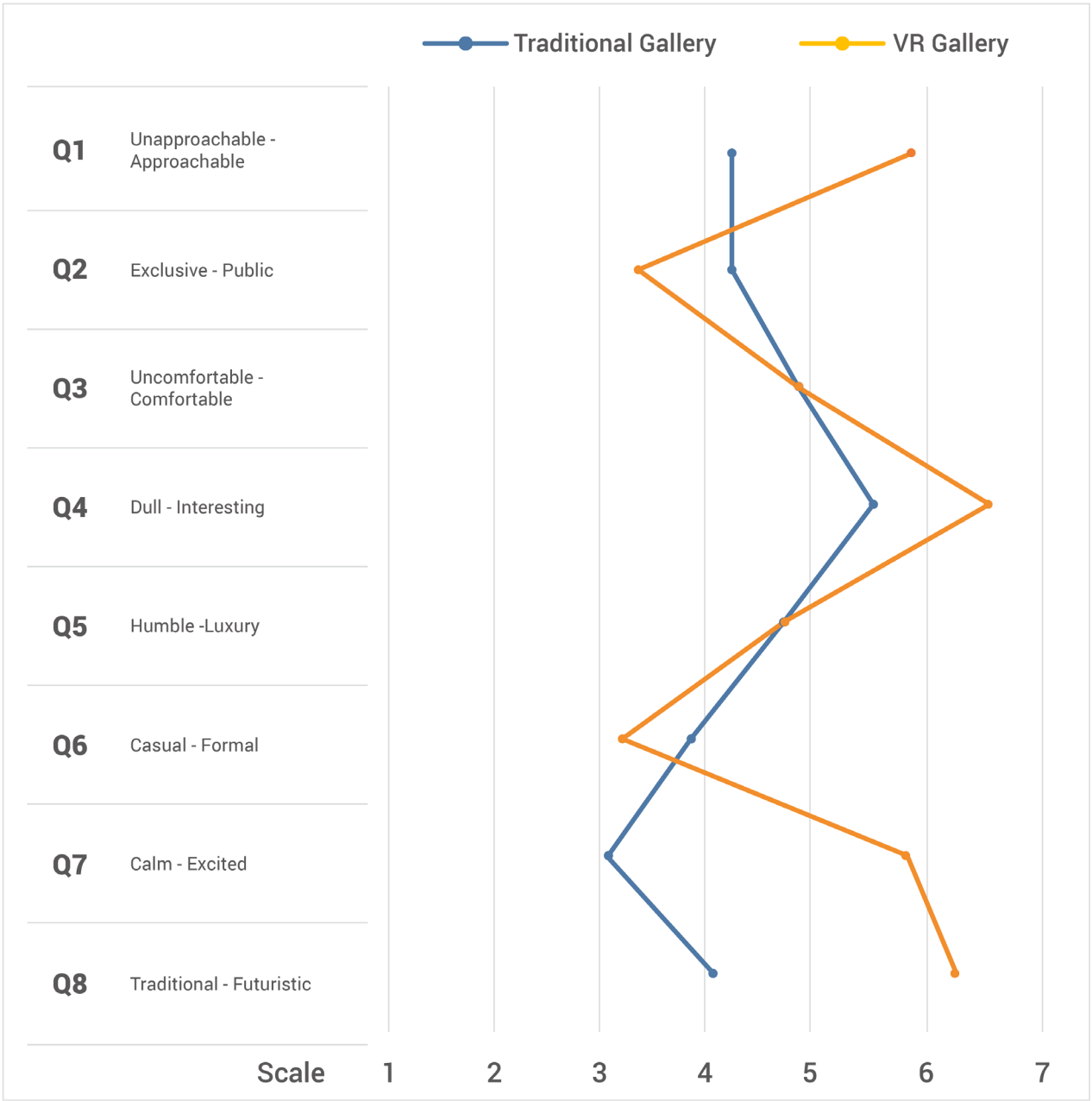


Figure 115. Result of question 6 & 9 comparison on average values

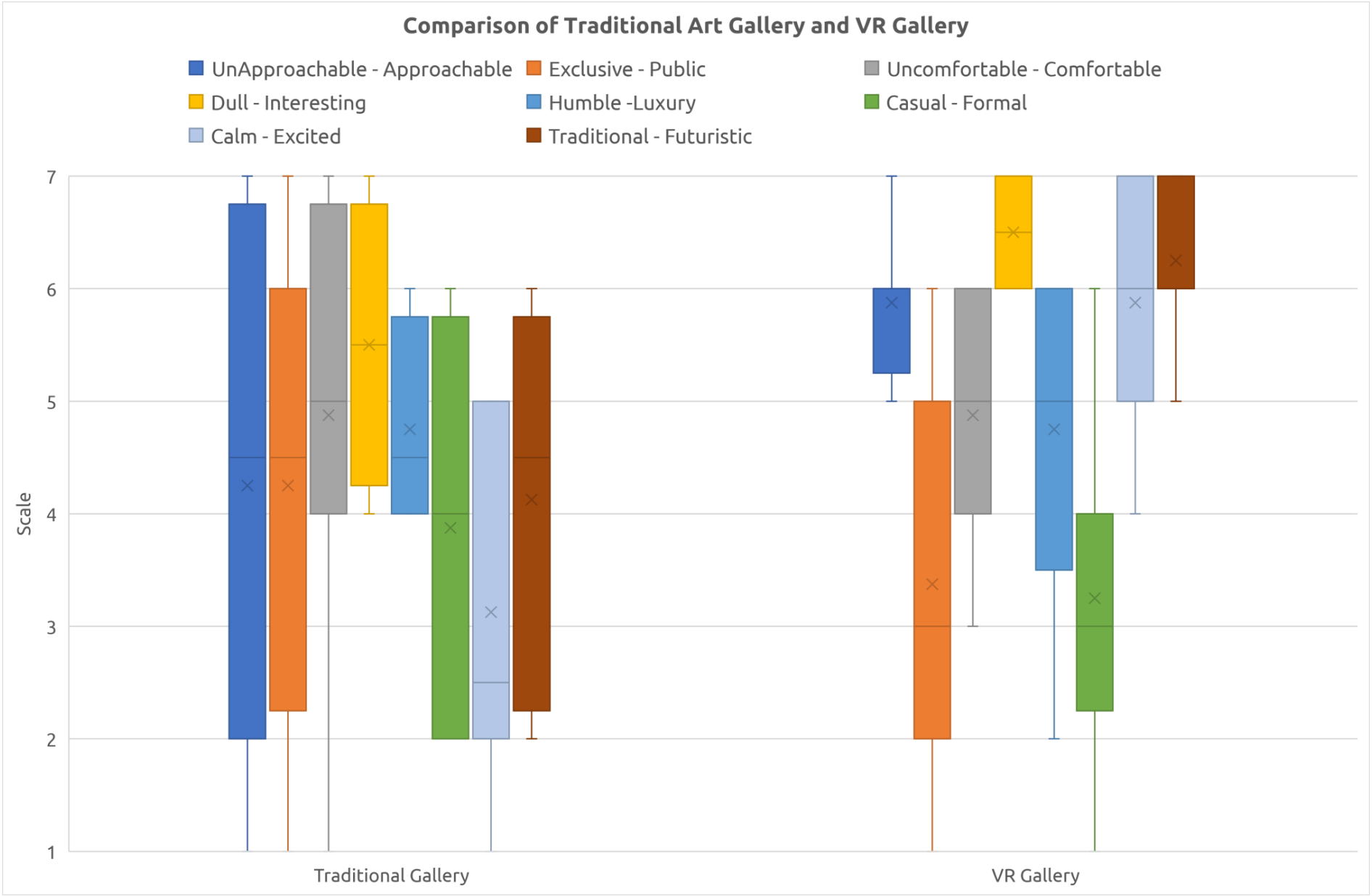


Figure 116. Boxplot diagram of results from question 6 & 9

Function Assessment

T-test was done for each function by comparing the mean of each aspect between Gallery 1 and Gallery 2. The complete result of T-test is in Figure. We were interested in the significance level that smaller than 0.05. The two that were significant were highlighted in red rectangles. Each function will be elaborated below. The complete raw data and boxplot analysis are in *Appendix 10*.

1. Guiding method

Gallery 1: With training session

Gallery 2: Only guiding tag on controller

As shown in *Figure 117*, people scored slightly higher for Gallery 2 in understandability, usefulness, and ease of use. Yet the first one is more interesting to interact with.

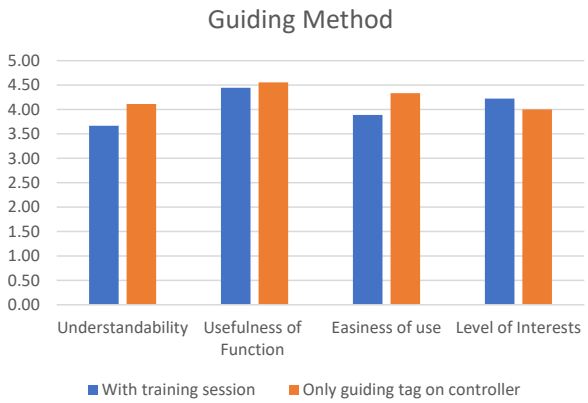


Figure 117. Comparison of mean values of Task 1.

2. Open infobox & Video canvas

Gallery 1: Walk closer to open

Gallery 2: Using a laser pointer to interact with icons

As shown in *Figure 118*, the same as the first result, people scored slightly higher for Gallery 2 in the first three dimensions. Yet Gallery 1 is more interesting to interact with.

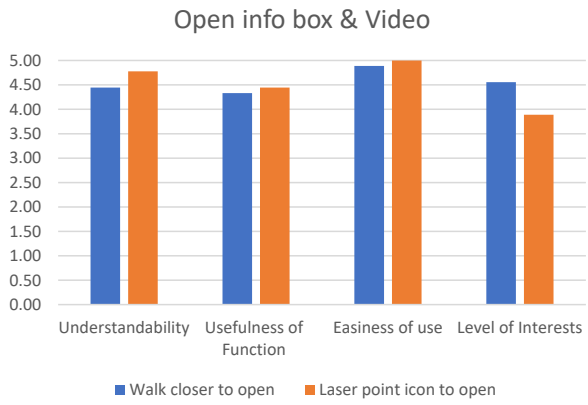


Figure 118. Comparison of mean values of Task 2.

3. See more works from an artist

Gallery 1: Without this function

Gallery 2: Open via clicking the name of the artist in the infobox

As shown in *Figure 119*, people are interested in using this function. Yet if they were not presented this function like in Gallery 1, they didn't express their needs to have this function.

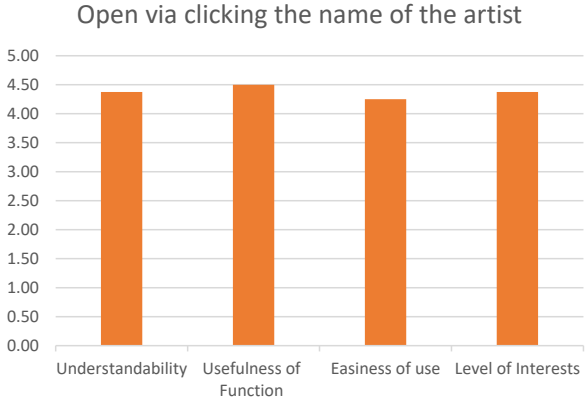


Figure 119. Comparison of mean values of Task 3.

4. Add artwork to Wishlist

Gallery 1: Physically hit the "like" button

Gallery 2: Laser point "like" icon

As shown in *Figure 120*, people scored much higher for Gallery 2 in the first three dimensions, which means it's more logical and easy to use laser pointer rather than physical interact. From the T-test we can also see that, the significance level of the "ease of use" is 0.02, which means that the ease of use of the interaction of gallery 2 was significantly better than in gallery 1. of Yet the level of interest is almost the same.

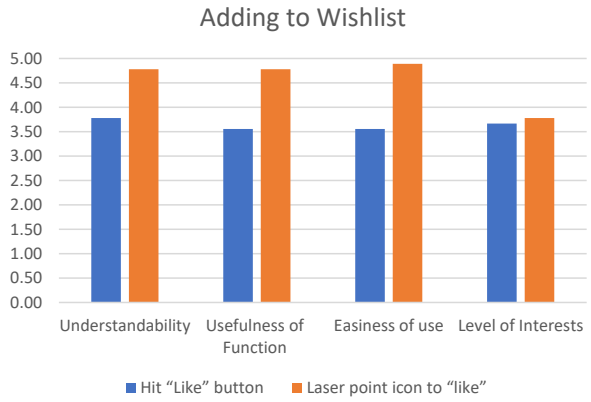


Figure 120. Comparison of mean values of Task 4.

5. Wishlist displaying method

Gallery 1: Wishlist shown attached to controllers

Gallery 2: Wishlist showed in front of eyesight, follows head movement

As shown in *Figure 121*, people scored higher for Gallery 1 in dimension "Understandability" and "easiness of use". From the T-test (*Figure 123*)we can see that, the significance level of the "Understandability" is 0.049, which means that people understand significantly better in displaying Wishlist in front of their eyesight in Gallery 2. The usefulness and level of interest are almost the same.

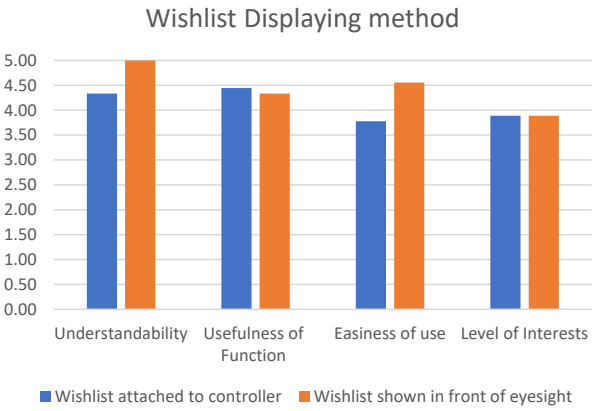


Figure 121. Comparison of mean values of Task 5.

6. Checkout

Gallery 1: Only "buy all" function

Gallery 2: "Save in postcard" function

As shown in *Figure 122*, people scored higher for only "buy all" button in "Understandability" and "easiness of use". They expressed that they can hardly understand "save in postcard" function when they first see it, but after getting the postcard, they can understand. Gallery 2 also scored higher in the usefulness and level of interests.

Figure 122. Comparison of mean values of Task 6.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
T1. Understandability	Equal variances assumed	1.929	0.187	-0.243	14	0.812	-0.125	0.515	-1.230	0.980
	Equal variances not assumed			-0.243	12.514	0.812	-0.125	0.515	-1.243	0.993
T1. Usefulness	Equal variances assumed			0.000	14	1.000	0.000	0.267	-0.573	0.573
	Equal variances not assumed			0.000	14.000	1.000	0.000	0.267	-0.573	0.573
T1. Easiness of use	Equal variances assumed	0.205	0.657	-0.323	14	0.751	-0.125	0.387	-0.954	0.704
	Equal variances not assumed			-0.323	13.633	0.751	-0.125	0.387	-0.957	0.707
T1. Level of interests	Equal variances assumed	0.042	0.841	0.218	14	0.830	0.125	0.573	-1.104	1.354
	Equal variances not assumed			0.218	13.984	0.830	0.125	0.573	-1.104	1.354
T2. Understandability	Equal variances assumed	2.800	0.116	-0.798	14	0.438	-0.250	0.313	-0.922	0.422
	Equal variances not assumed			-0.798	11.603	0.441	-0.250	0.313	-0.935	0.435
T2. Usefulness	Equal variances assumed	0.000	1.000	0.000	14	1.000	0.000	0.259	-0.555	0.555
	Equal variances not assumed			0.000	14.000	1.000	0.000	0.259	-0.555	0.555
T2. Easiness of use	Equal variances assumed	5.444	0.035	-1.000	14	0.334	-0.125	0.125	-0.393	0.143
	Equal variances not assumed			-1.000	7.000	0.351	-0.125	0.125	-0.421	0.171
T2. Level of interests	Equal variances assumed	0.013	0.910	1.667	14	0.118	0.625	0.375	-0.179	1.429

	Equal variances not assumed			1.667	10.986	0.124	0.625	0.375	-0.200	1.450
T4. Understandability	Equal variances assumed	2.032	0.176	-1.821	14	0.090	-0.750	0.412	-1.633	0.133
	Equal variances not assumed			-1.821	9.536	0.100	-0.750	0.412	-1.674	0.174
T4. Usefulness	Equal variances assumed	10.667	0.006	-2.017	14	0.063	-1.250	0.620	-2.579	0.079
	Equal variances not assumed			-2.017	8.044	0.078	-1.250	0.620	-2.677	0.177
T4. Easiness of use	Equal variances assumed	10.842	0.005	-2.923	14	0.011	-1.500	0.513	-2.601	-0.399
	Equal variances not assumed			-2.923	7.879	0.020	-1.500	0.513	-2.687	-0.313
T4. Level of interests	Equal variances assumed	1.088	0.315	-0.231	14	0.821	-0.125	0.541	-1.285	1.035
	Equal variances not assumed			-0.231	12.031	0.821	-0.125	0.541	-1.303	1.053
T5. Understandability	Equal variances assumed	29.167	0.000	-2.376	14	0.032	-0.625	0.263	-1.189	-0.061
	Equal variances not assumed			-2.376	7.000	0.049	-0.625	0.263	-1.247	-0.003
T5. Usefulness	Equal variances assumed	0.365	0.555	0.000	14	1.000	0.000	0.458	-0.982	0.982
	Equal variances not assumed			0.000	12.546	1.000	0.000	0.458	-0.993	0.993

Figure 123. T-test of values for each aspext. on two Gallery concpets

Overall Feedback

Points they liked:

- Great **interests** were triggered from the start of the experience, they all felt excited to experience the VR gallery.
- The **quality** of the artworks was ok to view, since there will be an AR app support more realistic viewing in the home scenario after.
- Most interactions were **easy to understand,** using the **laser pointer** to the icons was the most intuitive.
- They liked using **teleporting** functions, as long as they get the idea, they can easily move inside the gallery without moving. They preferred teleporting than move physically mainly because of laziness and lack of security to walk in a virtual environment.
- The **learning time** was pretty fast.
- **360-degree video**: very immersive and created a feeling that they can explore in the scene.
- **Stereo sound**: The stereo sound was a good way to block the outside noises, helped them be more immersive in the experience. Using stereo sound made them have a feeling of being in a real room.
- **The postcard**: It was a nice way to have a tangible gift from the gallery.
- **The AR app**: They expressed they normally need more time to consider a purchase of a high-value product, so the AR app would be a good tool to help them make decisions afterwards.
- The VR gallery offered **different perspectives to view the artwork**. The multimedia information provided was richer than in a traditional gallery.

Points need to improve:

- There should be some ways to improve the **comfort** of wearing a VR headset.
- There should be **more guidance** integrated into the VR gallery.
- The **controllers** should be **brighter** to see.
- The "watch" button for the video can be clearer. "**VR watch**" may be better.
- The **indication of opening an artist's work** should be clearer. Users were not sure whether it can be clicked.
- The "**buy all**" process is too fast, there should be some guiding/texts after they click it.
- The "**save in postcard**" button is not clear to understand, maybe just "save it" is better. Providing postcard can be a surprise.
- Considering a third option to **save in email**, one participant expressed she was less willing to collecting things now than before.
- The **use of the AR app** should be shown/illustrated in the postcard or in the store, otherwise, users can hardly notice it.

Functions willing to have:

- A time indication inside the VR gallery (e.g. **a clock**).
- An **exit way**: there could be some design of the end process of the experience.
- A way to experience the **material** of the artwork, maybe integrating touching materials in the grip of the controllers or in stores.
- **Presence of others** in the VR gallery. Some people express their loneliness when he/ she's the only one in the VR gallery. Even some models of human beings can help them reduce loneliness. Besides, some also liked to see what others are viewing, like in a real gallery.

Remarks:

- **3** out of 8 prefered the interaction in

Gallery 1, while **5** prefered **Gallery 2.**

- They would love to spend quite a long time (at least **20 minutes**) to experience if they are in the pop-up store. Yet we still need to consider how long the experience should be to ensure the waiting time of other customers.

Conclusion and discussion

Looking back to the research question:

Q: Does the user feel this VR gallery more approachable than the traditional gallery?

A: In general, the users felt the VR gallery was more approachable than the traditional gallery. Users said they used to afraid of going to the gallery because they don't understand much about art. Yet with the help of the VR gallery, they have more perspectives to know art and artists. Some users felt that the VR gallery was more luxury and exclusive mainly because they felt the VR devices were expensive.

The functions were mostly easy to understand, and intuitive to use. More guiding should be provided in the refined gallery.

Q: Does the user feel interested to explore the VR gallery?

A: All users expressed their excitement to explore in the VR gallery, and they were satisfied with the existing contents.

Q: Does this VR gallery encourage their interests to know more about arts? In order to purchase more arts?

A: Users expressed their willingness to visit the VR gallery again and would love to spend a long time to experience it. The AR app could help them to make decisions later but we couldn't be certain they will purchase more in the future. Some cheaper options related to the artworks are more welcoming to be purchased.

Q: What functions could be developed further?

A: Most of them didn't miss any functions they want during the experience of the VR gallery. One said it will be better if he can also experience the material of the artworks in some way. For example, integrating some touching samples in the controllers or in the store. Some also indicated the willingness to have the presence of others.

Q: How much time they would like to spend in the VR gallery?

A: They would love to spend quite a long time (at least 20 minutes) to experience if they are in the pop-up store. Yet we still need to consider how long the experience should be to ensure the waiting time of other customers.

Q: Which way of interactions do they prefer? Gallery 1 or Gallery 2?

A: 3 out of 8 prefered the interaction in Gallery 1, while 5 prefered Gallery 2. For integrating, it should be better to use the interactions that are based on the use habit of the touchscreens. People were more intuitive and learned quickly to use Gallery 2.

F

CONCLUDING REMARKS

This final chapter includes a short conclusion about the whole project and the value of the design concept. Limitations to the research and project and recommendations for further development are mentioned as well.

01 CONCLUSION

The goal of this project is to enhance the current gallery experience using VR technology and to encourage purchases. Based on the analysis of the user research and literature review, the reasons behind the current situation, fewer customers visit galleries and the threshold to participant in this activity is high for younger people, were revealed. On the one hand, current galleries often couldn't attract customers to view around for a long time. On the other hand, novice customers don't have an easy and friendly way to purchase artworks. Therefore, it requires the design to find a proper way to help the small art businesses adopt a more modern way of selling artworks, and attract younger customers. By analyzing from human, technology and business aspects, the desired user experience is determined:

"The envisioned new gallery will offer a more approachable way of visiting a gallery. The novice art buyers should feel comfortable to enter the café-like gallery, where they can explore different forms of interactions with VR HMD devices to have continuous stimulation. Furthermore, after the experience, they should be motivated to spread the word. They should be offered possibilities to schedule next visit or glancing desired artworks online."

Due to the time constraints, the design focuses were narrowed down to the experience inside the virtual gallery. By conducting a co-creation session, three concepts were determined using the Morphological Chart. These three concepts focused on three different directions based on the design requirements: Approachable, emotions, and purchase. After doing the user tests by using paper prototypes, key elements that should be included in the final design were concluded.

By conducting the prototyping process, four steps of building a virtual gallery were found, and the process can be used as a guideline for researchers or designers who want to develop a virtual gallery. In order to find a relatively better interaction of certain functions, two gallery concepts were created differs from the interactions.

During the evaluation user tests, users showed preference on the interactions designed based on use habit of touchscreens. Besides, they liked that the experience continues (postcard & AR app) even after they took off the VR goggles.

In conclusion, the actual VR gallery did offer a more approachable way of visiting a gallery, it gave the users opportunities to view artworks in different perspectives. Novice users are more encouraged to spend time in the gallery. The postcard and the AR app increased the possibility of making purchase decisions after visiting a VR gallery.

There are still steps need to be taken to complete the concept from both a technical perspective and a design perspective. Further developments and adjustments will enrich the user experience, and desired user experience can be realized better.

02 LIMITATIONS

This section will discuss the limitations of the project from research stage to evaluation stage and the possible implications.

Limited access to the real user group

One of the obstacles in the project is to get in touch with the user group, especially for non-Dutch speaking people like the researcher. The VR gallery was designed mainly facing Dutch locals, therefore the research about galleries and user characteristics were mainly from literature reviews. Although inquiry research was conducted, the sample sizes were not big, and there was not much verbal communication with the gallery visitors due to the language barrier. The user profiles and storyboards can be more explicit and convincing if more people from the target group join in the research activity and provide detailed information about their purchasing behaviours.

Besides, the participants in the final evaluation user tests were students and employees of Delft University of Technology. There is a chance that they are more open to new technologies and accept better than the average users, which may cause deviation in the result.

Limitation of the design iteration and validation

Due to limitations in time and resources, it is not feasible to carry out a real gallery visiting experience for the design iteration and the evaluation of the final concept.

Instead, evaluation sessions with peer students and concept tests with users were conducted during the design stage to check the effect of certain features and people's likelihood of use. User tests were conducted for the final evaluation. Although miniature models and introduction briefing can help the users understand the scenario better. The testing place is still different from a real pop-up gallery. The result of the final evaluation shows that the concept meets the design goal, but there are still things that need to be tested in a real-life context and during real experience.

Limitation of the project scope

For now, the project only focuses on the experience inside the VR gallery. However, when looking at the desired user experience, it's not only about the experience in the virtual environment, but the whole journey of purchasing experience. This design should not be limited to the interactions in the virtual environment, it should be about every stage of visiting a gallery.

In addition, according to the feedback from the evaluation, using VR technology is not always the best option to execute certain functions. If the new gallery wants to blend in more into people's lives, a more accessible technology like website or AR apps should be considered.

03 RECOMMENDATIONS

Based on the conclusion and limitations, recommendations for further development are given as follows.

Recommendations for further development

More guiding for better understandings

In order to keep the prototype a minimum viable product, it is ok to have fewer guidings, since the researcher can give instructions whenever the users have questions. However, if the product needs to be implemented in a real pop-up store, the staff won't have time to tutoring every single function to the customers. Therefore, more independent guiding like a tutorial should be given in the VR gallery, which is good for both customers to have a more immersive experience and staff to be less hurried.

More artworks implemented and change over time to time

In order to keep the VR gallery simple for people to experience, it is fine to have fewer artworks implemented. However, if the gallery wants to keep customers visiting more than once, the artworks implemented should be more and change over time to time.

Consistent designs

It is important for users to experience consistent designs / interactions. For example, if the VR gallery wants to use a laser pointer as the main interaction method, there shouldn't be things that triggered by walking closer. Too many different types of interactions will easily confuse users.

Recommendations for further validation

As mentioned in the limitations, the concept needs to be refined to enable users to experience in a real-world context.

04 PERSONAL REFLECTION

I was motivated to execute this graduation assignment mainly because of two reasons: One is I am enthusiastic about high-technology like Virtual Reality. The other one is I have a personal vision of properly educating people on how to deal with the changes in this fast world, and not lose themselves in the chaos and stress, the unique point of helping the traditional industry to adapt to the new digital world interests me a lot.

Before the project, I had almost zero experience in the art galleries. I was like the many others, interested in art but often couldn't understand much. Visiting an art gallery sounded like a "luxury" activity to me.

However, by conducting inquiry studies in the field, I found some galleries were more approachable than I assumed. I was able to step into the galleries and talked with some owners who were open to share their thoughts. During the research phase, I was glad to have a chance to talk with the artists and to see how their lives. It was like opening a new door for me to see the artists working behind an artwork. It was that time I have the idea that I should bring the stories of the artists to more people. Having different opportunities to conduct research really broaden my insights and showed me possibilities to design. I found it precious that as long as I had the courage to talk with people, they were mostly willing to share their stories.

Another thing I learned is that everything you did is useful. During working on the prototypes, I tried many things because of my curiosity. For example, renting a 360-degree camera to test recording 360-degree videos, and trying different methods to 3D scan artworks. I didn't plan to write down all the things I tried, because most of them are testing some hypothesis I suddenly have in mind. Yet after I talk to my mentor, she told me my experience are always precious for the other researchers. These tryouts can be useful and time-saver for others who also want to work on a similar topic. Therefore, I started to learn to organize my experience and wrote them into guidelines for others to use. That is exactly how millions of researchers work.

During the process, I also learned that it is impossible and unnecessary to present or share things until it's perfect. I used to spend a lot of time refining my ideas and prototypes before I want to share it with others. Yet later I realized a half-way finished prototype can often let others be closer to it. People are more willing to share their opinions on a basic model, while they tend to say all the good words to a finished product. People are afraid to criticize a perfect model because they feel you have already put many efforts into it. Now I started to remind myself to work with minimum viable product to give plenty of rooms to improve and save time on iterations.

After all, I had struggles but also joys during the project. I am proud of what I have achieved in this project. The final design reached my expectation to some extent; I can see the chance to attract more young customers and I hoped it could be developed further and really benefit the small art associations. This project was very valuable and meaningful to me because it brought me to a new field and pushed me to use the skills I learned from my life before to deal with all the challenges. It's definitely a unique unforgettable learning experience.

REFERENCE

Artivive. (2018). Artivive: #bringArtToLife. Retrieved June 23, 2019, from https://artivive.com/

Aschenbrenner, D. (2017). Human Robot Interaction Concepts for Human Supervisory Control and Telemaintenance Applications in an Industry 4.0 Environment. Retrieved from https://nbn-resolving.org/urn:nbn:de:bvb:20-opus-150520

Bardi, J. (2019, May 15). What is Virtual Reality? [Definition and... Retrieved June 22, 2019, from https://www.marxentlabs.com/what-is-virtual-reality/

Barquet, A. P. B., Cunha, V. P., Oliveira, M. G., & Rozenfeld, H. (2011). Business model elements for product-service system. In Functional Thinking for Value Creation (pp. 332-337). Springer, Berlin, Heidelberg.

Cachet, E., & Kroesemeijer, S. (2014). Herhalingsonderzoek kunstkopers (Z3707). Retrieved from http://nederlandsegalerieassociatie.nl/wp-content/uploads/2012/11/Marktonderzoek-2014-vraagzijde.pdf

Cachet, E., van der Linden, C., Tepaske, T., & Rooker, M. (2010). Herhalingsonderzoek vraagzijde beeldende kunst in Nederland (M4282). Retrieved from http://nederlandsegalerieassociatie.nl/wp-content/uploads/2012/11/Marktonderzoek-2010-vraagzijde.pdf

Charness, G., Gneezy, U., & Kuhn, M. A. (2012). Experimental methods: Between-subject and within-subject design. Journal of Economic Behavior & Organization, 81(1), 1-8.

Curat10n. (2019, March 10). Virtual Gallery - Immersive Art Exhibition & 3D Visualisation - Curat10n. Retrieved June 23, 2019, from https://curat10n.com/

Damen, D., & Cachet, E. (2017). Herhalingsonderzoek kunstkopers (Z7670). Retrieved from http://nederlandsegalerieassociatie.nl/wp-content/uploads/2017/09/Motivaction-Eindrapport-NGA-kunstkopers-2017-.pdf

de Jong, P., & Wolters, L. (2017). Ontwikkelingen Nederlandse galeries 2017 (Nr. 1566). Retrieved from http://nederlandsegalerieassociatie.nl/wp-content/uploads/2017/09/APE-Eindrapport-NGA-aanbodzijde-2017.pdf

Desmet, P., & Fokkinga, S. (2018). Human Exerience Catalog: Five Typologies of Human Experiences. Rotterdam: Emotion Studio.

Donald, R., & Lehmann, W. (1997). Product management. Irwin McGraw-Hill.

Fernandez, C. (2006). Acceptance of technological change: Do age, expertise and self-efficacy matter? (190). Retrieved from https://digitalcommons.unomaha.edu/studentwork/190

Google. (n.d.). Glass – Google. Retrieved June 22, 2019, from https://www.google.com/glass/start/

Google. (n.d.-a). Discover Street View and contribute your own imagery to Google Maps. Retrieved June 23, 2019, from https://www.google.com/streetview/

Google. (n.d.-b). Google Cardboard – Google VR. Retrieved June 23, 2019, from https://vr.google.com/cardboard/

HTC Vive. (n.d.). VIVETM | Discover Virtual Reality Beyond Imagination. Retrieved June 23, 2019, from https://www.vive.com/eu/

Jonathan Steuer, Frank Biocca, Mark R Levy, et al. Defining virtual reality: Dimensions determining telepresence. Communication in the age of virtual reality, pages 33–56, 1995.

Li, R., Luo, T., & Zha, H. (2010). 3D Digitization and Its Applications in Cultural Heritage. Digital Heritage, 381–388. https://doi.org/10.1007/978-3-642-16873-4_29

Microsoft. (n.d.). Microsoft HoloLens | Mixed Reality Technology for Business. Retrieved June 23, 2019, from https://www.microsoft.com/en-us/hololens

Microsoft. (2018). Microsoft In Culture | Mixed reality brings Ford GT supercars to life. Retrieved June 23, 2019, from https://www.microsoft.com/inculture/arts/petersen-automo-

tive-museum/

Oculus. (n.d.). Oculus. Retrieved June 23, 2019, from https://www.oculus.com/

Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley.

OWW. (2018). Occupy White Walls. Retrieved June 23, 2019, from https://www.oww.io/

Ozkaramanli, D., Fokkinga, S. F., Desmet, P. M. A., Balkan, E., & George, E. (2013, November). Recreating AlaTurca; consumer goal conflicts as a creative driver for innovation. In ESOMAR Qualitative Conference: Brilliant transformations (pp. 17-19).

Pavlidis, G., Koutsoudis, A., Arnaoutoglou, F., Tsioukas, V., & Chamzas, C. (2007). Methods for 3D digitization of cultural heritage. Journal of cultural heritage, 8(1), 93-98.

Pintus, R., Pal, K., Yang, Y., Weyrich, T., Gobbetti, E., & Rushmeier, H. (2015). A Survey of Geometric Analysis in Cultural Heritage. Computer Graphics Forum, 35(1), 4–31. https://doi.org/10.1111/cgf.12668

Reynolds, T. J., & Gutman, J. (1988). Laddering theory, method, analysis, and interpretation. Journal of advertising research, 28(1), 11-31.

Rijksmuseum - first floor — Google Arts & Culture. (n.d.). Retrieved June 23, 2019, from https://artsandculture.google.com/streetview/rijksmuseum-first-floor/rAG25bi4TlLfDg?sv_lng=4.884716465035126

Roozenburg, N. F., & Eekels, J. (1995). Product design: fundamentals and methods (Vol. 2). John Wiley & Sons Inc.

Sanders, E. B. N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. Co-design, 4(1), 5-18.

SINUS. (2018). Sinus-Milieus. Retrieved June 16, 2019, from https://www.sinus-institut.de/en/sinus-solutions/sinus-milieus/

Slime Engine. (2018). Slime Engine - 史莱姆引擎. Retrieved June 23, 2019, from https://720yun.com/t/c00jeztn5n4?scene_id=22814778

Snyder, C. (2003). Paper prototyping: The fast and easy way to design and refine user interfaces. Morgan Kaufmann.

Sony. (n.d.). PlayStation®VR. Retrieved June 23, 2019, from https://www.playstation.com/en-ae/explore/playstation-vr/

Space Plunge. (2018, January 25). Art Plunge. Retrieved June 23, 2019, from https://www.oculus.com/experiences/go/1358025144231073/

Steam. (n.d.). Welcome to Steam. Retrieved June 23, 2019, from https://store.steampowered.com/

Unity. (2019). Unity for All. Retrieved June 23, 2019, from https://unity.com/

Unreal Eingine. (2019). Unreal Engine | What is Unreal Engine 4. Retrieved June 23, 2019, from https://www.unrealengine.com/en-US/

VR3D. (2019). VR3D - Interactive 3D online and 3D scanning technology - Bring everything into Virtual Reality world. Retrieved June 23, 2019, from https://vr3d.vn/en/

Wikipedia contributors. (2019, June 20). Mixed reality. Retrieved June 23, 2019, from https://en.wikipedia.org/w/index.php?title=Mixed_reality