

SEEING SCHRÖDER

AN AUGMENTED
REALITY EXPERIENCE

GRADUATION
REPORT

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CENTRAAL
MUSEUM



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PREFACE

The Rietveld Schröderhouse is managed by, but not owned by the Central Museum. The visual rights are also in the possession of Pictoright. Every picture that is used outside of personal use needs to be approved by them. The use of pictures in the house is, for this reason, kept to a minimum. At some places drawings are used instead, to give a clear image of the situation, while preventing copyright infringement. The drawings for the chapters; Seeing Schröder and Future, are made by Martijn Steenken.

SUMMARY

This report describes the further development of the mixed reality (**MR**) experience for the Rietveld Schröderhouse (**RSH**). At the end of the analysis phase a design brief is formulated, this design brief functions as the base of this project, with the theme; 'Through time' as starting point.

To find the capabilities of myself and the technology, development and testing was done first, creating a basic understanding of the technical possibilities and problems. The problems showed the need for more extensive testing and comparing of several technologies, to see the difference in experience. The ideation phase builds on the technological capabilities, while focusing on enriching the visitor by telling them a significant story.

The final result is the design direction: Seeing Schröder. This direction tells a more detailed story about Truus Schröder, co-designer and resident of the house. It not only answers the questions about her the visitors tend to have, but it also shows the more human and warm side of the house it has lost after Truus passed away,

The tests are done in the RSH itself with actual visitors, testing the technology as well as the story.

INDEX

- 3• PREFACE
- 3• SUMMARY
- 4• INDEX
- 6• DESIGN BRIEF
- 6• THROUGH TIME

8• DEVELOPMENT

- 10• SETTING UP
- 10• SOFTWARE
- 11• TESTING ON LOCATION
- 11• MODELS
- 12• MARKERS
- 13• IN HOUSE TESTING
- 13• MARKERLESS
- 14• MARKERS
- 14• BEACONS
- 15• ARYZON
- 16• CONCLUSIONS

18• IDEATION

- 20• TELLING STORIES
- 21• EXPERT INPUT
- 21• SYMPOSIUM CENTRAL MUSEUM
- 22• SCIENCE AND COMMUNICATION
- 22• EXPERT INSPIRATION DAY
- 23• CONCLUSIONS

24•

- 26• TRUUS SCHRÖDER
- 27• THE TEST
- 28• OBJECTS FOR TESTING
- 30• THE RESULTS
- 30• MARKERS
- 31• THE MODELS
- 32• CROWDS
- 33• EASE OF USE
- 34• THE QUESTIONNAIRE
- 38• THE PLAN
- 38• PREPARATION
- 39• BEFORE STARTING
- 40• THE TOUR
- 42• THE NARRATIVES
- 42• SEEING SCHRÖDER (INITIAL)
- 43• THE MARKERS

44•

- 44• NOW
- 45• 5+ YEARS
- 48• RECOMMENDATIONS
- 50• AUGMENTED REALITY ON A TABLET
- 51• INTEGRATED AUDIO TOUR
- 52• MIXED REALITY GLASSES
- 53• POSSIBILITIES
- 54• POSSIBLE OTHER NARRATIVES
- 55• MARKERS
- 56• USER FRIENDLINESS
- 57• CONCLUSION

58•

98•

99•

SEEING SCHRÖDER

- TRUUS SCHRÖDER
- THE TEST
- OBJECTS FOR TESTING
- THE RESULTS
- MARKERS
- THE MODELS
- CROWDS
- EASE OF USE
- THE QUESTIONNAIRE
- THE PLAN
- PREPARATION
- BEFORE STARTING
- THE TOUR
- THE NARRATIVES
- SEEING SCHRÖDER (INITIAL)
- THE MARKERS

FUTURE

- NOW
- 5+ YEARS
- RECOMMENDATIONS
- AUGMENTED REALITY ON A TABLET
- INTEGRATED AUDIO TOUR
- MIXED REALITY GLASSES
- POSSIBILITIES
- POSSIBLE OTHER NARRATIVES
- MARKERS
- USER FRIENDLINESS
- CONCLUSION

ANALYSIS REPORT

REFERENCES

APPENDIX

DESIGN BRIEF

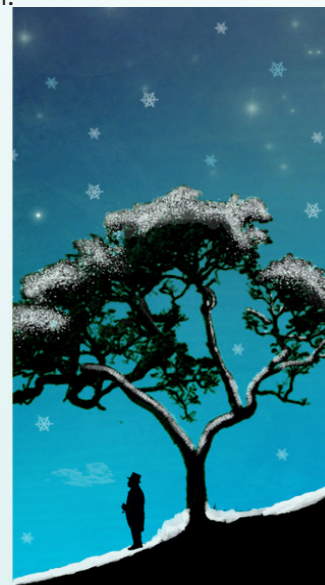
Prior to this report, an analysis report was created. The following design brief is a functional summary of the analysis report. The analysis report describes the internal analysis, about the companies, the external analysis, about external factors like users, and the way these results were processed. If needed the analysis report can be consulted on page 58.

THROUGH TIME

The Rietveld Schröderhouse is an architectural masterpiece just outside the Center of Utrecht (for more information see chapter 'House', on page 69). Witnessing the changeable partitions on the top floor leave many in awe. For this reason, people from all over the world come and visit the house. To accommodate these many different languages, the tour is given in over half a dozen different languages. The tour guides can not possibly be equipped with mastery over that many languages, so audio tours are there to support them.

The audio tours come in the form of a mobile phone like device, to which the visitor presses his ear. This way the tour is very individualistic and very static. With the outdated way the tour is done and to adapt to a rapidly developing society, the tour is ready for innovation.

This project is focused on delivering innovation in the form of enhancing the experience of the Rietveld Schröderhouse, through 'mixed reality' (MR, see appendix III). This project aims to add a virtual layer, which will create a more immersive experience and enhance the learning of the visitor. To give more direction for this enhancement a search area was described and selected. This search area is 'Through Time'. This search area focuses on showing the history of the house, the residents and the environment, informally showing extra depth of information.



Why

The house is nearing the age of 100 years old. Much has changed over this long period of time. Not only did many residents come and go, and furnishing go through many changes, but even the environment changed greatly. When the house was built, it was on the complete edge of the city, with just grasslands around, in a time when the T-Ford was still in production. Even though it has been built in another century, it still has a very modern twist. A great way to show things and events from other eras is mixed reality, which can show things that have once existed, but are no more. Implementing mixed reality has great benefit for the immersiveness and learning of the visitor, while being an excellent showcase for the project hosts.

Who

The target user will obviously be the visitors of the house, interested in the house and the story behind it, specifically the students and working visitors, willing to use mixed reality. The retirees showed to have a high chance of being reluctant to use mixed reality. The focus of this project will lie on people of various origin, for who the experience needs to be accessible.

Focus points

The focus of the project will lie on the bottom floor of the house. Adding to the bottom floor gives a lot of room for improvement, while having higher chance of acceptance by the visitor.

The information given will be correct history. Supplying information on Rietveld and the house. The learning that comes with it will be enhanced by mixed reality.

The transfer of information will be through mixed reality, also functioning as a technological showcase, where it should be innovative in showing of the technology.

How

The 'how' is the question which needs to be asked and answered in the next phase.

The biggest constant is 'mixed reality'. This project will be done with the use of that technology. The way it will be implemented will need to be expanded on in the next phase.

A large part will be prototyping. A lot of possibilities and limits will need to be tested, to be able to generate a fitting result. This will focus on three main points:

- How the visitors respond to the technology.
- How the visitors perceive the content.
- What is needed to create a perceived immersive environment.

Ideation will be done prior but also for a large part parallel with prototyping. This will focus on the content itself, as well as the broader story and the presentation. Broad lines can be sketched at the start of the next phase, which will be honed according to the found possibilities and limits found in the prototyping process.

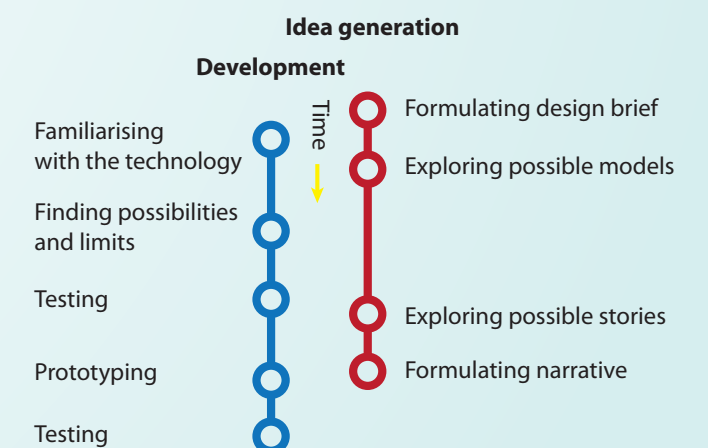
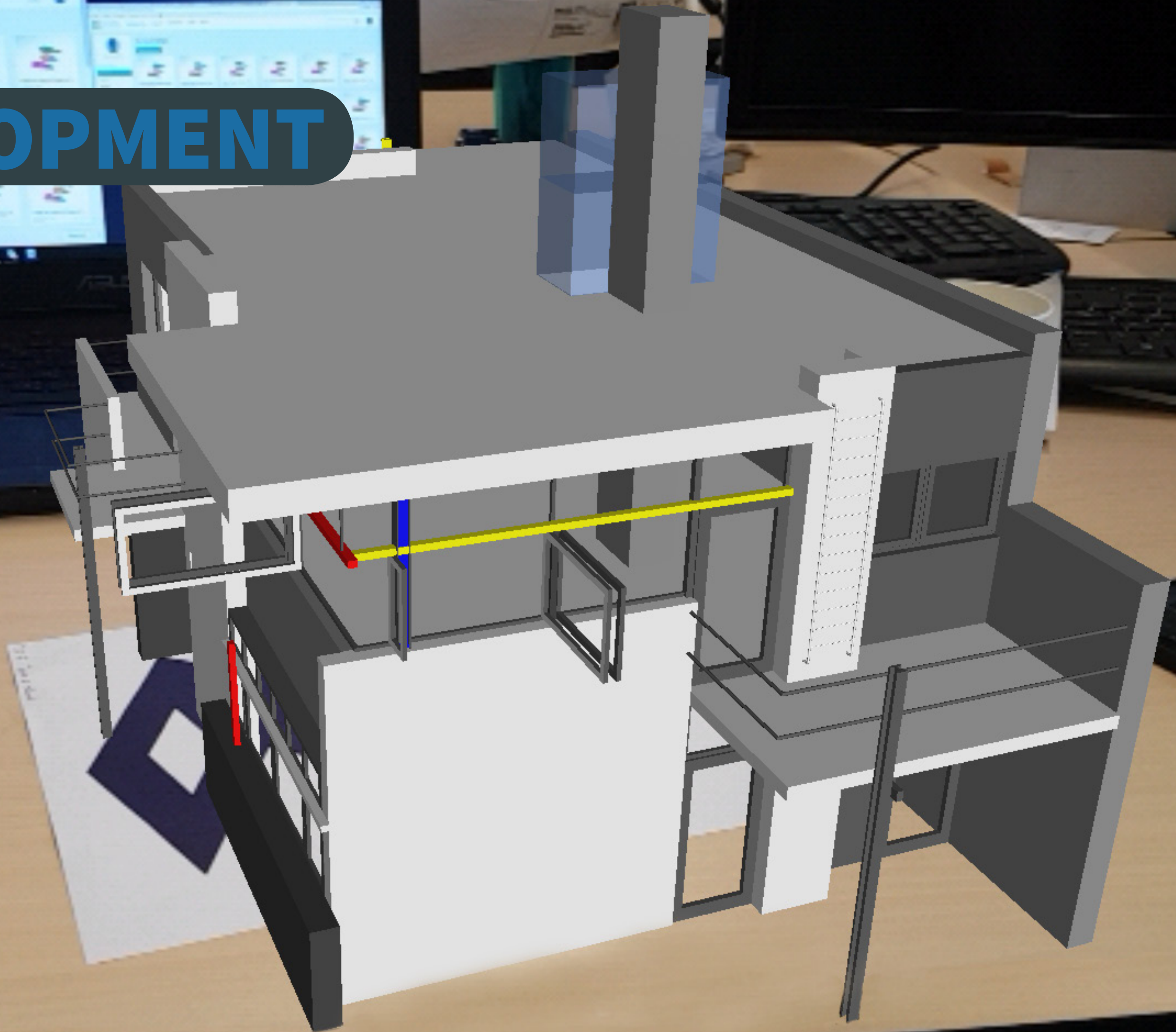


Figure 0.1: Schematic overview of the parallel processes

DEVELOPMENT

With the use of an unproven product; 'Aryzon' and Capgemini wanting a showcase, the possibilities to create this showcase had to be explored. To test the Aryzon initial tests needed to be done to see the worth to develop for this platform. Creating this initial test also creates the understanding in the capabilities and limitations of the software.



SETTING UP

In order to create a prototype to test the experience with, three aspects needed to be taken into account: The models, the placement and showing it on the device. These aspects ask for different types of software working together to create one experience for the user.

SOFTWARE

Showing

Unity is for many people, especially beginners, the go-to software to develop games and Augmented reality experiences. It is quite simple and supports a great amount of additional software packs to create a fitting environment to develop in. It implements many elements and makes it easily transferable to a device to test with.

Placement

Placement can be done with the help of marker-based software or markerless software. Markerless software makes it possible to detect flat surfaces with the use of just a camera. The model is then placed manually on this surface. ARKit(Apple) and ARCore(Android) are the main software packages to work with for markerless environments.

Marker-based software, like Vuforia, works with the use of images. By scanning the size and shape of the image, the software can recognize the distance and angle between the user and the marker, making it possible to project the model on this marker. As soon as the camera recognizes the marker it will show the model, which means it also can be moved.

Models

To create realistic enough models, while keeping form freedom, several software kits are used. For each case, the software kit(s) is used that best fits the model.

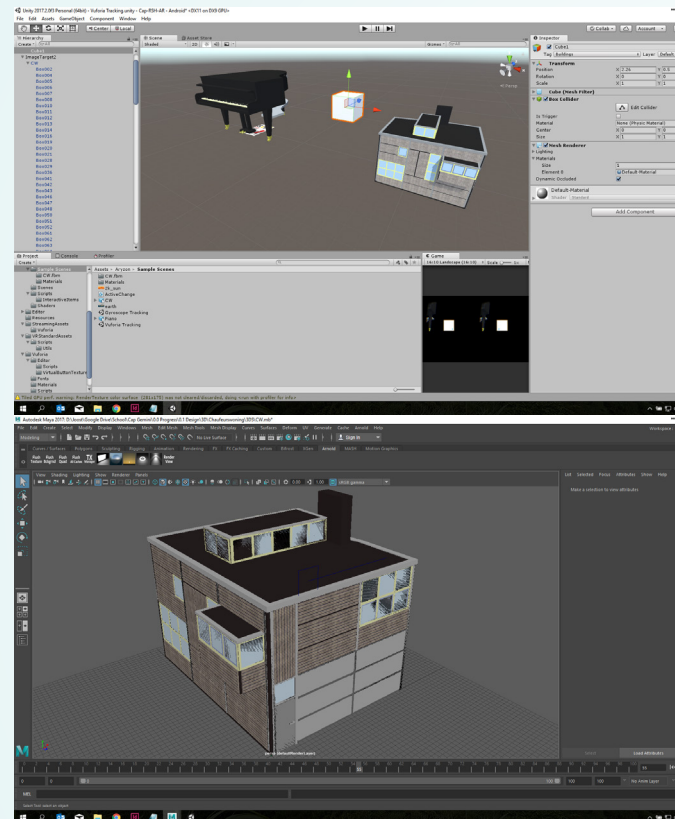


Figure 1.1a&1.1b: Unity and Maya

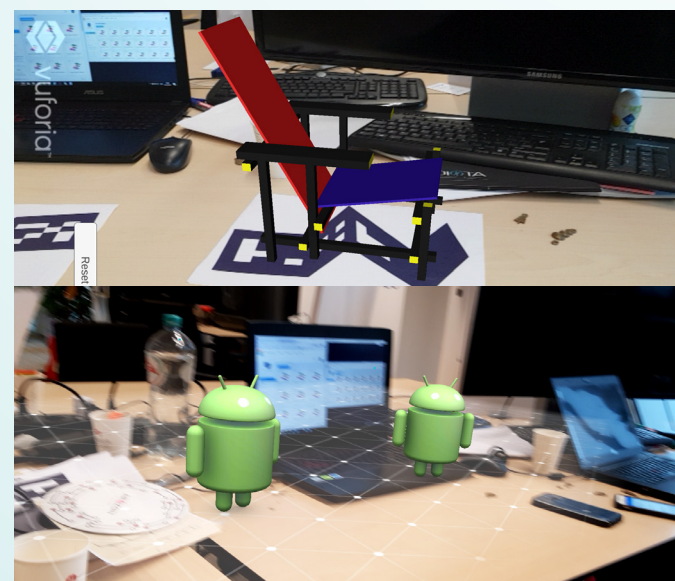


Figure 1.2a&1.2b: Marker-based and Markerless

TESTING ON LOCATION

Aryzon is a new and thus a hardly proven product, which means initial testing is necessary. The first part of research and development is working towards initial testing. The initial testing is mainly done to find out if the Aryzon is worthy of continuing with for this project. The initial testing will not only test the technological properties of the product, but also the way the user interacts with and feels about it. The questionnaire can be found in appendix VII.

MODELS

The initial models are a selection of products related to Rietveld, suggested by the representatives of the Centraal Museum. This selection was done on basis of the simplicity of the parts and the variety in shape, size and color. Aside from the iconic chair, the models are all custom made for the testing. The chair is used several times in different sizes and places, to test the influence of size and context. The objects are showed to the subjects, who are asked about their opinion on several aspects of the object itself, and how it fits in the context through a form. The opinions are tested on their opinion on a five point scale through a questionnaire(see appendix VII), filled in afterwards.

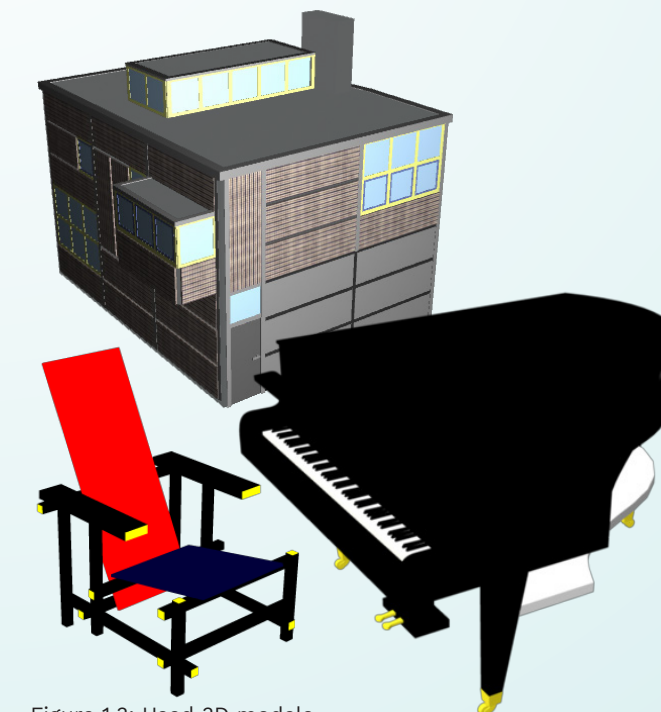


Figure 1.3: Used 3D models

Testing is done on a simple and small scale to form an early verdict. The preparation for this test is also used to practice with the use of several aspects of programming mixed reality. Every marker is different, but some models are duplicates. To prevent biased information, each subject started at a different model. The Piano model and marker was not seen by all participants, because of time constraints, so is less significant than the other models.

The models are better received when they appear to be logical in their placement in the house and their connection with the marker. Especially with the variations of the chair, it became apparent the models are best received when they are in line with expectations. Users said they found the real sized chair in logical context more appealing. However, this is not supported by looking at the scores. Especially the way the context is perceived is different from the user feedback.

The studio, the place the chair was designed, is given a lower overall score than the study room, while both showing the same chair. Arguably, this shows the marker to have a large effect on the perception of the context as well. This also shows the context being very important in the perception of the model, as the same models generate significantly different scores.

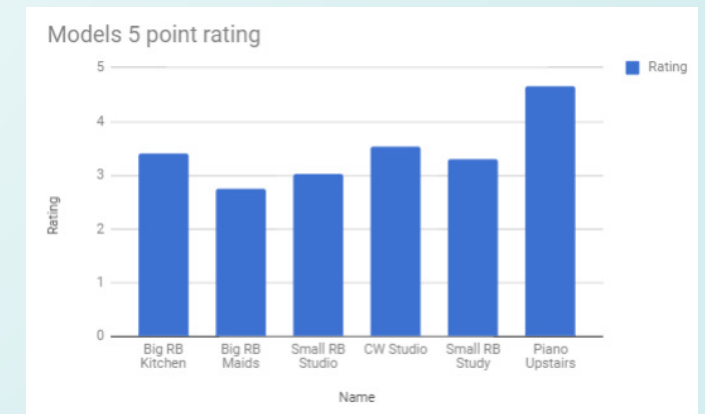
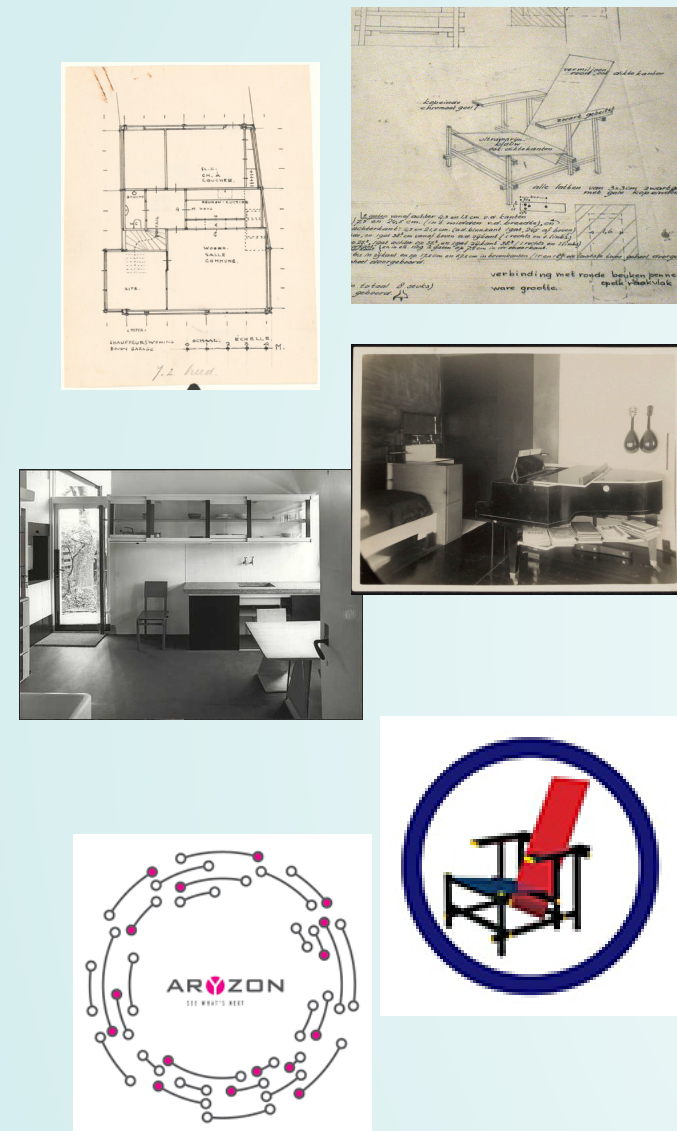


Figure 1.4: Average model score

MARKERS



Figures 1.5 A-F: Used markers

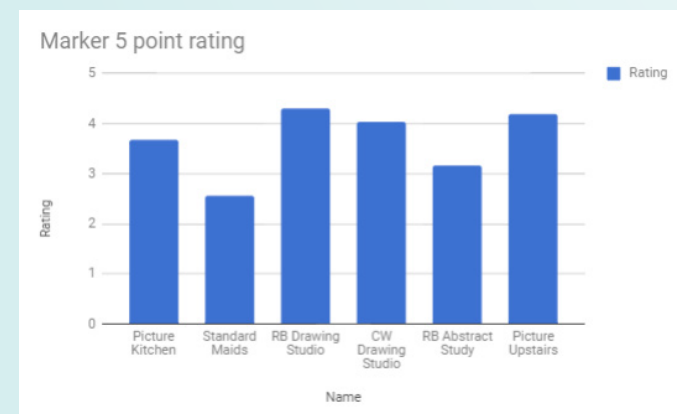


Figure 1.6: Average marker score

Markers are images, programmed to be linked to a model. Even the combination with a model already showed the impact of the markers. This already showed the experience will differ with different kinds of markers. The marker in itself also generated a lot of reactions with the users, ranging from being fascinated by the image itself, to being confused by the linked object.

The device can recognize the image and knows what model needs to be projected at what place. Three types of markers were used; technical drawings, pictures and abstract. These types were selected out of the assumption they would be significantly different from each other. The markers were made out of pictures and drawing deemed representative of the house and it's interior by experts in the Central Museum. Two more abstract images were created especially for this project, to see if the visitors responded differently

Technical drawings

The drawings' general score is the highest with margin, as can be seen in figure 1.6. It appeals to the imagination to use drawings with MR to show the 3D models that are based on these drawings. They were overall very positively received, but mostly were found to have a great positive influence on the room itself.

Pictures

The markers based on pictures were nearly as well received as the drawings, just falling behind slightly. Especially the photograph of the piano upstairs was very well received. People really liked it showed the historical layout, where this layout could be viewed by the user. The picture of the kitchen was used to show the model of the iconic chair. Even though the users were asked to imagine the iconic chair to be present instead of the chair in the picture, they indicated it appeared to be in an unfitting context.

Abstract markers

The abstract markers were better received than expected. Even though their influence on the rooms were not perceived to be positive, they did induce a high level of curiosity, as it was unclear what was to follow.

IN HOUSE TESTING

MARKERLESS

Markerless MR uses real world video to project 3D renders on, instead of markers. With the use of the camera, flat surfaces can be recognized and used to place objects on. (Figure 1.8)

Added value

Markerless MR has a great amount of added value. Not having to use markers take away restrictions in location of (variable) placement, as models can be placed anywhere, as long as it is a smooth and flat surface. It also takes away the restriction in design of the marker. Even if there needs to be a marker for the user to know where to look at the marker will be purely aesthetic and thus completely open for design.

Impossible (within scope)

The main markerless software kits at this moment are ARKit/ARCore. With these kits it is impossible to save the room to the device, as it has no long term spatial memory (Skarredghost, 2017). Software kits that implement this are unavailable to the private market.



Figure 1.7: Hololens Markerless (VRHeads, 2016)



Figure 1.8: ARCore Markerless



Figure 1.9: IKEA Markerless (Digiday, 2017)

MARKERS

After the first test in the house, the markers needed to be further explored, Vumarks in particular.

Vumarks

Vumarks are abstract shapes with high contrast, that have variable patterns in dark and light coloured shapes, working similarly as a bar-code. VuMarks can be really restricted in their form, but give the possibility to have nearly identical images paired with different models. It also takes away the possibility to show several models at once, as it projects both objects on the second marker. (Figure 1.11) The Zigzag chair was used for the Vumark, as can be seen in figure 1.10A and B, because of it's compatibility with the creation of Vumarks together with it's clear connection with Rietveld

Markers

Markers have a high level of form freedom, but needs a high level of individuality to work together with other markers. So very different markers need to be used in the same program. Changing markers will offer expectations as what objected will be projected, so should therefore be used cautiously.

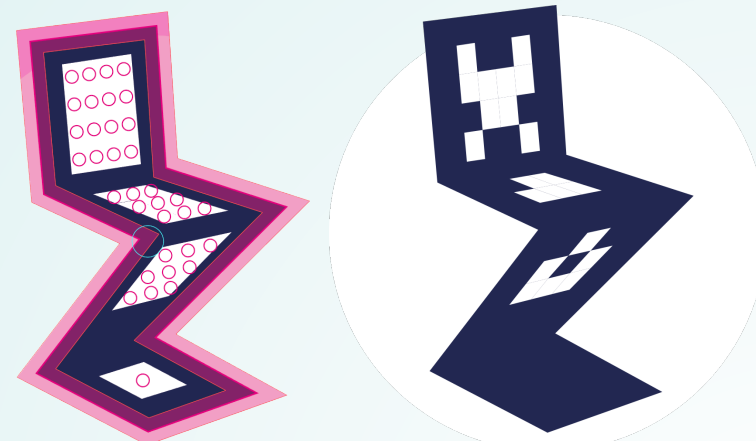


Figure 1.10A: VuMark setup 1.10B: Generated Vumark

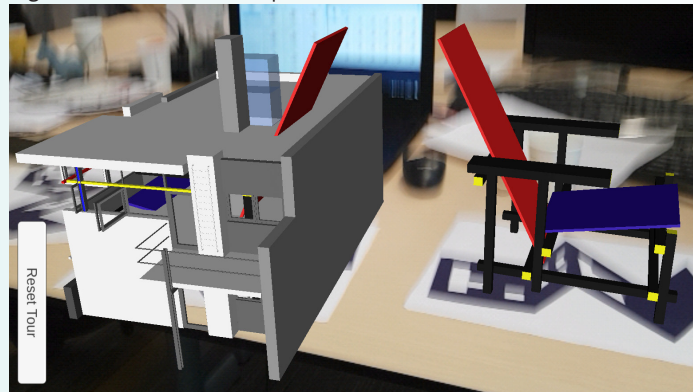


Figure 1.11: Use of multiple VuMarks

BEACONS

Beacons are small, battery powered devices that emit a BLE (Bluetooth Low-Energy) signal. Mobile devices can discover the signal, including the intensity. If the mobile device has a connection with at least three of these beacons, it can triangulate it's own location much more accurately than through GPS, making it possible to determine which room it is in.

By determining the current room Beacons can work complementary with the use of markers, where it could be a substitute for VuMarks. By programming models to be linked to rooms, only a single simple marker in every room can show unlimited unique models, based on the location the user is standing.



Figure 1.12A: Aruba beacon (Adaptive, 2018)

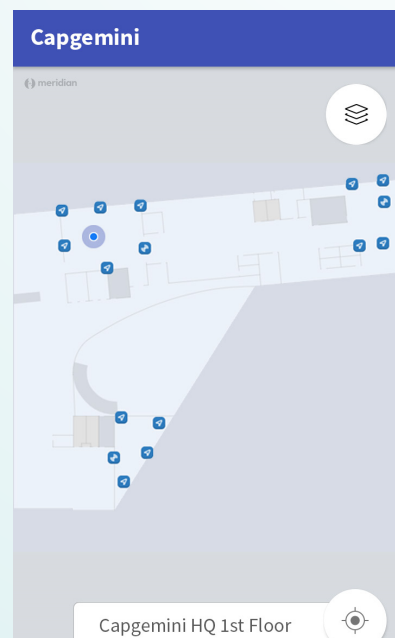


Figure 1.12B: Beacon navigation, showing current location (blue circle)

ARYZON

Testing showed the Aryzon to be inadequate. Even though the principle can generate very high value, in practice it is found to be quite a fun gimmick, but has some major problems.

Peepshow-effect

The best added value of the Aryzon, is the 'Peepshow-effect' (Overbeek, 2017). While you look through the glasses, the MR is everything you see, substituting that reality for your own, making you forget it is not real, which can sometimes even result in people trying to touch the model.

Shaky and incorrect placement

The models are interpolated onto the real world. The objected is projected on a black screen, where the model has to be placed exactly right to make it seem correct in the users view. In reality the view of the user and the model are disconnected, the model is retrospectively calculated and placed inside the view. These calculations do not always place the model correctly, making the model seem shaky. This creates a lag, where the model lazily follows the marker. The placement changes as well, even if the model is placed perfectly from one angle, a single shift in the position of the user or the angle of their head can make the model seem completely off. This unnatural movement and placement take away a large part of the immersion.

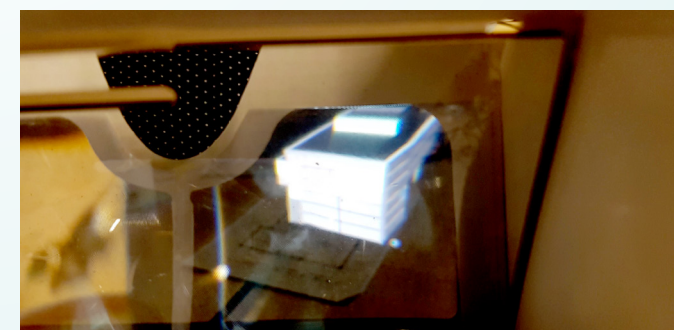


Figure 1.13: Askew placement

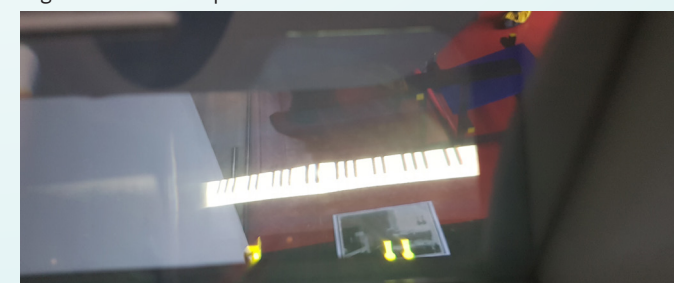


Figure 1.15: Black becomes see through

Range

The range of accurately showing models is quite low, with a normal A4 marker under and angle will let the user lose the model after roughly 1.5 meters. Depending on the situation, it is nearly impossible to show the model as soon as the user walks into the room, even after tweaking the image and enlarging the marker

See-through

The technology behind the Aryzon works by showing objects on a black background. This black background is then shown as see-through through the glasses, where the user only sees the object. This also means darker colours are more see-through as well. Objects with small patches of dark colours can still be completed with the imagination of the user. Objects with larger parts in a dark or black colour, e.g. a piano, can have a large part being nearly invisible.

Limited vision

The Aryzon has a rectangular window to look through, which takes away part of the peripheral view. In combination with the user being very focused on the objects in front of them, their spatial awareness suffers. In the Rietveld Schröderhouse, where people aren't allowed to touch most of the objects, this generates unwanted situations. In the short test, people already (nearly) walked into objects and walls.



Figure 1.14: A substituted reality



Figure 1.15: MR through a handheld smartphone

CONCLUSIONS

The use of markerless MR would be most ideal, but would require software developers. This does not fit in the current scope of the project but can be interesting for further development

VuMark or non-specific pictures are needed to accommodate changes in or use of multiple stories, so the user has no expectation for the projected object. The use of these markers make the location is always set, which narrows the possibility of narratives way down.

Beacons can be used to pinpoint location and to determine which object should be shown. This makes the use of a single marker for all of the objects, instead of VuMarks, possible. This single marker creates more freedom in its design.

Using the Aryzon comes quite naturally to people and having the ‘peepshow effect’ is a great benefit. However, the Aryzon’s capabilities are insufficient, so handheld MR will also be tested. The focus will lay on comparing the Aryzon with handheld phones and tablets, to see in what way the experience of the visit changes.

POSITIVE

Markerless is useful for further development

Beacons enable use of a single marker

Markers have a large degree of design-freedom

Use of Aryzon comes naturally

The implementation of multiple stories is possible

NEGATIVE

Markerless is impossible within the scope

VuMarks have limited design-freedom

Markers limit placement of objects

Aryzon’s capabilities are insufficient

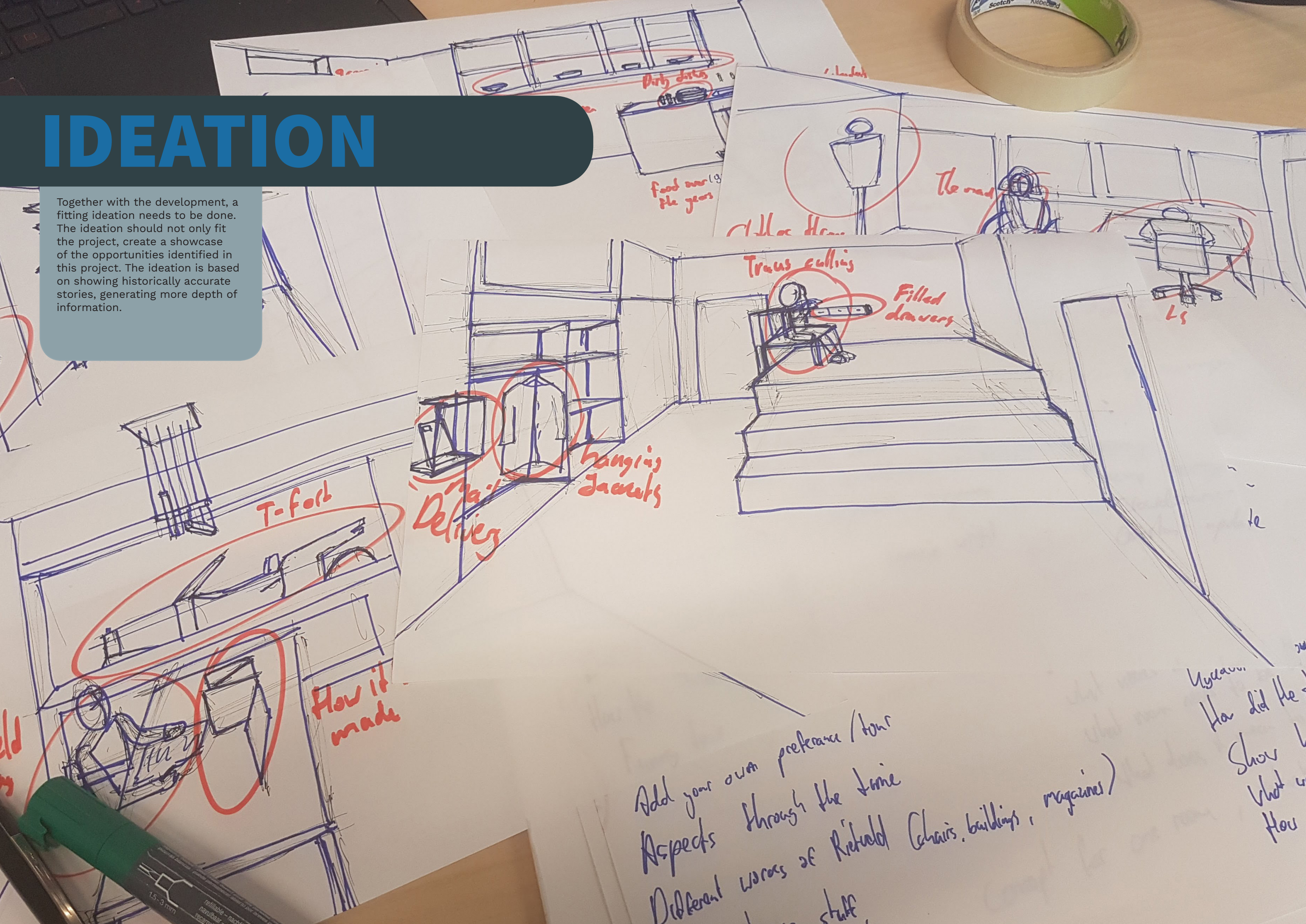
NEUTRAL

Markers influence the expectation of the showed object

Different types of MR need to be compared

IDEATION

Together with the development, a fitting ideation needs to be done. The ideation should not only fit the project, create a showcase of the opportunities identified in this project. The ideation is based on showing historically accurate stories, generating more depth of information.



Add your own preference / hour
Aspects through the time
Different words of Richard (chairs, buildings, magazines)
stuff

How did the
Show
What
How

TELLING STORIES

Telling stories has been the most fundamental communication method and has been used throughout the ages. Stories activate areas in the brain like the person is involved in the story, compared to only the language center being activated when it is just bullet points (Paul, 2012). Information will be more compelling if it is in the form of a story. In order to create a more dynamic and immersive experience as defined in the Design Goal (Design goals, page 97), story telling will be used to transfer information.

To gain more insight in the visitors, several conversations were held with the visitors inside the ticket office of the RSH. The gathered notes showed people wanted to have significant information about Rietveld. The story thus has to be focused on accurate history, taking the user along in a story showing aspects untreated in the audio tour.

The initial MR experience will be supplemental to the audio tour (Sighem, 2017). With the low acceptance of technology, the product first needs to be proven to be made to replace the audio tour. This does mean audio will be left out of the scope of this project.

The stories thus will initially be told solely through visuals via the placement of several virtual objects throughout multiple rooms in the house.

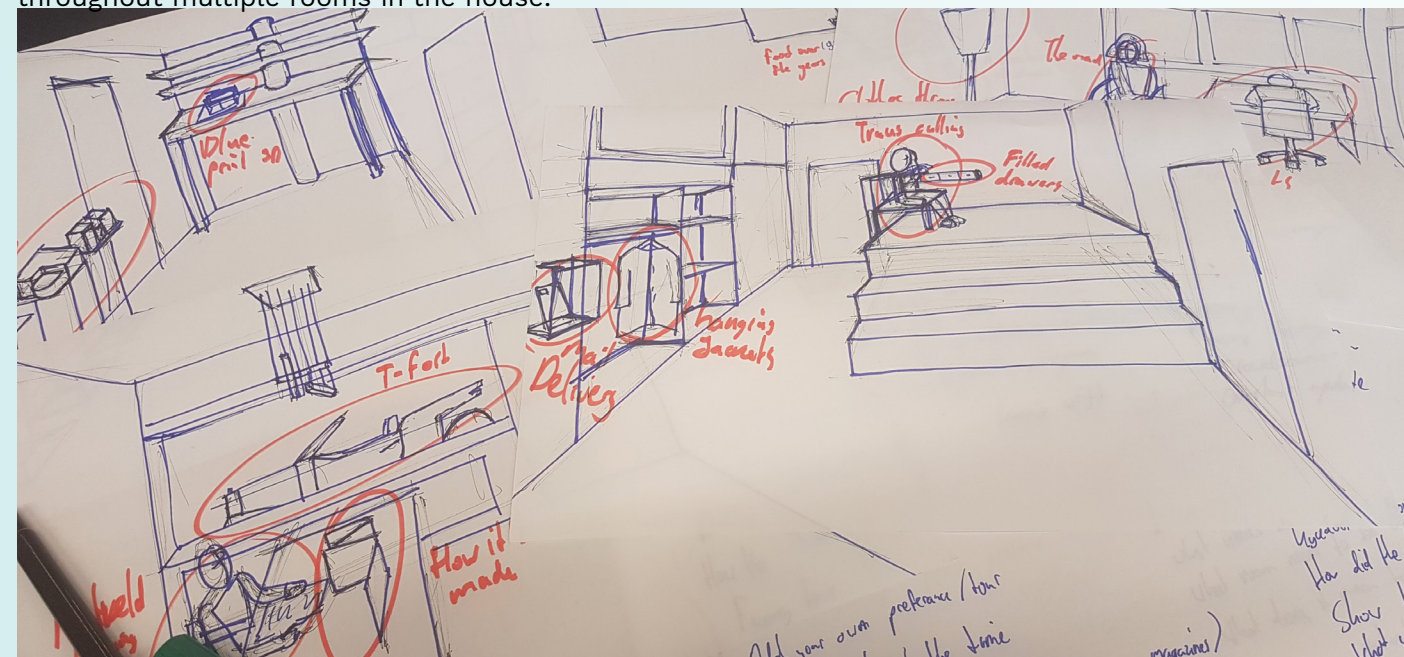


Figure 2.1: Possible scenes in each room

This way of story telling does lend itself very well for the other formulated search area: 'Variable Visits'. A framework was created to assist the possibility to let the visitor choose one of multiple stories to go through, the experience could be more tailor made, which could be proven to be more immersive.

This project will focus on the experience of the use of MR. To test this experience, a part of a single story will be used, so all of the test subjects share the same experience. Due to the limited abilities in the production of these visuals, the custom visuals will be static only. These limitations result in less dynamic storytelling, but will still be usable to test the experience.

The story that will be told has been looked at from multiple angles. This includes the opinion of the tour guides. The tour guides know all of the stories, so their opinion on what would like to see added, outside of the audio tour is very valuable.

The visitors themselves are also taken into account. Several guides indicate most questions, by a large margin, asked by the visitor concern the life of Truus Schröder.

EXPERT INPUT

During the project, close collaboration was held with several parties, next to the TUDelft and Capgemini, also the Central Museum and the employees at the house itself were often consulted. These expert opinions and in depth information was used to support the project. Aside from these obvious partners, several events were used to gather external experts and gain even more information. These experts ranged from experts on industrial design to family of Truus Schröder herself.

SYMPOSIUM CENTRAL MUSEUM

The symposium at the Central Museum Utrecht was aimed to talk about the restoration and further future of the Rietveld Schröderhouse. It was a gathering of mostly experts on the house, from the Central Museum and external, including several family members of Mr. Rietveld and Miss. Schröder

The experience of being in the room with people so closely related to the house and its creators was very impressive. The fact these people were so closely related or even related to Truus and Gerrit was very noticeable in their opinions. The most common opinion was; the spirit and values of Rietveld and Schröder should be kept alive and needs to have overall priority, the two founders should be handled with utmost respect. Dynamics is a very big item here. The whole top floor was designed to be dynamic. Truus even said she didn't want the house to become "the Czaar Peterhouse", where the whole house would be frozen as if Truus could come back any moment. Not taking the spirit into account, like by adding modern art to the walls, went very unappreciated by the attendees, also the use of mixed reality created some friction.

The discussion showed many points of friction within the crowd; a debate about the use of replicas instead of original furniture create two teams, one of which wanted to go for preservation, versus wanting to keep the experience authentic. In the length of the discussion more and more people wanted to join in to give their opinion on that matter.

One of the things this really showed was that the RSH was more than a house. The emotions the attendees showed in their opinions really showed the personal nature of their connection with it. It was not only a house, but the life's work of two people they knew and held so dear. For most of the attendees it seemed the house was not even an object, it was part of the family and should be treated as such.



Figure 2.3: Central Museum presentation

SCIENCE AND COMMUNICATION

SciCom NL is an organization, aimed at scientific communication. A network event for this organization was used to gain some expert feedback. These experts are working in different areas within the bounds of SciCom’s field, most of which at museums.

With a short presentation and discussion afterwards, it could be concluded the use of mixed reality in a museum has great potential, if the realization is of high quality. It can be of great use in telling the stories a museum tells, especially scenes including moving people would be greatly enriching. In this way it not only tells the story, it lets the user be there. Also the possibility of making a connection with other similar houses of works of art can be truly enriching, as it widens their view.



Figure 2.3: SciCom presentation

EXPERT INSPIRATION DAY

The Expert Inspiration Day of the Museum Futures Lab was an event for about a dozen students and just under ten experts of design companies and museums. The aim of the day was for the students to get input and direction from the experts, while the experts gained some inspiration from the works of the students.

The experts showed great interest in the direction of showing the story of Truus Schröder. Especially considering the sterile and ‘un-homy’ air of the house at this moment. The experts found showing this very human part of the house makes great use of MR.

Even though no real new insights were found, all of the existing insights were reaffirmed. This reaffirmation made it possible to pursue the current direction more surely and confidently.



Figure 2.4: Expert inspiration day

CONCLUSIONS

Stories are one of the best ways to share information about the RSH with the visitors. The choice of narrative that will be told will be influence by many types of people.

Several types of experts in the area of design and museums, but foremost experts on the RSH itself, all have different opinions which should be taken into account. However, all these different opinions do have one thing in common; their belief the story of Truus and Gerrit is one worth telling, which should be done with utmost respect.

The tour guides and other staff of the RSH are a great source of information on possible narratives and wishes of the visitors. In the end the visitors will be the users, so they are the most important. Through interviews and the guides, the opinion of the visitor can be outlined.

REQUIREMENTS

The narrative should be significant information

Only (static) visuals will be used

Rietveld’s and Schröder’s spirits needs to be kept alive, with respect

WISHES

MR should be used to tell a story

A framework for multiple stories

The MR experience should be off high quality

The house should be dynamic and lively

SEEING SCHRÖDER

Truus Schröder is the designer, owner, caretaker and foremost resident of the Rietveld Schröderhouse. Her spirit can be found in most of the house, especially the interior, as it is like she liked to live herself, simple and soberly.

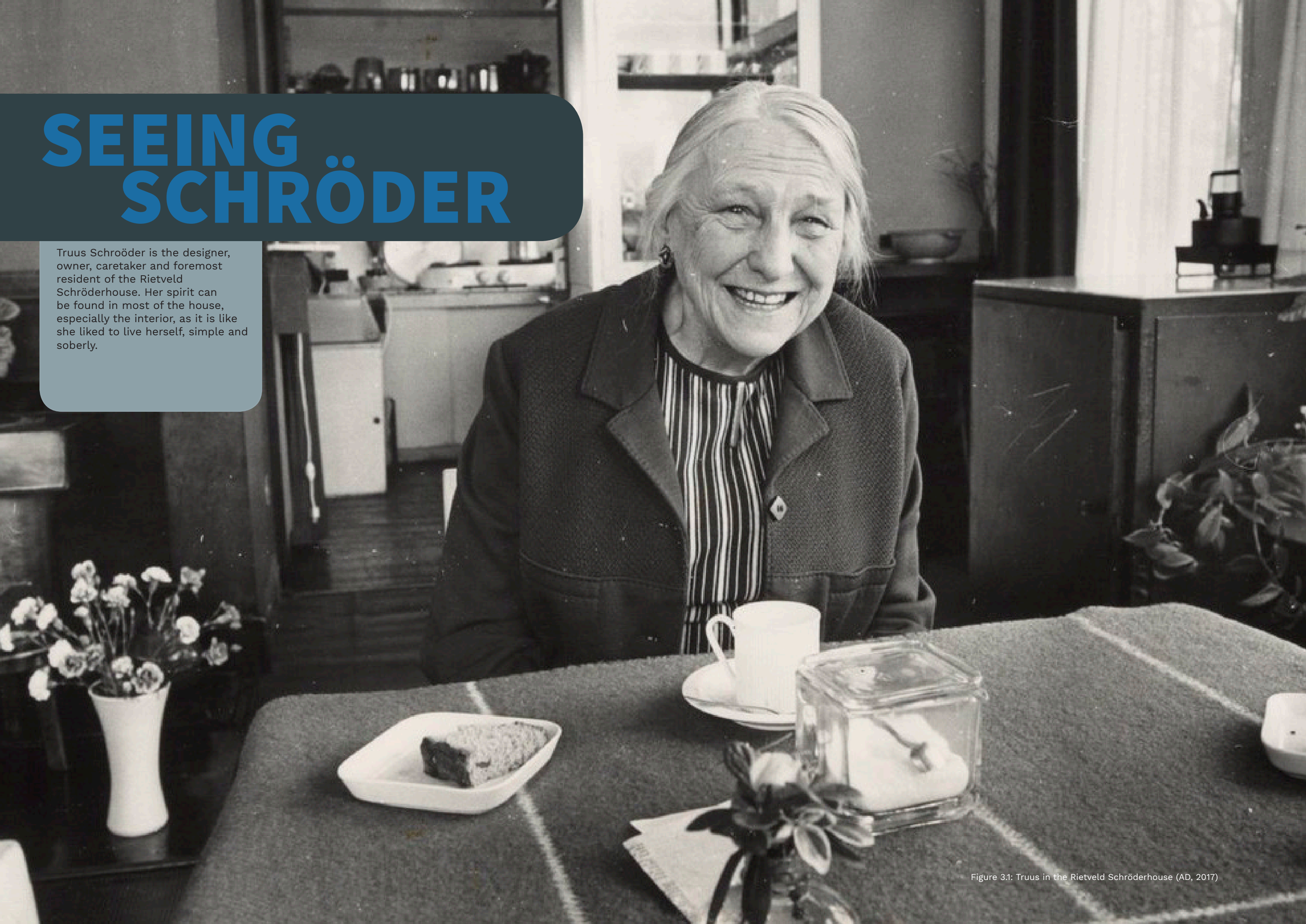


Figure 3.1: Truus in the Rietveld Schröderhouse (AD, 2017)

TRUUS SCHRÖDER

Truus Schröder, visionary, designer and mom. Truus Schröder was an exceptional woman. She was very modern in spirit and action. She did not only commission the Rietveld Schröderhouse, she co-designed it. The like mindedness of Rietveld and her, developed in a fruitful relationship of 40 years, in which she helped with many ideas and design of Rietveld. Aside from her modern spirit in architecture, she was also very progressive in her way of living. Being a well spoken feminist and very interested in art and literature.

Aside from being a forward-looking woman, she also was a mom. The RSH was created to accommodate her vision of living together with her children. Living in the house was described by Truus as “It takes a lot, but can fill and enrich your life”.

Both Truus herself and how she lived were both extraordinary, especially for that time. Many current visitors ask about her and her way of living. Giving the visitors more insights into her life, would be very enriching. The information given about her can be divided in four themes: Interests, living, effect and collaboration with Rietveld.

Interests and mindset

Truus, a feminist, was largely influenced by her sister An and the works of Ellen Key. Truus read a lot about feminism, as well as thought-provoking books and papers on literature, art, architecture and philosophy. She even had a brief period of writing columns for the magazine “de werkende vrouw” (the working woman). While being partners with Rietveld, after she co-built the RSH, she admittedly knew little about construction and materials, following written courses under a pretend name.

Living:

Living in the house was rewarding but also came with its own manual. The house is very practical, but also needs a lot of attention such as when removing the panels in the kitchen as well as the kids not being allowed to make a mess. The constant needed upkeep was complained about by others, though Truus did not mind it all compared to the benefit of the house. All of the meals were cooked downstairs, but only dinner was eaten downstairs, the rest of the meals were sent up with the elevator to be eaten upstairs.

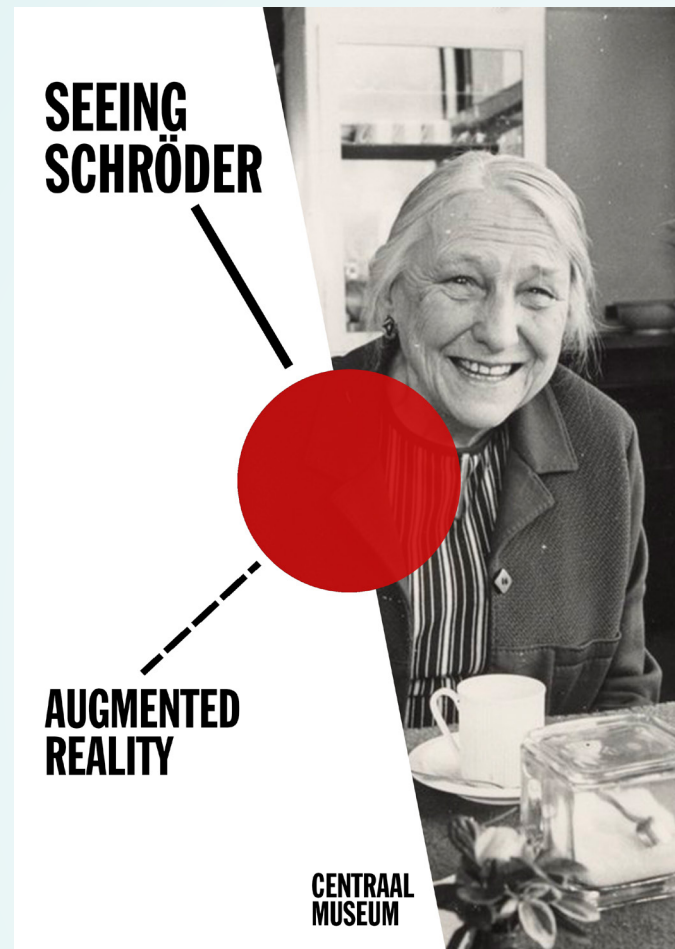


Figure 3.2: The marker

The effect of the house:

In the beginning it even had a very negative image for the surrounding residents. Truus' daughter Hanneke even came home one day crying, as she was being teased for living in the “loony house”. The house sometimes was even referred to by architects as ‘how not to build a house’. Truus did try to make living in the house so happy and inspiring as possible, inviting many people to have intellectual discussions, for themselves and as a good influence on the children.

The collaboration between Truus en Gerrit:

Truus not only was co-designer of the Rietveld Schröderhouse, she helped in other works as well. Though maybe most important was her influence on Rietveld. He was highly inspired by her and her ideas and used this throughout his works.

THE TEST

All of the previous research gives a clear indication of the opportunity for MR in the Rietveld Schröderhouse, the biggest unclear factor in here is what form of MR will be best received by the visitors. The Aryzon has several clear shortcomings, but it is unsure if it can be written off completely, as the futuristic air of wearing the glasses makes up for some of the limitations. Handheld MR in contrast, shows higher quality images, but can already be considered traditional in the use of MR. Even though summing up the faults and merits of both handheld and the Aryzon, how the visitors will experience their use of the products cannot be determined without tests, so tests were necessary.

One of the problems with the current audio tour is it's individual nature, everyone is almost solitarily listening to the device. So in the tests the handheld MR were further split into individual telephone and shared tablet, to also test the influence of this lack of personal contact.

The three devices were tested in the Rietveld Schröderhouse, spread out over three days using one device per day, with normal visitors. This way the amount of visitors were similar, while nobody was influenced by an other device.

The testing itself was done with two objects giving extra information about Truus Schröder and two different markers. This replicates a basic version of the envisioned experience, while also testing the reception of two different markers. The markers were placed on the table in the studio and the ground in the hallway. Halfway through the day, the markers were switched, to prevent the influence of the marker on the models.

During the explanation about the tour, the test was presented to the visitors, explaining it was a voluntary experiment, if they liked they could join in. The test was started in the studio, next to the first marker, where the visitors could try it.

During the tests, the visitors were asked about their opinion and thoughts while they were using the device. Afterwards they were asked to fill in a questionnaire about the experience. The amount of taken pictures were limited, so the users were not influenced or disturbed by the presence of a camera.



Figure 3.3: The second marker

OBJECTS FOR TESTING

For the initial testing, it is too time consuming to create a complete storyline, while it is also redundant as the test is focused on the experience with mixed reality. The largest problem was the necessity of a self-explanatory objects. No sound can be utilized because of the audio-tour and no movement can be shown within the scope of this project. The choice was made to show two relatively simple models, to be able to run tests focused on the use of mixed reality.

The first model is the magazine “werkende vrouw” to which Truus contributed. Added were some works of Ellen Key, her big influence. This gives a significant information about Truus while it gives a good opportunity to see how people react to paper information and to test how readable the devices are.

The second model is a pair of old fashioned shoes, like the children would be wearing. These shoes gives the house a more lived-in feel, while testing the reaction of the visitors to 3D models.

By placing the object on the table, visitors can come up close to view and even to read them(see figure 3.10). The placement on the floor, in contrast, is the least convenient. A small sign was added to give necessary information about the objects the users saw and their relation to Truus (see figure 3.6). With this sign all the necessary information could be given through visuals. In this way the experience can be tested with a proper theme, while staying identical for both the Aryzon and the handheld MR.



Figure 3.4 and 3.5: The main models

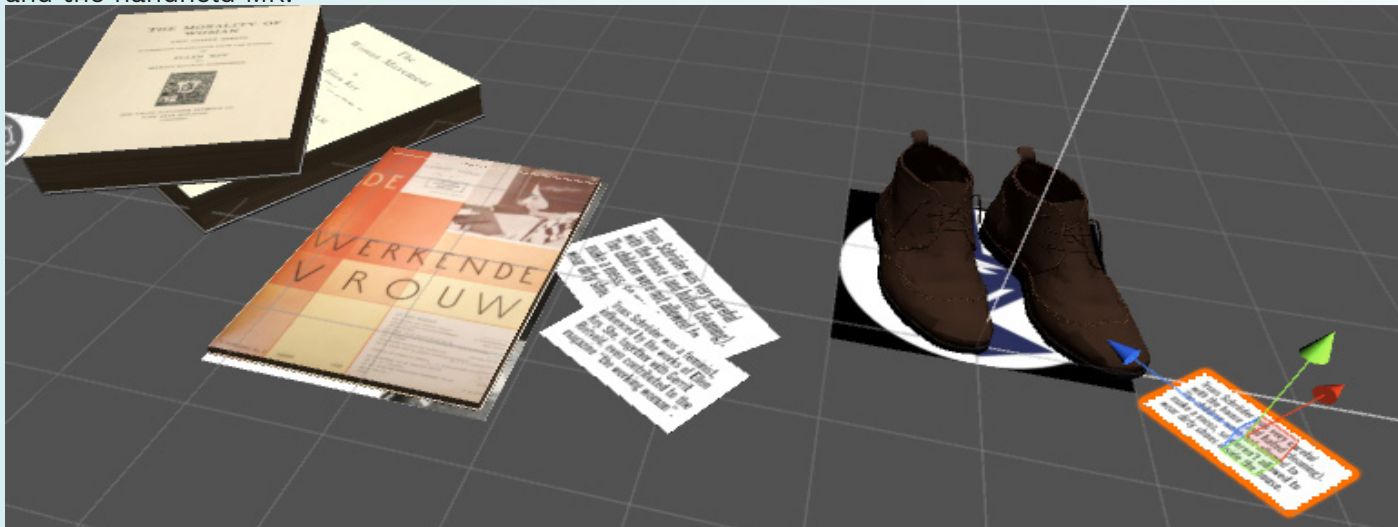
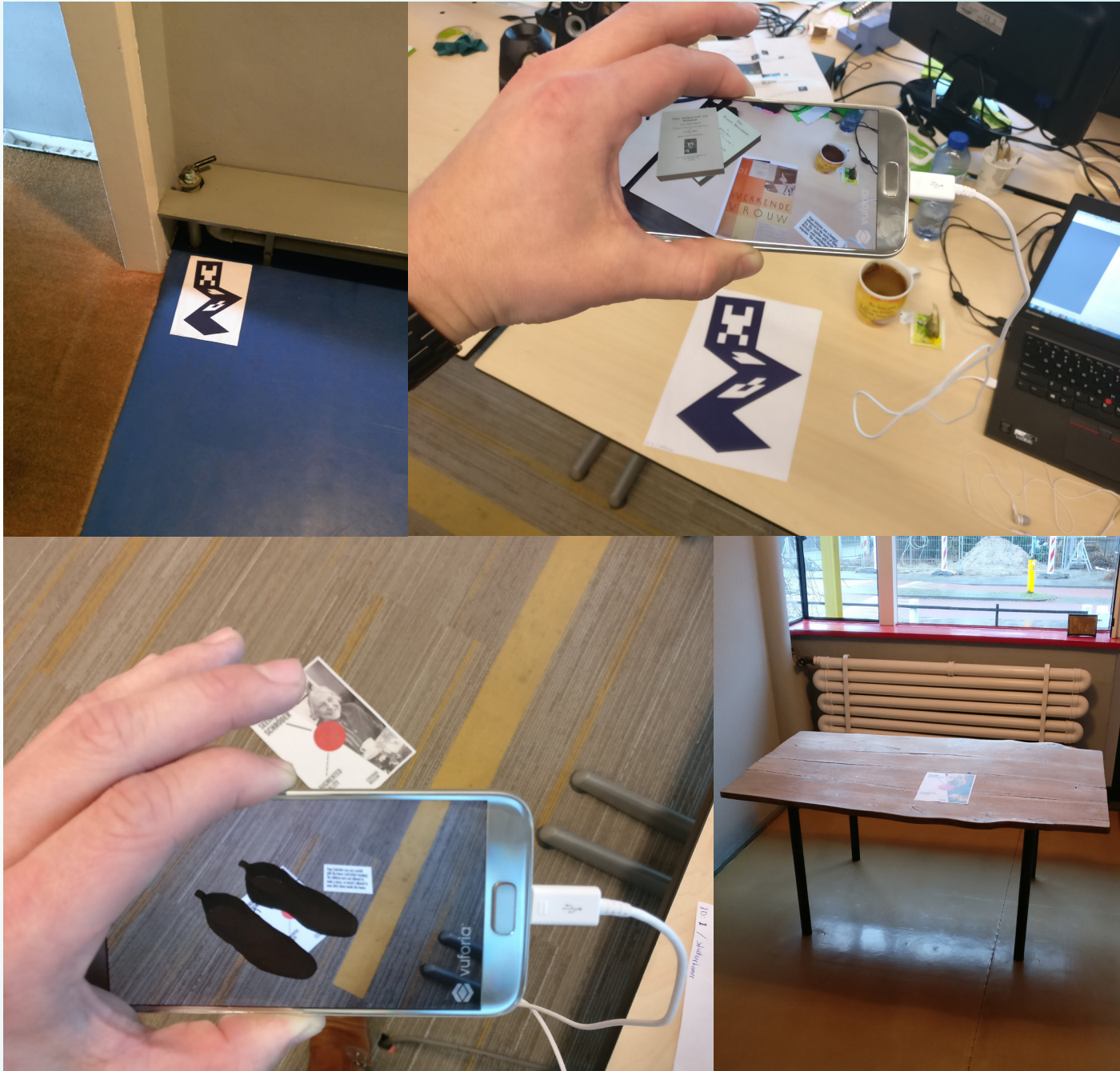


Figure 3.6: The models on their markers, including information texts



Figures 3.7-3.10: The interchangeable markers and their placement

THE RESULTS

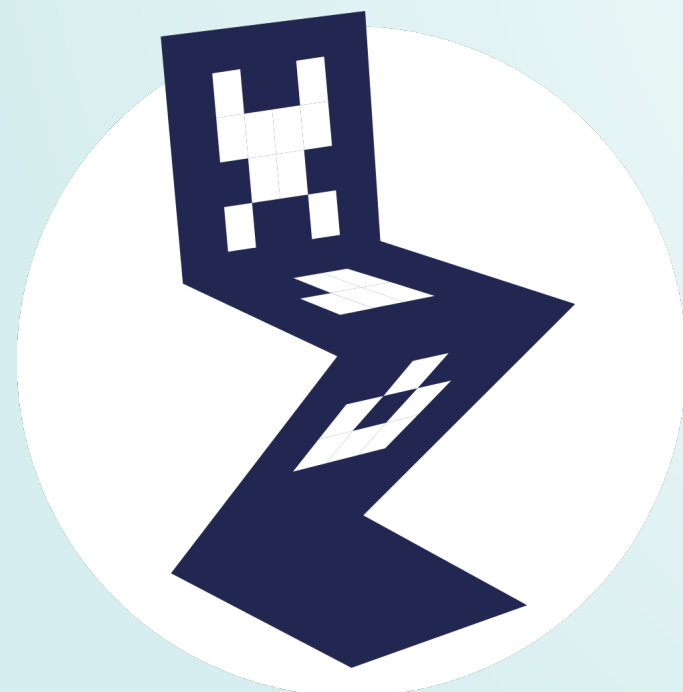
The results were gathered through observation during testing, and the results and comments of visitors in the questionnaire. The observations and comments are grouped in the most noteworthy aspects in the tests, which are compared to the questionnaire in the end.

MARKERS

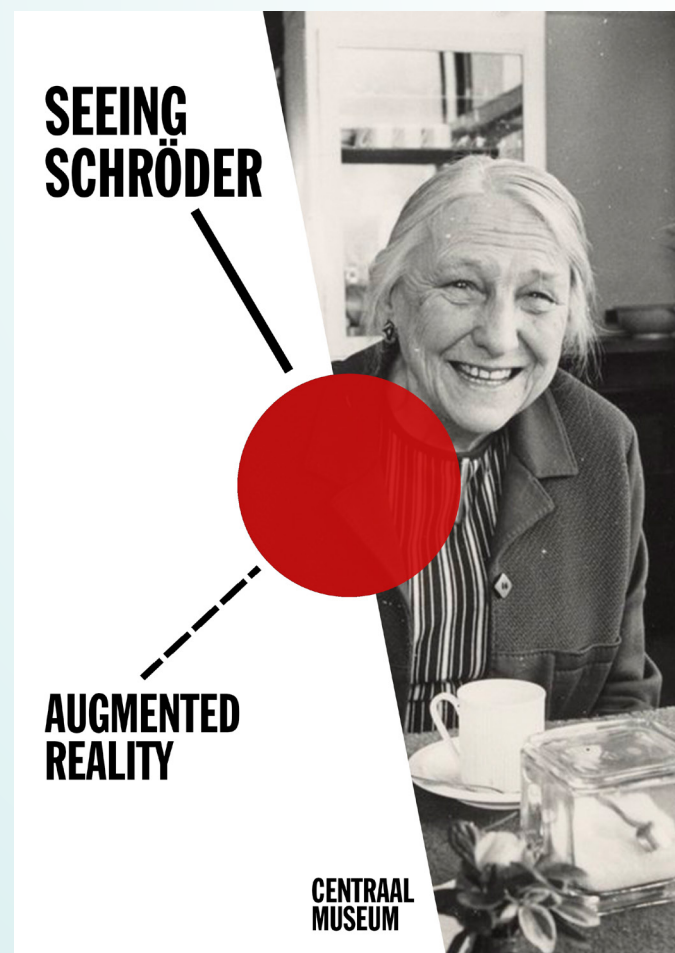
Aside from being used by Vuforia to place the objects on, the markers are also indications for the users where to look. Without the markers, people would not know where to aim at to see the objects.

Through the alternating placement of the markers, it automatically showed the “Seeing Schröder” marker provoked a lot more reactions, making it easier for people to break through the hesitation to try the device.

Even though the Zigzag marker is very abstract, people did recognize the chair in the contours. This did bring up some false expectations, where people were expecting the chair to be shown on the marker.



Figures 3.11: The Zigzag chair marker



Figures 3.12: Seeing Schröder marker

THE MODELS

The first and foremost comments and observation was the problem with readability. **The** less than perfect stereoscopic makes the vision slightly blurry, making information card next to the object nearly unreadable. For the visitors with less than perfect sight, where a lot of visitors were retirees with that affliction, the phone wasn't sufficient either, as the letters were too small. This meant visitors with the Aryzon and the telephone needed to crouch down in front of the shoes, which was not possible for all of the aged visitors. The tablet was the only device that worked for the whole spectrum of visitors.

The less than perfect placement and movement of the models with the Aryzon was also commented on by a large part of the visitors. In contrast, comments were made about the use of the handheld devices, that 'AR headsets could make it a lot cooler'.

The current (amount of) static objects were found insufficient compared with expectations, but did spark the imagination of many. The largest part of imagination went to seeing Truus and Gerrit inside of the house. Throughout the devices visitors stated they would love to see people with MR. Also the possibility to give extra depth to the information in the audio tour got very positive reactions by the visitors, up to comments about getting rid of the audiotour completely.



Figures 3.13: The Aryzon made users crouch down



Figures 3.14: The objects were barely readable with the phone



Figures 3.15: No special movement was needed with the tablet

CROWDS

Crowds easy form in the house, Even though only 15 people (guide included) can enter the house, the small spaces easily get cramped. This is already noticeable at the entry to the house. With everyone wanting to get into the house, while putting on the overshoes, the hallway is completely full of people.

During the tour the crowds fluctuate, but the studio is often the most busy, also because two longer audio tour fragments are played there. The largest difference however is between tours run by different guides. One tour guide explains the tour to be according to your own path, as you can start anywhere and just start listening to the fitting audio fragments, while the other guide explains the tour to be more linear. As soon as the tour is presented as linear, the congestion worsens gravely.

This congestion also influences the visitors themselves, especially with the use of MR. As soon as larger groups would gather in the studio, less people would try the experiment, possibly because people did not want to be the odd one out.

This speculation was enforced by the crowds that formed as soon as someone was using it. As soon as one person used it, more people followed their example. This also showed in groups; even though people were instructed to use the phone themselves and to let the other try on a later time, many visitors watched over shoulders. Especially when a visitor makes an exclamation, the surrounding visitors were very quick to come watch what induces that exclamation.

Some people came in late and lagged behind the crowd. Some visitors were even seen stressed out at the end, because most visitors were ready to go upstairs and thus were waiting on them.



Figures 3.16-3.17: Crowds were quick to form



Figures 3.18-3.19: People were eager to watch over shoulders

EASE OF USE

Even though the Aryzon is very intuitive through its clear purpose of being looked through, the link with the markers was a bit harder. Nearly everyone needed at least some instructions to understand the link between the device and the paper on the table. Even after the instructions, people still often stood still immediately as soon as they saw an object on the marker, needing another instruction before they started to move around the object.

With the phone and tablet the only difference was people moving the phone from the start, moving it closer to their eyes or to the object to focus. The result of this movement was often the realization of the possibility to move around the object, sometimes resulting in strange postures in trying to see it from all of the angles. The handheld devices do give expectations about other possibilities, nearly all of the users try to tap the object and zoom in as soon as they find it too small, leaving them confused as soon as it is not working.

Peripherals do prove to create some difficulties. The audio tour is the largest problem. Though they can be hung around the neck with a key cord, because of their phone like handling, they need to be pressed against the ear to listen to the fragments. These devices are also a hazard for the furniture in combination with the Aryzon. Because the user is moving their head to better see the models, the hanging devices can swing into the object they are hovering over. The added map also poses some difficulties, especially with the Aryzon and tablet, as they need two hands to be used. Large glasses also do not work well with the Aryzon, as they do not fit properly into the device.



Figures 3.20-3.21: People stayed in place with the Aryzon



Figures 3.22: Handheld induced trying out angles

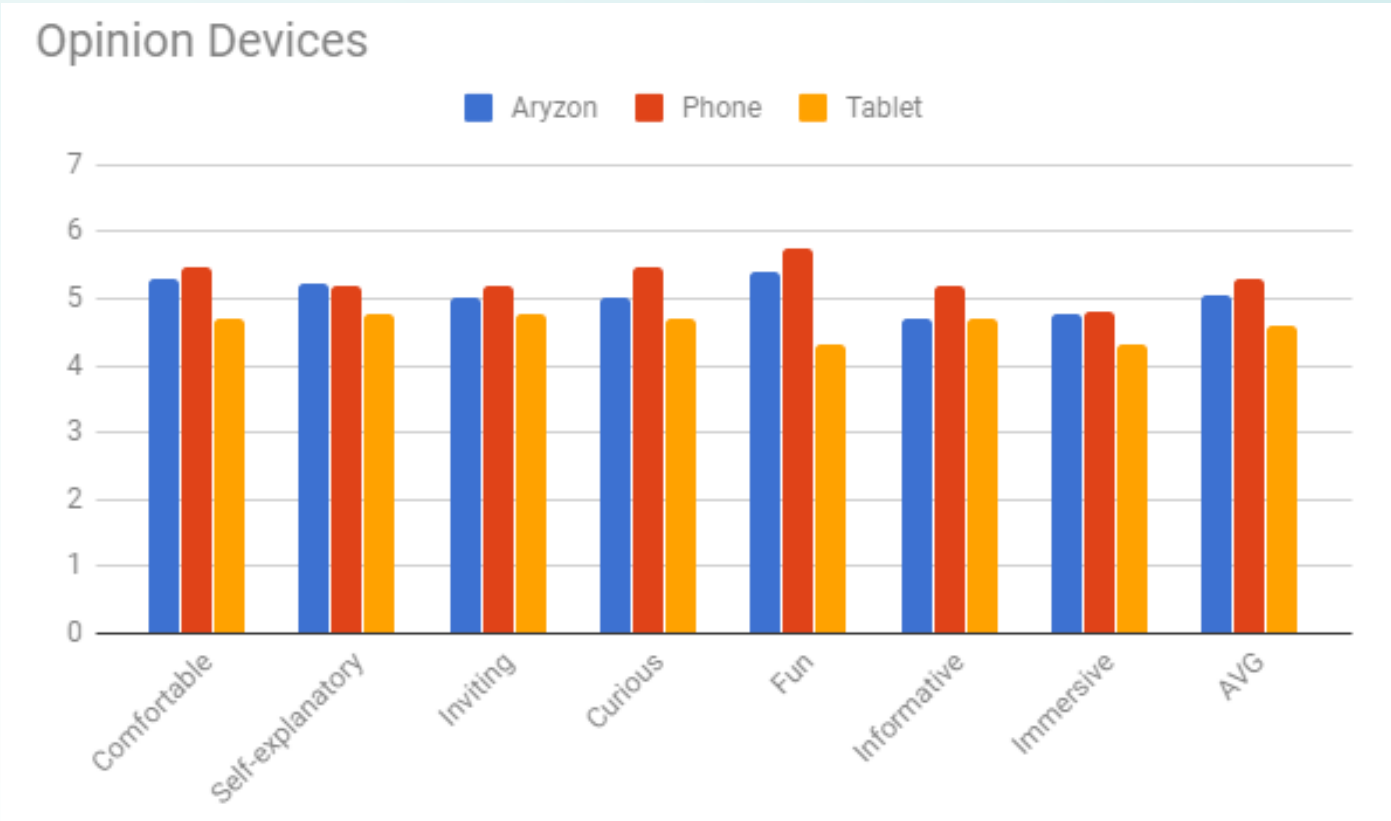
THE QUESTIONNAIRE

The questionnaire (found in appendix X) was mainly focused on the opinions of the visitors on the markers and the devices. Over the three days, 38 visitors filled in the questionnaire, which gives an indication of the opinion of the visitor, but is not enough for quantitative research.

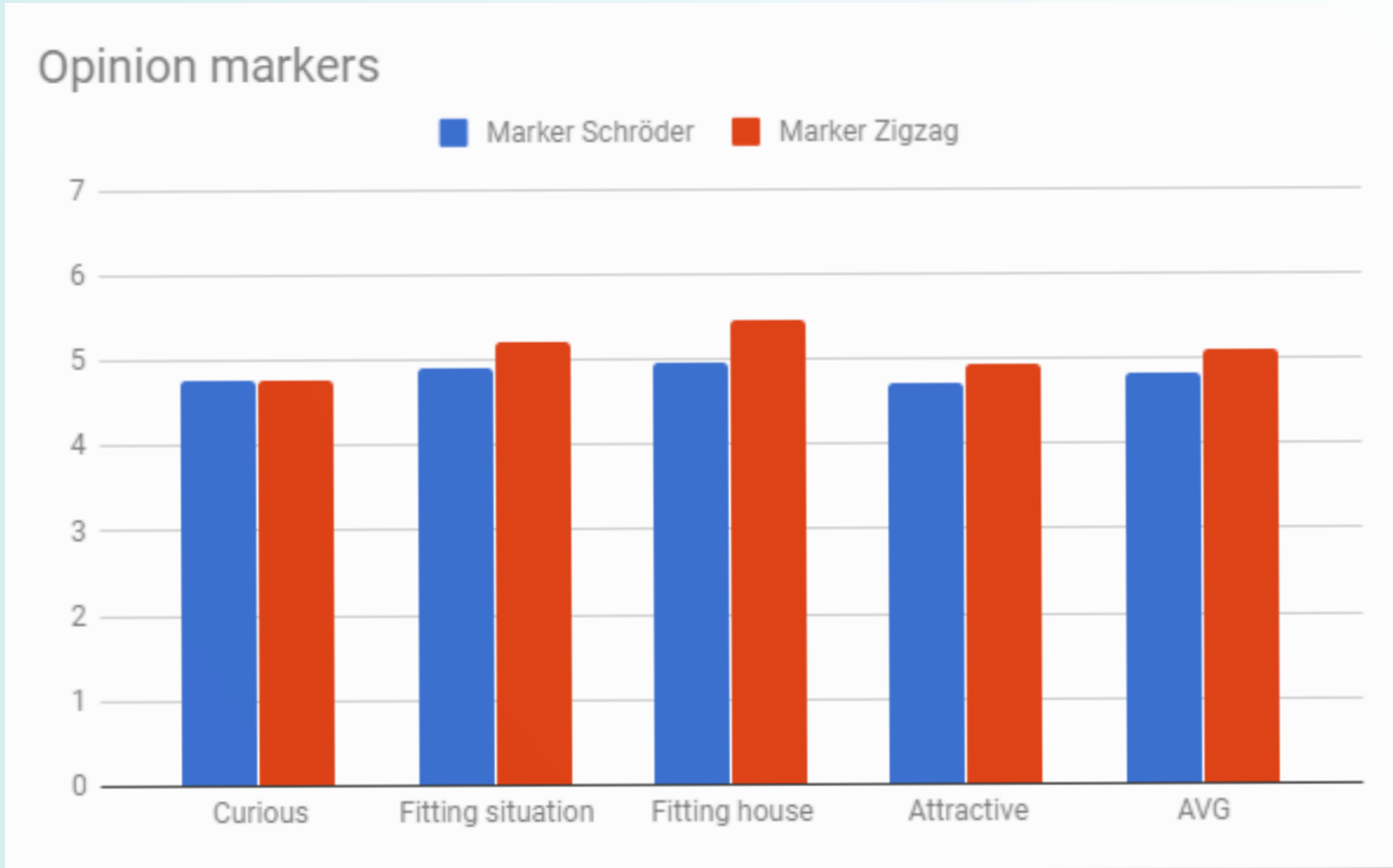
Even though the visitors seemed more responsive and drawn to the Schröder marker, the Zigzag marker scores marginally higher in the questionnaire, though both getting an acceptable score. This does mean more research should be put in different markers, to get a more definitive result on the opinion of the visitors.

The phone scores higher than the Aryzon on all but being self-explanatory, combined with the lacking quality of the visuals, it is apparent the Aryzon will not be further developed with.

The tablet scores consistently lower than the phone, up to over one point difference in fun, ending up in over half a point on average. Even though the tablet scores lower, the tablet will still be used for further development. The lower average score does not compare with the more accessible use of the tablet. By using the tablet a more broad spectrum of users can have full access to the added MR, as the images are larger and thus clearer for visitors with impairment in sight. The second benefit is the shared nature of the tablet. The solitary nature of the current audio tour misses a lot of positive emotions through the collaboration and sharing between visitors, Creating the possibility to tap into this co-operation, outweighs the difference in scores with the phone.



Figures 3.24: The opinion of the visitors on several aspects of the MR device



Figures 3.23: The opinions of the visitors on both markers

CONCLUSIONS

- Zigzag marker creates expectations for the virtual object**

The markers are marginally different, more research should be done on the visitors' opinion

The hall cannot be used for distribution of tablets, because of the forming of crowds

One single linear tour creates congestion

Using a single device makes people hesitant in use

People are drawn to also try or watch other users

Representations of people will need to be added as virtual objects, to live up to the imagination of the visitor

The models should not be accompanied by papers with explanations

Listening to the audiotour demands a free hand

Visitors have limited amounts of time, latecomers can become very stressed
- The devices need instructions to be used properly**

The objects shown on the Aryzon and phone are both not clear enough

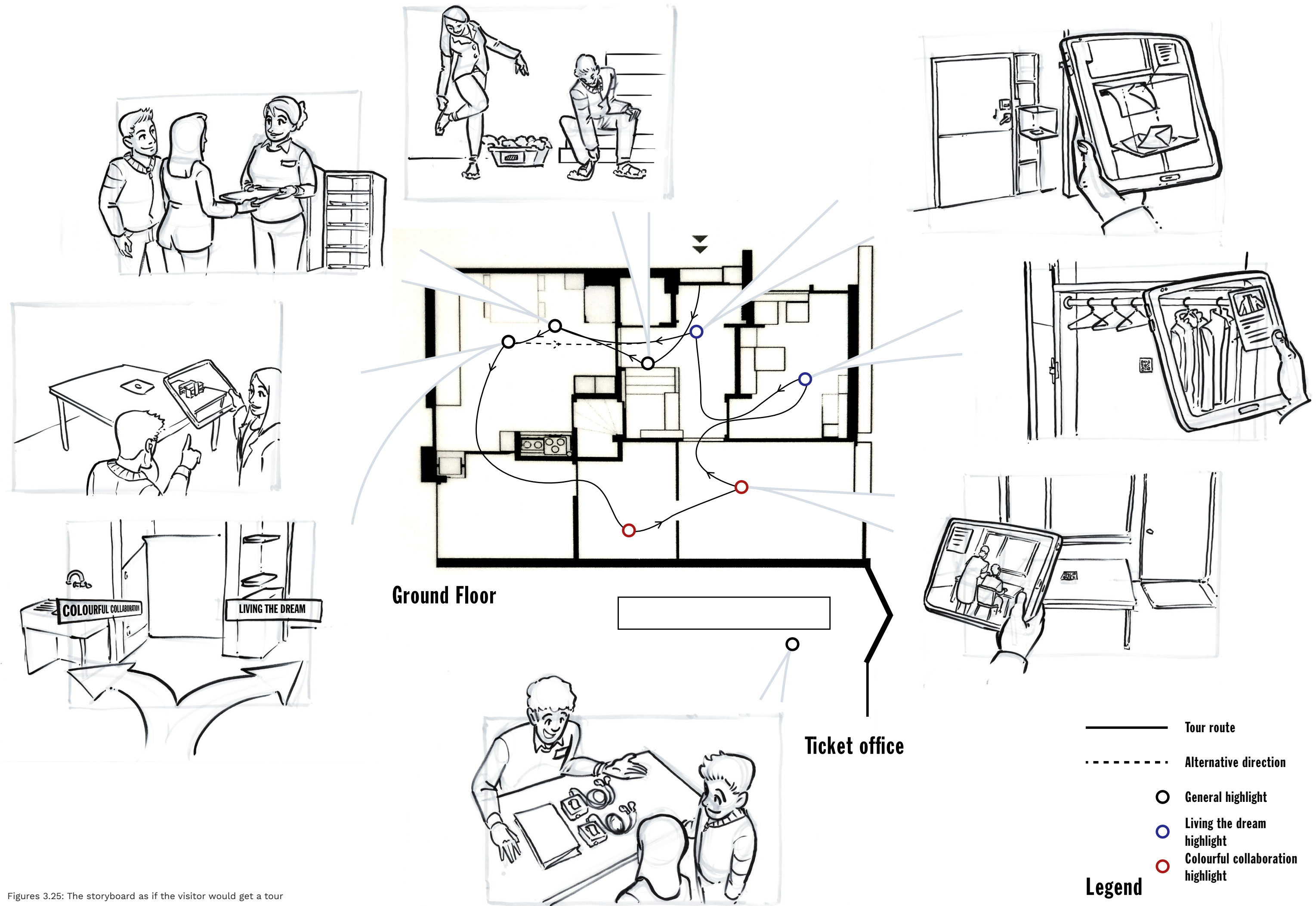
Both the Aryzon and phone ask for a crouching position for objects on the floor

The Aryzon does not deliver enough quality to be further used

The tablet invites zooming and clicking

The tablet will be used for further development

A MR headset is interesting to be used as soon as the technology develops further



Figures 3.25: The storyboard as if the visitor would get a tour

THE PLAN

Based on extensive research and user testing, a plan for the implementation of the mixed reality in the RSH can be formulated. The 'Seeing Schröder' and augmented reality assisted tour in general will still need further research and develop to become a finished product, but the plan will function as a base for the development. By and during the implementation of the plan, further research can be done and the tour can be developed further. The first year will thus function as a pilot period, not only to perfect the tour, but also to create more awareness and acceptance among the visitors. At the end of the pilot period, a certain base should be achieved to give the visitors what they want. The plan explains the expectations and necessities for the tour at that point. This plan will be explained by running through an augmented reality assisted tour, as can be seen in figure 2.25.

PREPARATION



Figures 3.26: The guide hands the visitors the attributes



Figures 3.27: The visitors put on the overshoes

The tour starts in the ticket office, next door to the RSH. In the ticket office, visitors get the audio tour and the corresponding floorplan, and instructions about the tour and how to behave inside of the house. During this preparation, visitors are asked if they would like to join in the augmented reality tour. Because of the high amount of seniors, inexperienced with this technology, visiting the house, using the AR will be complete voluntary. When the visitor indicates wanting to participate, they will only get one floor plan and have the option to receive headphones, when not in possession of their own. After this they are sent to the house like regular visitors.

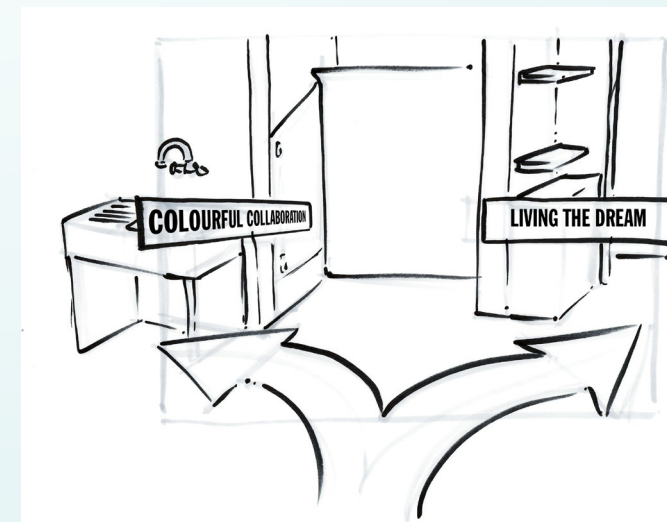
After the walk to the house, the visitors can enter the house. In the house they are requested to put on overshoes, to prevent the house from getting dirty or damaged by shoes. Because of the simultaneous entry of all of the users and clumsy action of putting on the shoes, the hallway becomes very congested. The visitors are therefore not yet introduced with the tablets until they reach the kitchen.



Figures 3.28: The guide hands the visitors the tablet



Figures 3.29: The visitors run through the tutorial



Figures 3.30: The visitors can choose from two directions

BEFORE STARTING

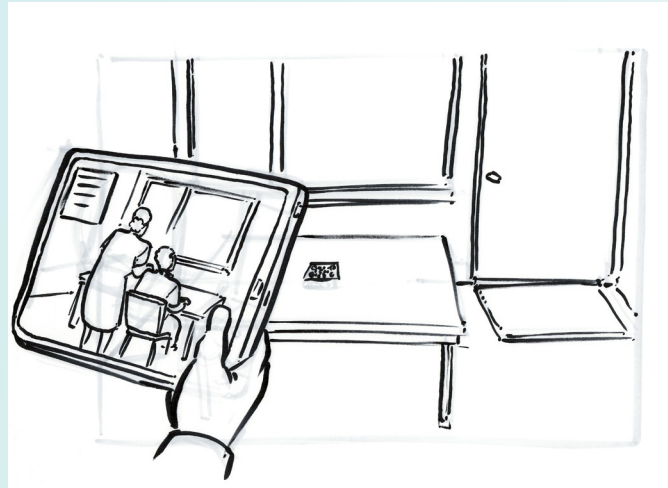
While the visitors are busy in the hall way, the guide goes on ahead to prepare the tablets. The tablets are stored in the unused closet in the kitchen. This way they are out of sight, while not having added any form of storage to the room. After entering the kitchen, the guide will ask the visitors if they indicated they wanted to join and what country they are from. The guide then sets up the app and hands out the tablets to the joining visitors. The guide stays in this place during the ground floor tour, as it creates great oversight over the whole floor.

The tablet has an equal amount of language settings as the audio tour. As soon as the visitor gets the tablet, instructions will be shown on the screen. These short and mostly visual instructions will give the user a quick run through the functionality of the tablet. The first marker is placed on the kitchen table and will contain a small object to practice with. The object will be neutral, as it needs to fit in with several tours, while being specific in involving the house. A 3D model of the house itself is an excellent choice, as it enables the user to see the house from all angles, while it is applicable to all narratives. By using this example, the user can learn about the use of the markers, how to view an object and other functionalities like zooming and clicking.

After the tutorial, the user is asked to make a choice of two directions, signifying two different stories. Both stories highlight Truus and how she was living in the house; "Colourful collaboration", tells about her collaboration with and influence in Rietveld's other works, and "Living the dream", tells more about how the house was being lived in by Truus and her children. Both routes have their own added objects, representing the respective narrative.

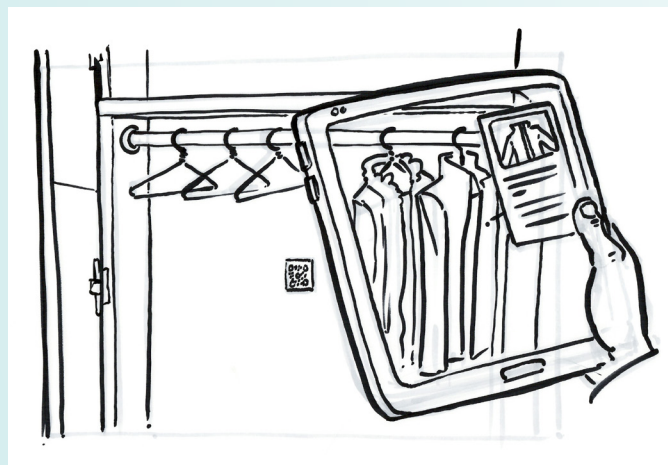
By splitting the group up into two directions, congestion gets prevented. The mixed reality objects are also placed at the ends of both routes in different rooms, making sure people have had the time to complete the whole audiotour. This prevents people having to rush to complete the whole tour, because they were looking at the objects too long, and becoming stressed.

THE TOUR



Figures 3.31: Visitors want to see representations of people

After the choice is made, the tour starts. 'Colourful collaboration' will first advance to the hallway. With this route, the studio and adjoining storage will be second to last. In here the collaborations and the influence of Truus on Rietveld can be shown through the works and documents. One added feature should be Rietveld working in the studio and Truus standing over him. With the visitors indicating the desire to see human representations with the augmented reality, this expectation can be met by having the human representation sit with the back towards the entry, with movement resembling talking and working. To prevent the uncanny valley, additional research should be done to find out the limits on this representation. By using a more cartoon like style, or by having them disappear as soon as the visitor comes close, like with a mirage, can help implementing the representations while evading the uncanny valley*.

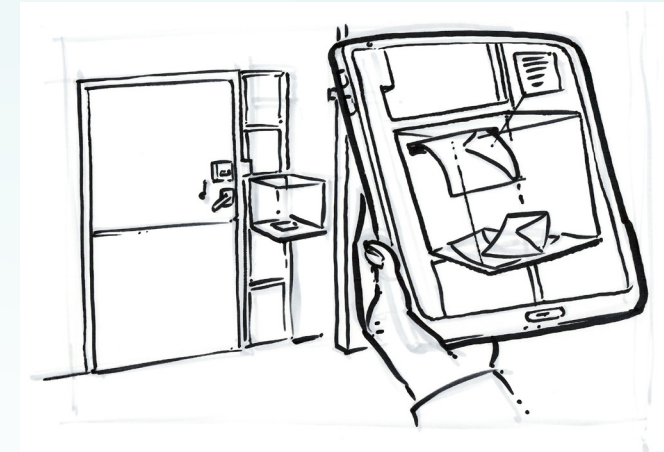


Figures 3.31: Jackets presented on a marker

'Living the dream' will advance into the maids room and end in the hallway. Most of the objects will thus be showed in the hallway. The hallway is an excellent place to show clothing as objects. Objects like these are great ways to create a sense of life in the house, while using very unobtrusive objects

All of the objects will be projected on markers. Aside from the technological advantages in using markers, it will also direct the view of the users. By placing markers in the house, the users will not wave the tablet around aimlessly, but they can look around the house and only aim the tablet at the moment they notice a marker.

*: The proverbial valley in positive feelings to a humanoid figure. As soon as likeness to a real human starts to increase, the feelings toward it will become more positive, with a perfect replication scoring the highest. As soon as the figure nearly replicates a human, but not completely, the positive feelings will plummet. At this point the brains sees a human figure, but cannot put it in proper context. This is an evolutionary response, credited to seeing a corpse. (Mori, 1970)



Figures 3.33: Letters are an excellent way to present information

A lot of documents involving Rietveld have been spared and collected by Truus Schröder herself. These old and very precious documents can be shown with the use of MR. By using the letterbox, letters can be shown to come in. The letters can be models based on the original letters, giving it extra impact through them being real. By clicking on the letters they can be virtually opened or information will be shown about the letter. The zoom function in turn can be used to see and read everything better. In this way the expectation of the user will be met in a functional and significant way.



Figures 3.25: The visitors hand the tablet back to the guide

The whole audiotour typically takes roughly 20 minutes and the guides aim to be upstairs before 30 minutes. This small window of spare time means the MR content should be around five minutes, leaving a buffer of a couple of minutes. For this reason the user will also only go one of the two directions. If the user still has more than five minutes left, for instance in case of a lack of interest in the audio tour, the user can choose to also do the second tour in the end. This is only in case of a large amount of time, as only doing one tour also promotes a return visit.

After having finished the tour of the ground floor, the guide will receive the tablet and put it back in the closet. Tablets should be able to handle 5 hours of use, but in case the program uses too much battery, powerbanks can be put in the closet with the tablets, as there is no power in the closet.

THE NARRATIVES

At the start of the implementation of mixed reality in the Rietveld Schröderhouse, two separate tours will be usable by the visitor, each with their own narrative; ‘Living the Dream’ and ‘A Colourful collaboration’. Both of these narratives are in the theme; ‘Seeing Schröder’. However, one of the great things about MR is its modularity. As soon as a framework is made, it becomes very easy to add narratives or modify existing stories. So next to the initial narratives, some possible narratives for the future are also looked into.

SEEING SCHRÖDER (INITIAL)

Truus Schröder was an extraordinary human being and a lot can be told about her and her life in the house.

For the first MR experience, the two narratives could be translated in several virtual objects. The time is also estimated, with the aim for the total experience being around 5 minutes

Living the dream

Tells the story about Truus’ life in the house; how she used it, the constant upkeep it needed and her aversion for messiness

Fixed objects:
(Readable) mail coming in
Truus helping the kids with homework
Truus hanging the blinds in the kitchen
Kids hanging up the coats

Optional:
Truus making lunch and putting it in the elevator
Someone sitting while calling, while reaching into the dresser

A colourful collaboration

Rietveld and Truus mutually influenced each other not only through their collaboration but also through their life. This narrative shows the works they created together and Rietveld’s works, Truus had a clear influence on

Fixed objects:
Truus and Gerrit working at the table
A collection of:
Models
Drawings
Books and magazines
(A rose; to elude to their relationship)

Possible narratives:

Inspirational influence

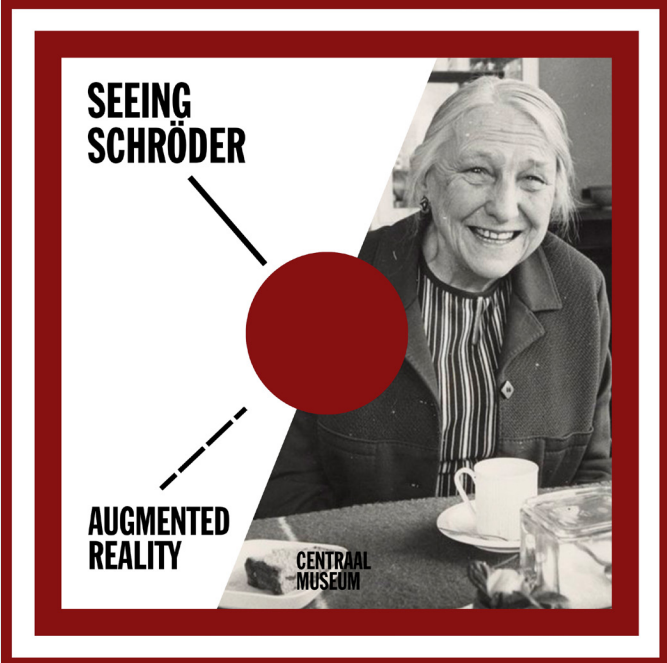
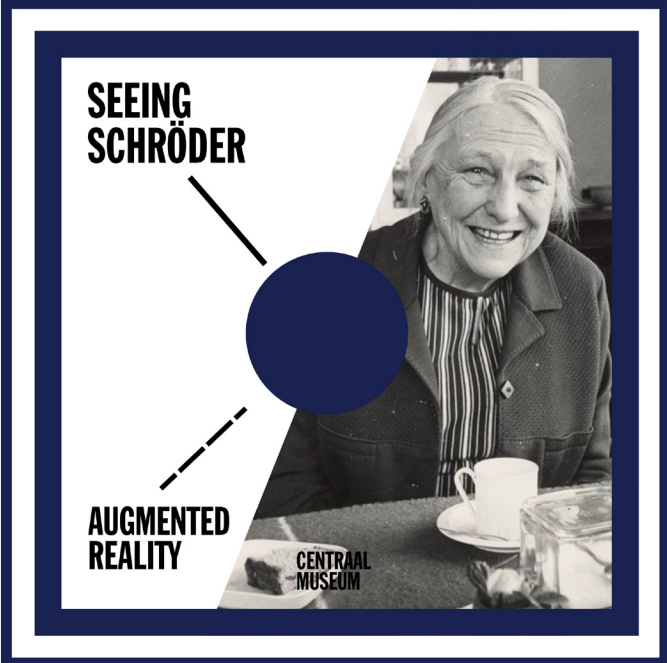
Truus tried to create an environment of good influence on the kids, by inviting progressive intellectuals for deep conversation. Truus herself was also an enlightened feminist, influenced by her sister and feminism. Her mind also influenced by a vast array of subjects, from art to construction. In this narrative, the focus lies on showing how progressive her thinking and environment was.

Don’t go too far ahead

At the beginning, the house received a great amount of scrutiny because of its unusual design. This negative opinion went on to even have one of the children come home crying because she was teased for living in it. This controversy is a very interesting topic to be showed with MR.

THE MARKERS

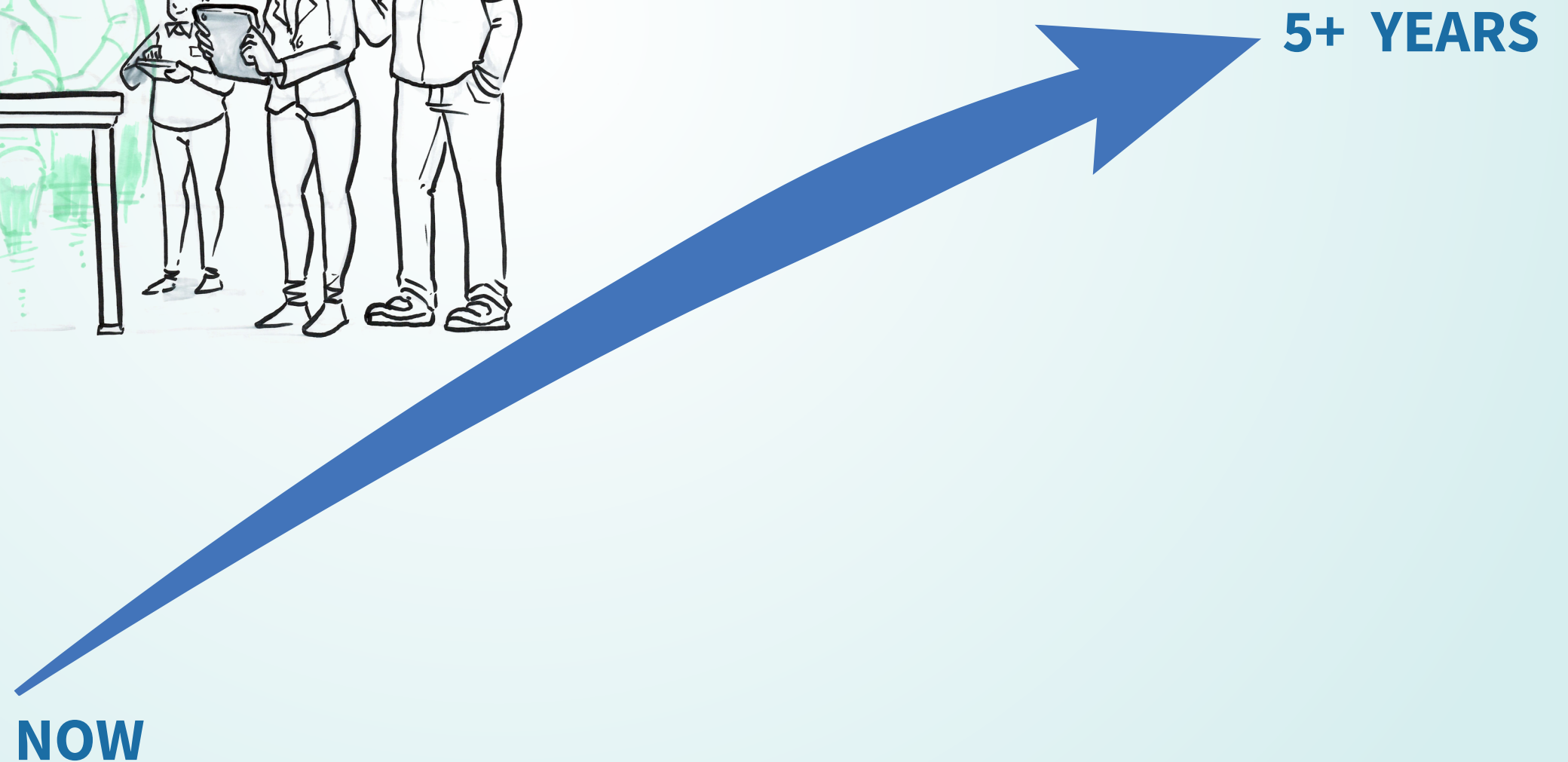
The markers are crucial to the experience. Not only to be used by the technology, as well as indicating the way the visitor should look. With the worse functionality of the VuMark and the created expectation because of the chair, the choice is made to proceed with the picture. The picture is adjusted to look more like the QR-code like chair. With two directions in the house, two colours are used, in line with the colours used by Rietveld.



Figures 3.26-3.27: The improved marker in two colours

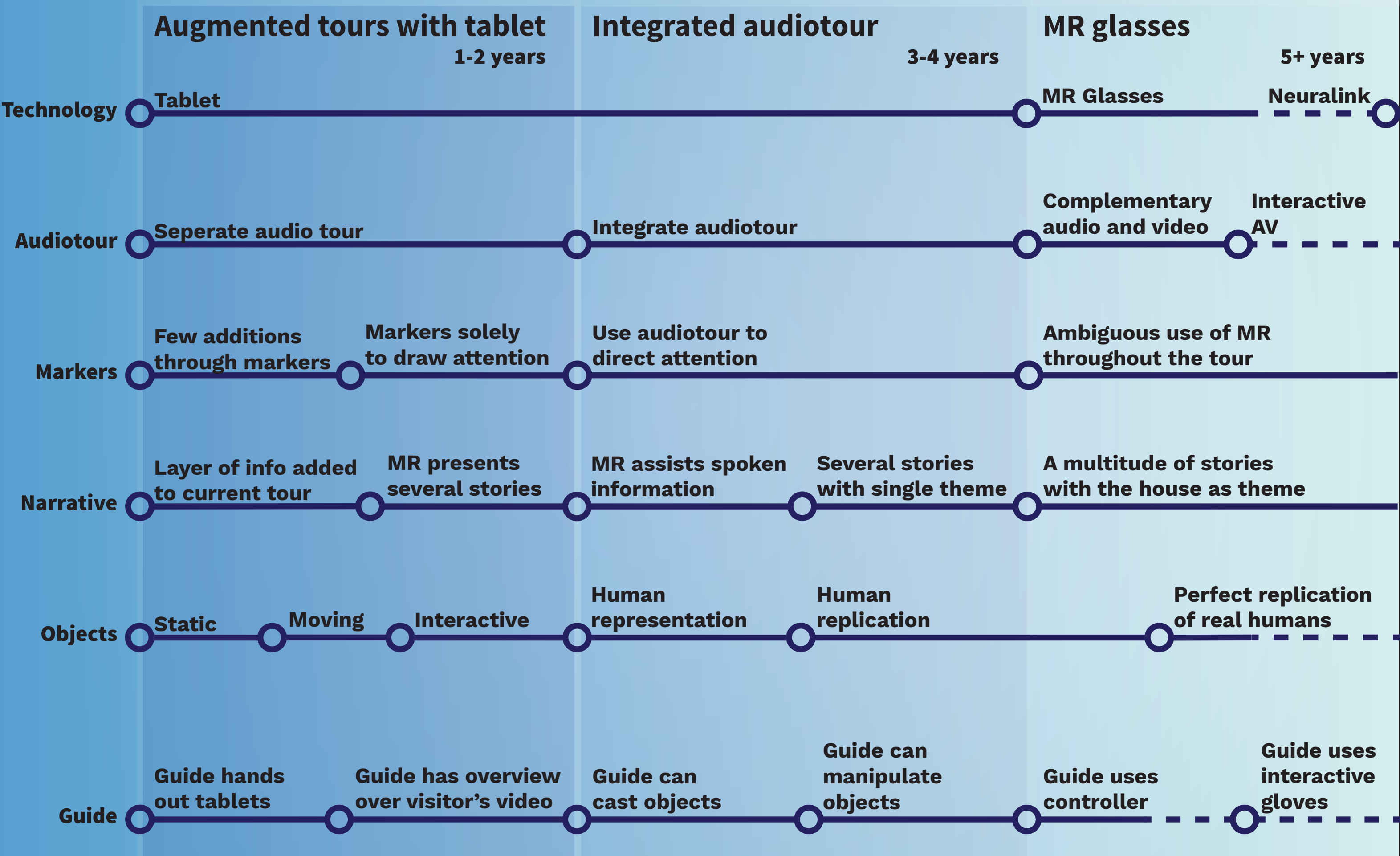
FUTURE

Capgemini and the Central Museum chose to enlarge the scope. The potential for the use of mixed reality in the Rietveld Schröderhouse greatly enlarges with it. The possible future for the continuation of this project is discussed in this chapter



Figures 4.01: The progression of the experience over time

Timeline for Mixed Reality in the Rietveld Schröderhouse



Figures 4.02: The timeline for using MR in the RSH

RECOMMENDATIONS

The potential of the implementation of mixed reality in the Rietveld Schröderhouse goes beyond the 'Seeing Schröder'(SS) tour. SS is created as a plan for the upcoming year or two years and is focused on the current technological possibilities. However, because of the satisfaction in the progress of the project, Capgemini and Central Museum decided the collaboration will be continued, beyond the scope of this project. With this change of scope, comes a wide array of possibilities. Many of those possibilities were encountered or formulated during this project, but were dismissed because of the scope of the project. The adjusted scope, gives room for an more extensive future plan. The recommendations will thus be formulated into a five year plan. This five year period is chosen because of the rapid technological advancements, beyond the five year mark, the predictions would be too unreliable. Predictions beyond these five years are thus indicated as being unsure, but give an indication of the expected future possibilities.

The plan is divided in three stages. The three stages are based on the three most important developments for the mixed reality tour. The first stage is based on the start of the implementation of mixed reality, based on this report. The second stage is after the implementation of the audio tour in the tablet, combining the audio and mixed reality tour into one. The third stage is after the market for mixed reality glasses has further matured, so that the glasses can be used for the tour.

With the five year plan, the approach is more holistically. The focus here not only lies on the creation and improvement of the tours and the stages, but also in laying the framework necessary to advance to a new stage. Each stage can be considered a logical step in working towards the final stage. So in the explanation of the stages, the stage itself will be handled, as well as the necessary steps that are taken for the advancement into the next stage.

Note: These predictions are still research based guesses and should not be tied down to, especially the time frame can differ through breakthroughs of setbacks in the development of the field.

Stage 1



Stage 2



Stage 3



1. AUGMENTED REALITY ON A TABLET

The first stage is the starting point. The starting point is based on the results formulated in this report. 'Seeing Schröder' will be the first narrative to be worked with. In this first stage, the narrative will be told by using the tablet, as is stated in the plan.

The starting point will thus be the use of two separate storylines, shown through objects projected on markers. The objects will be gradually improved, quickly upgrading the static quickly to moving objects, after which the use of interactive models should be pursued to adhere to the expectations of the visitor. This progress is paired with the markers, where a markerless framework will be set up. Making it possible to place the objects everywhere in the house, where markers are only necessary to attract the visitors' attention.

Without the necessity of markers and thus limited restriction in the placement of the objects, more than two tours can be implemented in the tablet. At this time the guide needs to be included as well. By giving the guide a terminal with an overview on what the visitors are looking at, the guide can answer questions or join in conversations easier, without having to crowd around a tablet. The added benefit is the involvement of these highly qualified individuals in the tour, making it more fun for the guide, while adding value to the visitor.



Figures 4.03: Visitors using the tablet

2. INTEGRATED AUDIO TOUR

The first big change in the further development of the tour is the integration of the audio tour. Having a multi-functional tablet in hand, makes the physical audio tour redundant. For the optimal experience, a (cheap) bluetooth headset can be used, so the users are not necessarily connected with cables.

Integrating the audio tour comes with a range of possibilities, with the largest; getting rid of the markers. As soon as the audiotour is integrated, the audiotour can also be used in steering the vision of the users. Using audio instructions for looking make the markers redundant. Removing the markers will then bring the house to its original untouched form. The other added benefit is creating the possibility of showing (moving) representations of humans. At first these humans will be far from realistic, only feigning the presence of residents or visitors, but in the process can be improved to proper replications. These improvements will be slowed due to the uncanny valley.

The stories that then are told can become more extensive, weaving the audio and visual tour into a more complete tour, where mixed reality is used as support for the audiotour. The amount of stories can then also be enlarged, having a multitude of stories with the house as the main theme. This larger amount of stories will create a more personal tour for the visitors, as they can select their own preference, while also stimulating the demand for return visits.

With the larger amount of tours, people will be shown more diverging storylines. To cope with the problem of visitors seeing objects on the screens of other visitors, the guide will gain the option to cast objects, where the guide can place objects on other users' devices. This option will include the guide further and will make it possible to show mixed reality objects that are concurrent with short stories he or she tells the visitor. From here it is a small step to making it possible for the guide to manipulate objects looked at by the visitors, fully utilizing the potential of the mixed reality to fit the story or answer given by the guide.



Figures 4.04: The visitors using the integrated audiotour

3. MIXED REALITY GLASSES

The final stage is the implementation of mixed reality glasses in the tour. Looking at the progress in virtual reality, where in 2013 the first Oculus development kits were shipped (Oculus, 2013), compared to the quality of the HTC Vive, the current leading VR headset, five years later, it can safely be assumed the mixed reality headsets will be high quality consumer products in five years from now. With these high level mixed reality glasses, a more enhanced tour can be realised.

Using these improved mixed reality glasses makes it possible to use MR ambiguously. With the headset implemented in the glasses, audio and video can morph into one, where the audio adjusts to the video and vice versa. Instead of having to both look at the same screen, visitors can link their glasses, so they both can see the same mixed reality. In this way the real and virtual truly morph into one, creating a tour where the user can experience the house with added enhancements, like Truus Schröder talking and walking through the house. The guide can then use a controller to have the same possibilities as on the tablet.

As soon as this completely ambiguous use of MR is implemented, the house can also become interactive. With the glasses tracking the movement of the user, no single path is necessary. The user can roam around the house and tour adjusts accordingly, giving the information fitting for that moment, adjusting to the path of the user, comparable with the way the TomTom readjusts routes.

This ambiguity also gives room for adding MR upstairs and on the outside of the house, possibly giving extra information about the house in a non-invasive way.



Figures 4.05: The visitors using the MR glasses

POSSIBILITIES

Interaction with a deceased, it talks to the imagination of nearly everyone. With current text to speech technology and advancements in artificial intelligence, it is now unlikely human behavior can be replicated to a certain extent. At the moment a real looking and moving virtual Truus Schröder can be shown, adding the possibility to have limited conversations with 'her' will be a logical next step. The biggest problem here is not the technological development, but it will be the human factor. Depending on the mindset of the visitors in five years, having the possibility to talk with a known deceased person will quite surely move into the uncanny valley.

Instead of the controller, the guide will at some point be able to use gestures or interactive gloves to replace it. Gesture control is currently used to some extent in the HoloLens by Microsoft and in gaming consoles like with the Kinect for the Xbox. This technology has already been showed in a wide arrange of science fiction videos. In five years from now, this technology would likely have matured enough to create a natural interaction with the glasses.

Last year Elon Musk started Neuralink (Wu, 2017); a company focused on an implant in the brain, connecting the brain with computers. This falls in line with Google's Ray Kurzweil's prediction of humans being able to completely upload their brain in 2040 (Independent, 2009). In the early development stages it could become possible to stimulate the visual cortex or optic nerve to show mixed reality without the need of external devices. This however is complete speculation, but the idea being backed by both Kurzweil and Musk makes it noteworthy and even possible.

POSSIBLE OTHER NARRATIVES

The possibilities the future plan creates, also gives room for the implementation of other narratives besides ‘Seeing Schröder’. These narratives are all based on the house, the occupants and its surroundings

Comparison with “de Stijl”

Even though the RSH is interesting on its own, it has a clear part in the art movement ‘de Stijl’. Showing the clear similarities and differences are very interesting to the more architecturally schooled visitors.

How the house would have looked to the regulators

Through clever use of drawings, the drawings made the house seem as a much more regular house. Rietveld did this as a work around the regulations, as the regulations were quite rigorous in that time. This narrative would show that cleverness.

Objects in the house throughout history

The house is nearly a hundred years old. Showing the progression of objects in and around the house gives a lot more insight into the real age of the house.

Other works by Rietveld

Rietveld has made many products over the years, many of which are too precious to be shown inside the house. Mixed reality can be used to show the ever versatile designs of Rietveld.

Add your own preference/model

Creating the possibility for the visitors themselves what should be added, makes the tour very personal. By letting the proceeding visitors choose pre-made tours, this also creates a connection between visitors.

Through the eyes of the guide

All of the guides have their own specialized knowledge and personal fascination with the house. Tapping into this information by letting the guide use MR as an aid to their story, creates an enhanced visit for both the visitor as the guide.

The progression in residents

Over the years, the only constant resident was Truus. Many changes in occupancy and furnishing that went with it, made the house ever changing. This narrative would focus on this dynamic nature of the occupancy.

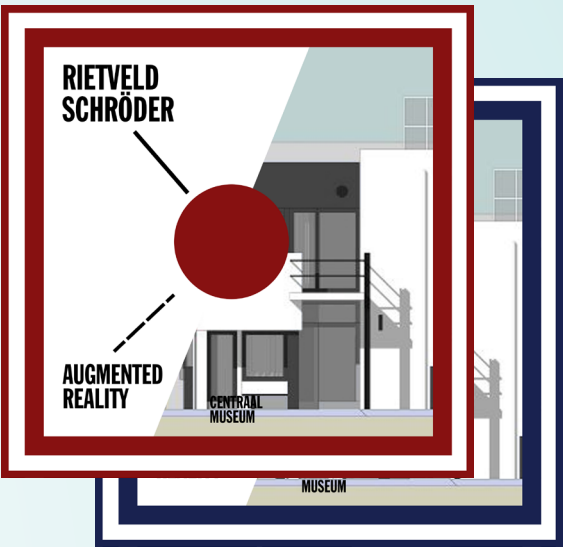
How the surrounding changed

When the house was built, it was built on the edge of the city. But over the last century, Utrecht grew ever larger. The changes that have been made over this period is so extensive, even Rietveld wanted to tore down the house, because it lost its purpose. Showing the progression of the surrounding is a difficult but great story to show with MR.

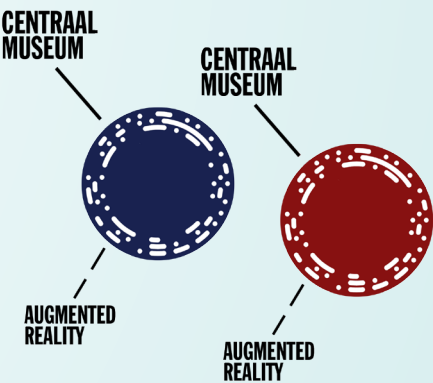
MARKERS

As soon as other narratives will be used, these markers can be changed into the same layout in style of the Central Museum, where Truus makes way for the house itself, leaving it relatively neutral for expectations.

When the step is made to use markerless technology, the marker will only be used to give the visitor an indication where to look. At his moment, no recognizable image is needed, as the device does not need to recognize it. This freedom allows the iconic dot of the Central Museum to be used. Added elements, comparable with those of an QR-code, makes the connection with MR more clear.



Figures 4.06-4.07: Markers usable for other narrative



Figures 4.08-4.09: Markers usable for markerless MR

USER FRIENDLINESS

Aside from the possibilities to enhance the tour for the current visitors with high level technology, it can also be used to create possibilities for less fortunate people.

Stage 1:

A handle on things

The tablet can be made more user friendly by adding a handle, making it possible to use the tablet with one hand. Several handles are already on the market today, so with research the most suitable handle can be added.

Individual

By using an app on the tablet, it can also be used with a phone, making it unnecessary to have a tablet for one person, as that visitor can just use a phone if that is preferred.

Statistics

With the app created specifically for this case, it is possible to gather statistics. This information about things like walking speed and time looked at an object can be used to fine tune the experience.

Individual

With the guide overview, it becomes possible for a user to watch with another. This also makes it possible that a tablet is brought upstairs, generating a link with a visitor downstairs. This makes it possible for a person unable to climb the stairs, to also have a live experience of the top floor. (This advances with the use of MR glasses)

Stage 2:

Language

As soon as the audio tour is integrated in the tablet, more languages can be used, to accommodate more foreigners with limited skill in the English language. With current advancements in automatic translation and Text-to-Speech technology, it would become possible to have more languages than the current eight.

The deaf

As soon as the audio and mixed reality tour are integrated, the tour itself will become more visual. Mixed reality can give extra information, including textual. This can be easily enhanced to a completely visual tour, to give a deaf person full autonomy in the house, without the need of a sign language translator

Stage 3:

The blind

Even though unconventional, the blind do visit the house as well. It has been said they “can feel the space opening up”. As soon as the visual and audio is completely blended together, the audio tour will adjust to the place and object the user is looking at. This can create a more autonomous tour for the blind.

CONCLUSION

Adding mixed reality to the Rietveld Schröderhouse is an excellent way to enrich the experience of the visitor, while using it a technological showcase. The plan created is a good point to aim for to implement in the tour. The research done for this report is a great base and starting point to further develop the experience. By using the future plan, the experience can even be enhanced even more, but does take an additional investment.

The collaboration between Capgemini and the Central Museum can be very fruitful for the long term project, as their shared knowledge about the history of the house and the technology necessary to bring it to life can generate a great experience.

ANALYSIS REPORT

CAPGEMINI & CENTRAAL MUSEUM



JOOST OVERBEEK
4111486

INDEX

58•	INDEX
59•	INTRODUCTION
60•	ASSIGNMENT
61•	INTERNAL ANALYSIS
63•	HISTORIES
65•	GOALS AND ASPIRATIONS
67•	MAIN STAKEHOLDERS
68•	THE HOUSE
69•	RESOURCES
71•	CONCLUSIONS
72•	EXTERNAL ANALYSIS
74•	VISITOR/USER
76•	THE TECHNOLOGY
76•	DEFINITION OF MIXED REALITY
77•	HOW IT WORKS
78•	TYPES
79•	TRENDS AND DEVELOPMENTS
79•	IN MUSEUMS
80•	IN AUGMENTED REALITY
80•	IN COMBINING THE TWO
81•	NOTEWORTHY APPLICATIONS
83•	CONCLUSIONS
85•	THE RESULTS
87•	SWOT
89•	SEARCH AREAS
89•	COLLABORATIVE COLLECTING
90•	THROUGH TIME
91•	VARIABLE VISITS
92•	WORKSHOP
93•	CHOICE OF SEARCH AREA
94•	THROUGH TIME
94•	DESIGN BRIEF
96•	DESIGN GOALS
96•	PLAN
97•	REFERENCES
98•	APPENDIX
98•	I. History
99•	II. Interviews
100•	III. Mixed reality
100•	IV. How it works
104•	V. Trends
106•	VI. Workshop
108•	VII. Questionnaire for initial test
116•	IX. Results initial questionnaire
117•	X. Questionnaire for testing
122•	XI. Results test questionnaire
123•	XII. References

INTRODUCTION

Augmented reality, most ‘tech enthusiasts’ are already well know with the technology and it is becoming more mainstream everyday. An ideal technology to dive into, with the eye on innovation in the coming future. Capgemini’s Applied Innovation Exchange is a division that does just that, find new and trending technologies, and looks at possibilities in the technology and ways to couple it to another company. For this project, the connection was made with the Central Museum in Utrecht. Together they decided a great location to apply augmented reality would be the Rietveld Schröderhouse. The Rietveld Schröderhouse is a architectural masterpiece just outside the center of Utrecht. Developed in 1923, it is well ahead of its time in its use of space. Since the death of Truus Schröder, in combination with making the house publicly accessible, the Rietveld Schröderhouse became connected to the Central Museum. The Central Museum manages the house, while the ownership remains in the hands of the Rietveld Schröder Foundation. Right now, public audio tours are held inside the house,

a quite outdated way to have a tour, leaving a lot of room for improvement. This improvement will be done through the application of augmented reality, more specifically the form ‘mixed reality’. This project is focused on using design thinking, to look a fitting application for the house and its visitors, and to ultimately come to a prototype. This prototype will then be used to clearly communicate the concept to the Central Museum, while also functioning as a showpiece to be used by Capgemini. Because the focus lies only lies on the implementation in the RSH, the concept will be limited edition and non profit, so the focus lies less on a competitive advantage and more on the subjective added value for the visitors.

The whole project is a thesis done at the technical university Delft (TUDelft). The project is guided by the Museum Futures Lab at the TUDelft; A group of several graduate students under a professor, all sharing their work to exchange information, help and inspiration

ASSIGNMENT

Using Augmented Reality in the Rietveld Schröderhouse, to create a more immersive experience and enhance the dynamics of the tour. This is the essence of this project, the spine of it all. Mixed reality is an ideal medium to create more immersion, as it not only delivers 3D video and audio, but it also gives the user the opportunity to walk around the virtual image, making it seem it really is at that location, creating a high level of immersion. This enhanced

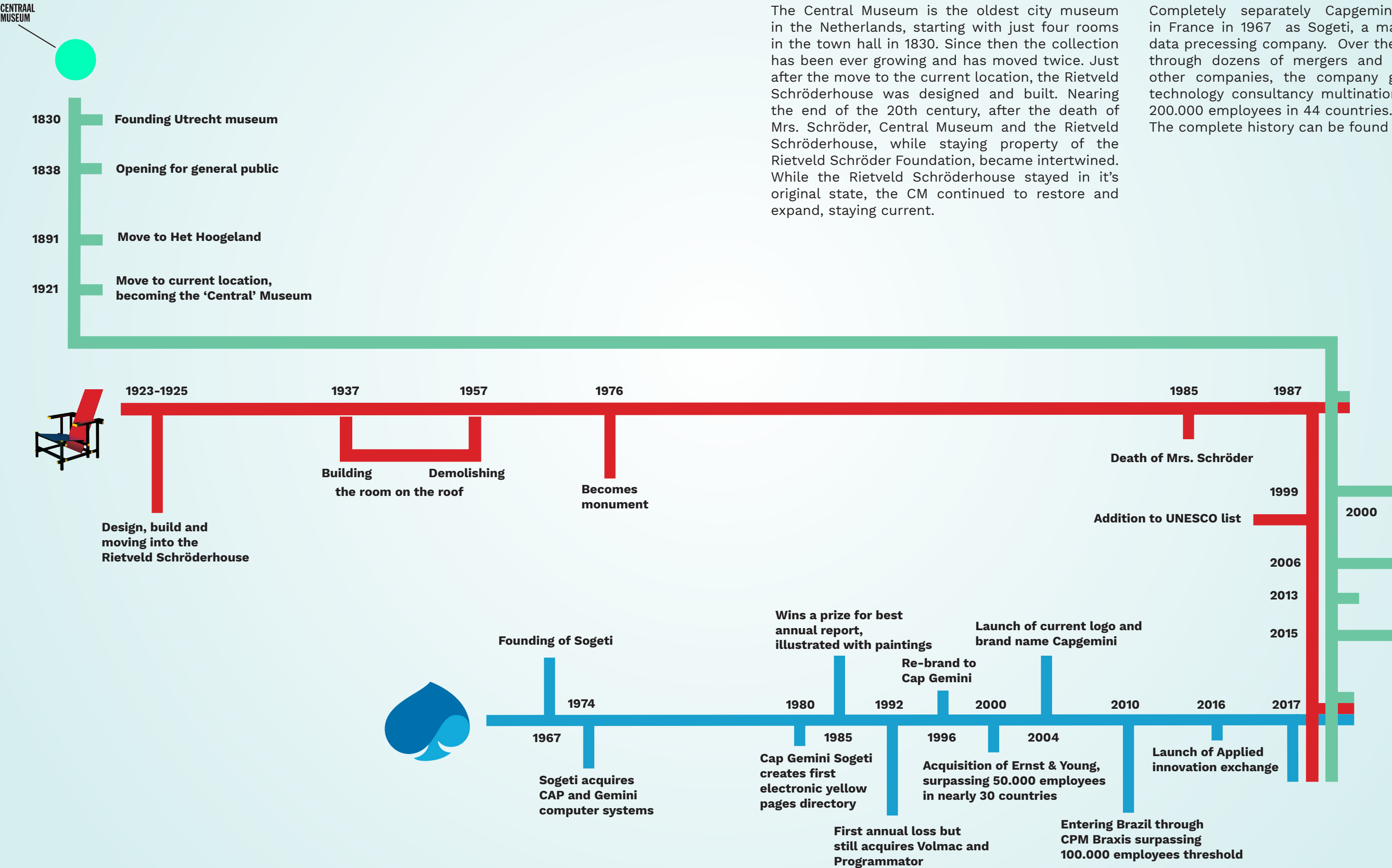
experience will be optimized through research into current cases and opportunities within the realm of Augmented Reality, and possible information to exchange about the Rietveld Schröderhouse. With this internal and external research, an experience will be created not only fitting the market but also the companies involved. Here the aim for the Central museum lies in creating a more memorable and more informative tour, together with the aim for Capgemini to showcase possibilities of Augmented Reality.

INTERNAL ANALYSIS

Before looking what Capgemini and Centraal museum could do for the prospective user, it is beneficial to look at the clients themselves. In this analysis information is sought after to explore the brand it has to fit into. By looking at this identity provides a clearer context for the product to fit into.



HISTORIES



The Central Museum is the oldest city museum in the Netherlands, starting with just four rooms in the town hall in 1830. Since then the collection has been ever growing and has moved twice. Just after the move to the current location, the Rietveld Schröderhouse was designed and built. Nearing the end of the 20th century, after the death of Mrs. Schröder, Central Museum and the Rietveld Schröderhouse, while staying property of the Rietveld Schröder Foundation, became intertwined. While the Rietveld Schröderhouse stayed in it's original state, the CM continued to restore and expand, staying current.

Completely separately Capgemini started out in France in 1967 as Sogeti, a management and data precessing company. Over the next decades, through dozens of mergers and acquisitions of other companies, the company grew out to a technology consultancy multinational with nearly 200.000 employees in 44 countries. The complete history can be found in Appendix I.

GOALS AND ASPIRATIONS

The Central Museum is constantly looking to improve the experience of the visitors. To this end, the museum says it is very willing to work with innovative concepts (Centraal Museum, n.d.-a). In this willingness it found an ideal partner in Capgemini. Capgemini has a vision where technology gets its value through people. For this reason it is constantly trying to innovate, to find new angles to apply and use technology to create the best possible connection between people and technology. So Capgemini can be very helpful in the search for innovative concepts by the Central Museum. Making this collaboration of these two companies for this project mutually beneficial. Capgemini can explore new angles in technology and can create a new showcase, while the Central

Museum can enhance the experience of the visitors. The Central Museum wants to enhance this experience through showing the modern spirit of the house and sharing additional knowledge about the Rietveld Schröderhouse and the environment through and in which it was built and maintained. The goal is to use this additional knowledge, to make the tour through the house less static, to get a more dynamic sense of the surroundings, as is fitting with such a dynamic house. All of these points should be to conserve Rietveld's legacy, to stay true to his work and to spread it out into the world. The content already makes return visits not uncommon, which the new experience should add to. This array of goals is nicely reflected in the mission statements of each stakeholder.

MISSION STATEMENTS

Capgemini

“with you, we create and deliver business and technology solutions that fit your needs and drive the results you want” (Capgemini, 2017-a)

Central Museum

“Enriching the visitor with art and culture out of the world of Utrecht” (Centraal Museum, n.d.-b)

Rietveld Schröder Foundation

“Sharing Rietveld with the world” (B. Sighem, Personal Communication, September 27, 2017)

GOALS



Technological Showcase

Capgemini and in particular its branch Applied Innovation exchange is designed to enable businesses to find relevant innovations. This means Capgemini also needs to be constantly up to date with new innovations and their possibilities. With this project, in order to deliver the best possible product, the technical limits need to be searched for and documented. This can best be achieved through the creation of a technological showcase.

Show the modern spirit of the house

One of the most intriguing part about the design of the Rietveld Schröderhouse is the modern spirit, even though it has been built nearly a hundred years ago. This modern design and idea behind it really comes to its own, if shown in context with the time it was built. Even if some aspects of the house, seem totally normal now, for the time, it was very progressive in the way it was designed. The design was completely focused on its function, it had to be as practical as possible.. Showing this true modern heart through how advanced it really was, truly shows how brilliantly the house was built.

A less static tour

The current tour through the house can be considered quite static. It is a prerecorded audio tour, giving the visitor information about the location he or she is at, through an outdated, large phone-like device. Even though the order can be determined by the visitor, it is still quite dry information delivered through an outdated communication system. Addition of/ replacement by this new method, should mean the visitor gets a more dynamic tour.

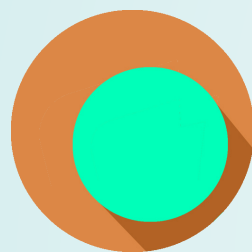
Conserving Rietveld's legacy and sharing it with the world

The Rietveld Schröderhouse is one of the most iconic designs of both Rietveld and De Stijl. This icon should be preserved and receive the respect it deserves. This means the project should revolve around the legacy of Rietveld and his works.



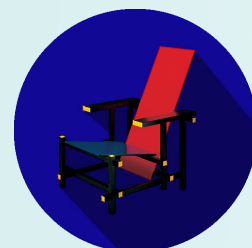
MAIN STAKEHOLDERS

With the collaborative nature of this project, a wide range of highly influential stakeholders are present. Each stakeholder has its own stake and influences.



Central Museum

Would benefit from: Product and promotion
Role: Co-main stakeholder and client



Capgemini

Benefit: Information, insights and promotion
Role: Co-main stakeholder and assignment. owner.
Functions as design team and main office.



Rietveld Schröder Foundation

Benefit: Enhanced experience of the legacy
Role: Owner of the premises. A controlling entity to make sure the legacy is preserved.

RSH staff

Benefit: Better fitting, more personal
Role: Run the tours. Use of the product directly affects their work.

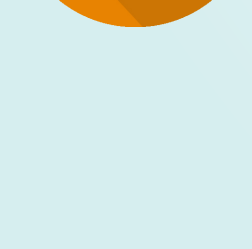


TUDelft/Museum Futures Lab

Benefit: Information and insights
Role: External intellectual partner. All of the information gathered during the process can help future students.

Visitors

Benefit: More fun and informative experience
Role: Users. All added value will be experience by the visitor.



Utrecht

Benefit: More publicity for the city
Role: Municipality. With Rietveld Schröderhouse already being a monument and a sight, added value can create more interest by tourists.

Possible augmented reality device supplier

Benefit: Publicity and sales
Role: Supplier of technology. The technology used will not only be bought by the museum, but can also be shown in the final promotion.



THE HOUSE

The Rietveld Schröderhouse is an architectural masterpiece just outside the Center of Utrecht. Witnessing the changeable partitions on the top floor leave many in awe. Capturing the changes is difficult to impossible, as it needs to be experienced. Tour guides even tell stories of blind people “feeling” the changes in layout. For this reason, people from all over the world come and visit the house. To accommodate these many different languages, the tour is given in over half a dozen different languages. The tour guides can not possibly be equipped with mastery over that many languages, so audio tours are there to support them. These audio tours come in large cellphone shaped boxes, where the visitor uses a number to

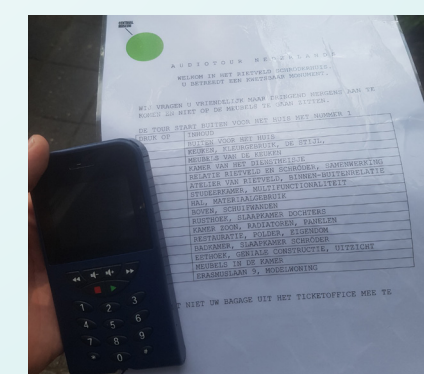
indicate the current location. The tours tell about the way it was designed, the different aspects, and how and what residents lived there.

Next to the audio tour, a human guide is present at all times. The house is old and quite fragile, so cannot be handled by the common visitor. The visitors even get protective wear on their shoes and the guides even wear gloves when handling artifacts and the changing partitions.

The house itself shows as much as possible of the way it was intended. It shows the way Rietveld optimized the use of space, to create a very adaptable way of living.



Figures 5.01A&5.02B: Transition from the open upper floor to closed



Figures 5.02A-5.02D: A glimpse into the tour

RESOURCES

To be able to create a product resources are needed. Both Central Museum and Capgemini has a range of resources. These resources are mostly intellectual, which is perfect for a non-physical product. One of the more important resources is the available information and documentation

The Rietveld Schröder Archive

Vast banks of information have been preserved and is in their possession.

Contact with former residents and family

Access to first and secondhand information about the house and the life within.

Several experts on the house

Several experts and curators are employed, also handling the tours

Accessible visitors

The small intimate tours gives a high enough turnover while keeping the visitors willing to answer some questions

Willingness to innovate

The management of the museum is quite progressive and willing to innovate, not when it is necessary, but as soon as it would add value.



Figures 5.03: The house before construction of the road

on the Rietveld Schröderhouse itself. Throughout the years, a vast bank of documentation is made, for a large part by Truus Schröder herself, nearly all of which has been placed in the hands of the Rietveld Schröder Foundation's hands and will be accessible for this project.



Figures 5.04: An VR expert at Capgemini

A wide range in technology available

For research and development purposes, Capgemini is in the possession of a wide range of technology

Vast banks of expertise through in house experts and employees

This wide range of technology is worked with and explored, generating a large base of shared knowledge between the employees

Many technological partners

A good standing with many clients and partners makes it possible to easily and swiftly get additional information and hardware if needed

Well-known brand name

A globally known name generates trust and recognition.

CONCLUSIONS

The internal analysis gives an overview of the most important strengths and weaknesses of Capgemini and Centraal Museum.

The biggest strength is the combined resources of Capgemini and the Central Museum. With this technology based project, intellectual resources are of utmost importance, to be able to create a well functioning, high fidelity prototype and to have all of the correct data to assimilate into this prototype.

The biggest weakness is the presence of three highly influential stakeholders, all adding their own restrictions. However, aside from these restrictions, these stakeholders have got quite matchable goals and aspirations.

Based on this internal analysis, strengths and weaknesses can be formulated.

STRENGTHS

- Central museum and Capgemini are well established brands
- Central museum and Capgemini are progressive in their management
- Central museum and Capgemini are visitor\ client oriented
- Central museum and Capgemini have a lot of resources in the form of employees and data
- Central museum is in contact with old residents
- The Rietveld Schröder archive has vast banks of information about the house

WEAKNESSES

- No consensus on the usefulness of AR within the board of Central museum
- Capgemini is focused on a technological showcase, taking away focus on the user
- End users would not likely know Capgemini played a part in the project
- The unproven technology comes from an external startup, leaving uncertainties
- Small amount of possible visitors per day

EXTERNAL ANALYSIS

Next to internal factors, the external factors are of equal importance. The external analysis focusses on these factors and their implication for the project. These external factors together form a base of threats and opportunities to further develop on to get a design direction.

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VISITOR/USER

To gain more insight in the users of the product, personas are made, based on prospective users. The prospective users of the product are the visitors of the Rietveld Schröderhouse. These visitors come from very diverse backgrounds from all over the world. To cope with this wide range of people, three personas are established. Each persona represent a main group of visitors. These personas are based on interviews with visitors and staff of the Rietveld Schröderhouse. On a regular day, basic interviews were done to find out about the opinions of the visitors on the house. The interviews were done as natural as possible, using the questions (found in appendix II.) as a

guideline, to make room for possible follow up questions regarding answers. Even though the visitors were very diverse, some parts were the same between them. In the interviews all of the visitors almost seemed like they had forgotten about the ground floor. When asked what they found interesting in their visit, nobody even mentioned the ground floor, only talking about several aspects of the top floor. Return visits are not uncommon. Also the term ‘augmented reality’ was unknown to all but a few, often even after showing an example, having used it was even more uncommon.

<i>Natalya Ivanov</i>		
Nationality	Russia	
Occupation	Student	
Highlight	How far ahead of it's time the top floor is with the modularity, feeling spacious while being tiny	
Reason for visiting	Studies in the Netherlands, went with class. Has an interest in the very progressive type of architecture	
Augmented reality	Hasn't heard about AR, has tried VR, doesn't like glasses but doesn't mind them as long as they have contextual value	

<i>Kees Schippers</i>		
Nationality	Netherlands	
Occupation	Retired	
Highlight	The sliding partitions	
Reason for visiting	Day out, Rietveld is Dutch pride, heard about it through word of mouth. Is interested to see the partitions.	
Augmented reality	Never even heard of augmented reality, 3D glasses are already too invasive, augmented reality glasses are out of the question.	

<i>Ji-Yong Kang</i>		
Nationality	Korea	
Occupation	Working	
Highlight	The flexibility of the top room	
Reason for visiting	Trip through NL, saw it in a brochure. Finds the modularity of the house very interesting	
Augmented reality	Never heard of AR or VR, would find it funny to try AR glasses.	

THE TECHNOLOGY

With 'augmented reality' still being a relatively newly introduced technology for consumers, the whole concept, or at least parts, is still unknown for parts of the population. Adding the term "mixed reality" to the balance, can even throw off more technically adept people. To first make sure there are corresponding ideas of these technologies between the reader and this report, an introduction and overview is presented here.

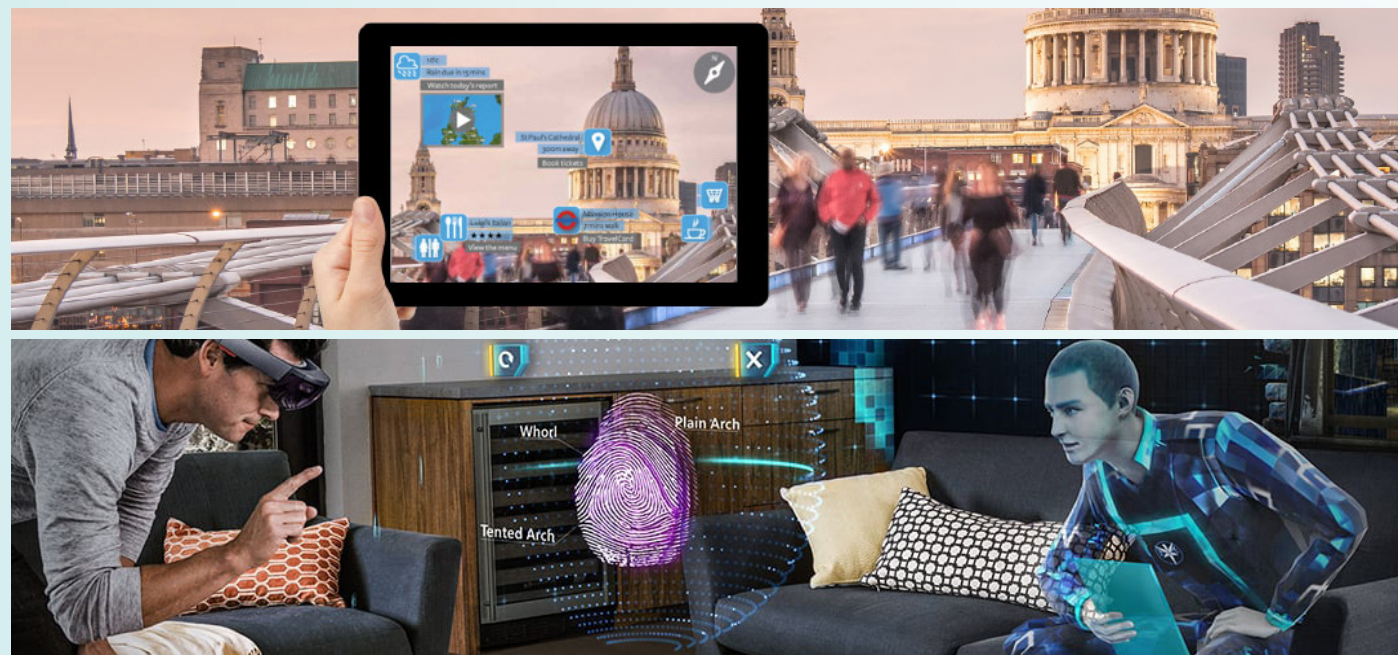
DEFINITION OF MIXED REALITY

There is a lot of debate (See Appendix III) going on about the exact definition of "augmented reality" and "mixed reality". From this point on, in this report the term 'mixed reality' will often be used for the used technology, to clearly distinguish between an overlay and the desired placement of dynamic interactive virtual objects. So here mixed reality is:

"The addition of 3-dimensional virtual objects into the perception of the real world, where the virtual objects are dynamic and interact with the world around them."



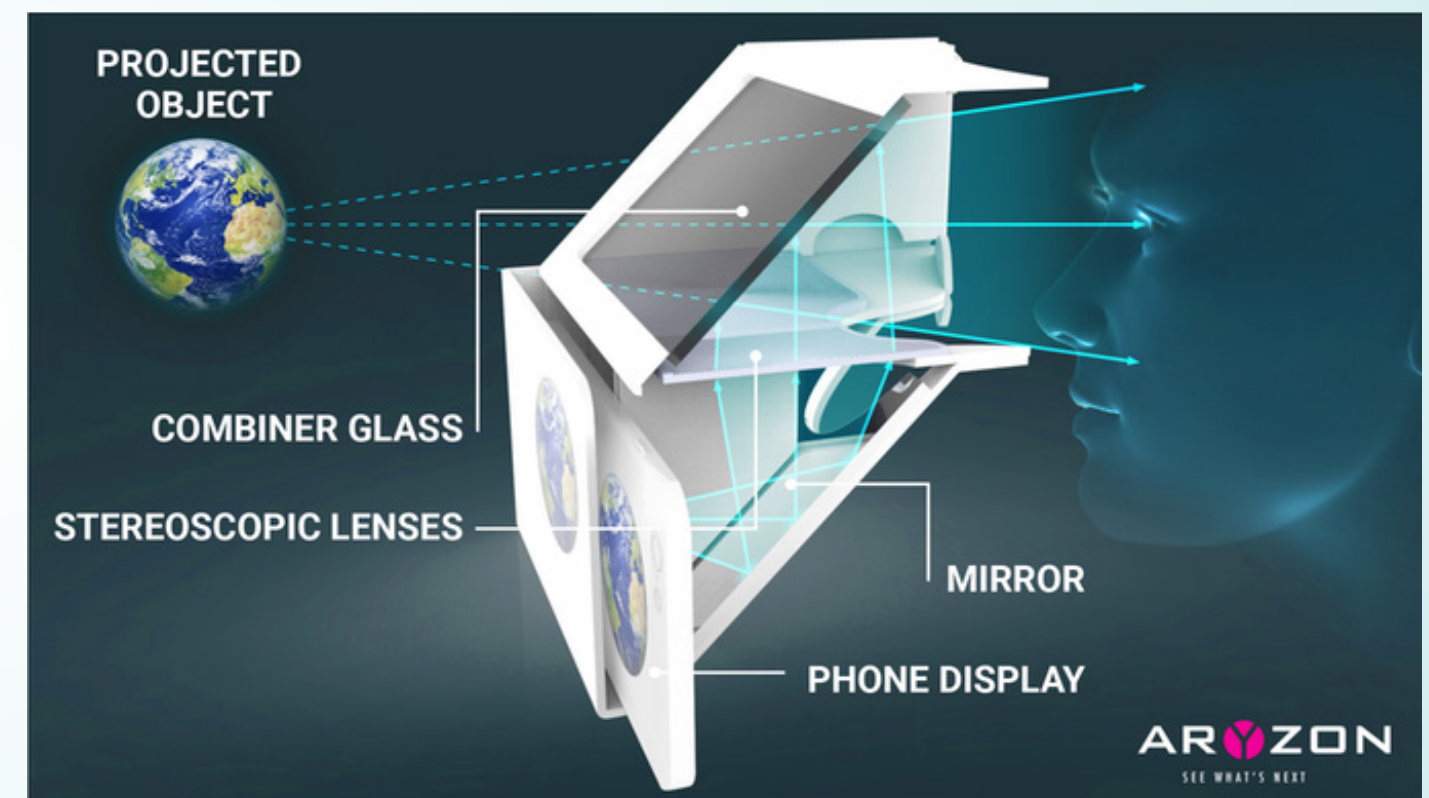
This definition, meaning the technology best seen in the Microsoft HoloLens, makes a nice distinction between showing information in the users' field of vision and placing virtual objects in the users' environment, capable of interacting with said environments, as seen below with AR above and MR below.



HOW IT WORKS

In essence, for current MR headsets to work, it needs to do four things:

- It needs to determine the Pose (translation and orientation) of the headset
Done by using internal sensors registering position and movement
- It needs to map out the environment around the user
Done by using sensors like depth sensors and stereoscopic cameras to 'see' surrounding
- It needs to correctly visualize virtual objects fitting with that Pose and environment
Done by using the map of the surrounding and complex calculations to place objects in this environment and generate the correct viewpoint
- Get this visualization in 3D vision to the users eyes
Done by using two screens for stereoscopic video, mirrors to get the video into the combiner glass and combiner glass to see through while the video gets reflected into the users eyes



Combining these four points creates a 3D vision of a virtual object, seemingly positioned in the environment the viewer is in, like a physical object would be.

With mobile device based MR, the first three points remain the same. However, showing the image happens in a direct overlay over the camera image, which also does not have to be stereoscopic.

For a complete explanation how mixed reality works, see Appendix IV.



TYPES

Mixed reality comes to two main forms; Headset based and mobile device based.

Only a few companies are working on or have completed a MR headset. The most well-known headset at this moment is the Microsoft Hololens. With this headset, the viewer can see through the glasses, while stereoscopic visuals are projected onto the screen, to generate an overlay over the real world. The two other main competitors, Magic Leap and Avegant, are still in the production phase and have not yet released a product.

A very well accessible version of MR is mobile device based. With initiatives as Apple's "ARKit" and Android's "Project Tango", platforms are also developed for people to create their own mixed reality experience. Also large concerns like LEGO and Albert Heijn have created apps for their young consumers to experience mixed reality with their own mobile device.

Projector based is a form of AR, where MR is not applicable. By projecting video on a surface, information or visuals seem to be added to the view. But because of it's 2D, static nature, it cannot interact and isn't 3D.



Figures 6.03: Projector based AR

Within the types of hardware different categories of mapping can be recognized:

Marker based AR

Marker based AR is the most simple way of mapping. The technology reads a marker (e.g. QR-code), by which it can recognize the object it is that needs to be projected. By the angle of the corners and the ratio between the faces, the angle and distance can be determined, so the software knows what to place where and under what angle.



Figures 6.04: Marker based AR

Markerless AR

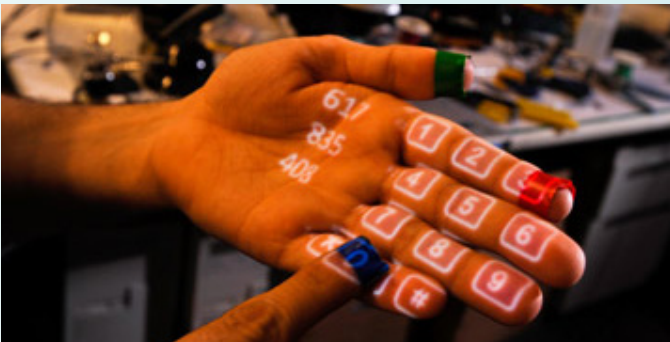
Markerless AR uses multiple technologies, for example GPS, to determine Pose and the view that needs to be shown. It can then overlay an approximation of the necessary visuals that need to be shown on the screen and where.



Figures 6.05: Markerless AR

Projection based AR

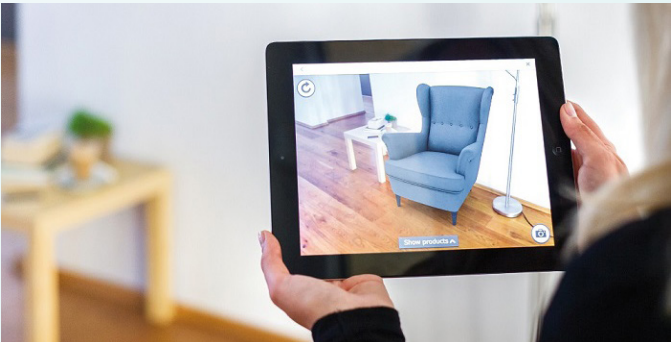
Projects light and reads the users movement within this light, by differences in the reflected light.



Figures 6.06: Projection based AR

Superimposition based AR

Superimposition based AR works through object recognition for placement of virtual objects.



Figures 6.07: Superimposition based AR



Figures 6.01A&6.01B: Mobile device based MR



Figures 6.02A&6.02B: Headset based MR

TRENDS AND DEVELOPMENTS

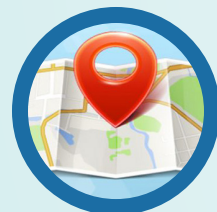
Research into trends and developments gives a glimpse into the status current market and it's readiness to evolve. By looking at several external factors, a clearer view of probable favorable directions. The main trends are listed, divided in three categories, regardless of their reach out of these categories. For the complete list, see

Appendix V.
The augmented reality market is developing at such a fast rate, it almost has new publications every week. From the moment this piece is written till it is read, several new developments will have come up.

IN MUSEUMS



Awareness of Informal Learning



The Power of Place: Place is more than just the physical, it is an experience.



Mass personalization



New Roles for Museum Professionals: Explaining curators become assisting guides

Extending the Museum's Age Range



Collaborative Experiences



The "Open" Economy: Uncontrolled, easily accessible information for everyone



The Slow Movement: Doing it quickly doesn't mean doing it right



IN AUGMENTED REALITY



Walk through historic or futuristic places



Browse through digital options



Gaming



Digital activism

Overlay directions and information



Training through added hypothetical situations



Hologram conferencing



A need for intuitive interaction with virtual objects



IN COMBINING THE TWO



Visitors learn and remember significantly more from augmented exhibits



AR has a positive influence on the emotion and engagement of the visitor.

Using AR to create an informal learning environment



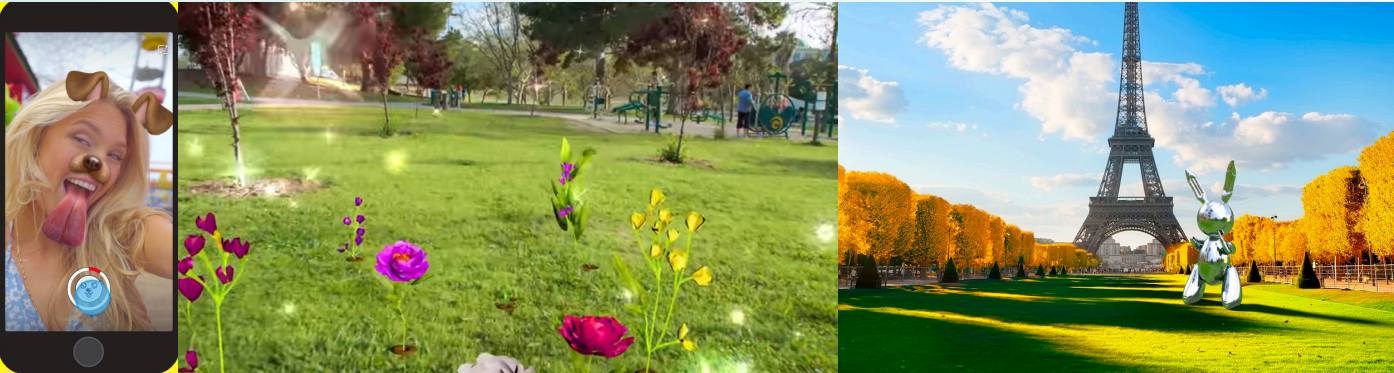
AR improves the interaction between audiences and exhibits.



NOTEWORTHY APPLICATIONS

Today’s market has a vast array of augmented and mixed reality programs. The aim of these programs generally fall into two categories: Delivering information or for entertainment. The functionalities differ wildly, ranging from complete 3D representations of parts of the city, to a simple overlay giving extra information about the thing the user is looking at. Probably the most well known app which uses mixed reality is SnapChat. This app, downloaded half a billion times, is used to make and send photos with to friends. These photos delete themselves after a limited time, so the developers have made a habit of creating options for the users to take exuberant pictures, through filters. These filters scan the persons face or the environment around and places virtual objects on these surfaces. SnapChat is one of the earlier widely adopted mixed reality apps,

generating affinity with the technology throughout the world. This acceptance created through these kind of services came paired with the offer of new product and services. Some of these products are made by small (private) developers, for example a tattoo artist who developed an app to select and ‘test’ tattoos. Very big commercial companies like IKEA and LEGO also have started to create mixed reality apps, for the user to gain more insight in their products. Even several museums apply augmented and mixed reality in their exhibitions, showing extra information, inside closed artifacts or representations of how things looked back in history. Amsterdam now even has a complete poetry museum in mixed reality. On a certain location, through using a phone, the exhibitions show up, through which the user can walk.



Figures 6.08a-6.08c: Examples of the use of snapchat (see references)



Figures 6.09a-6.09k: Examples of the use of mixed reality (see references)

CONCLUSIONS

The external analysis gives an overview of the most important opportunities and threats.

The visitors are both a opportunity and a threat, they have clear shared interests and reason to visit the Rietveld Schröderhouse, while at the same time being very diverse in their personal life.

With the visitors' limited interest in augmented reality, the focus will lie on the bottom floor. The chance of visitors using it on the top floor, on which they are already in awe, is significantly lower than the ground floor, on which many improvements can be made.

A wide array of trends and developments are applicable to this subject, generating many opportunities. These opportunities are all very likely to be able to function in mixed reality, as there are also a lot of technological developments in the realm of augmented and mixed reality.

OPPORTUNITIES

- Capgemini has a large customer base
- Opportunity in bottom floor, as it has much room for improvement.
- Love for the house and the history is a shared interest between visitors
- Many different ways to apply mixed reality
- Informal learning
- Extending the age range
- Collaboration
- Power of place
- Personalization
- Slow movement
- Role change guides
- See the non existent
- Overlay information
- Gamification
- No placement on the commercial market
- Content delivers return visits

THREATS

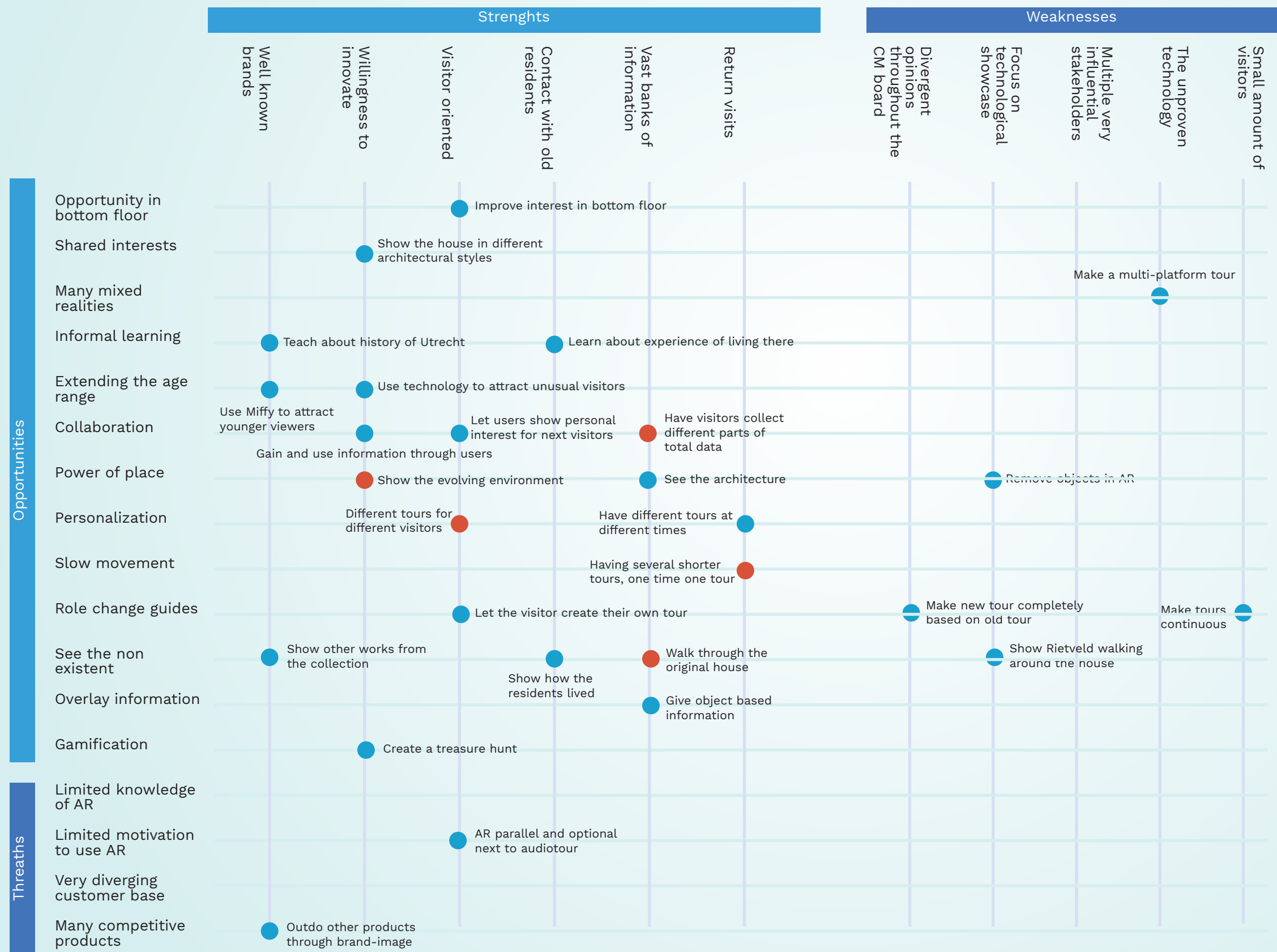
- The project has multiple very influential stakeholders, creating many restrictions
- Limited knowledge and interest in AR among visitors
- Very diverging customer base
- A lot of already existing mixed reality products makes it harder to create something unique

THE RESULTS

After the internal and external analysis, the gathered information could be combined, to be analyzed further. From this further analysis, search areas; subject areas worth looking into, could be defined.



SWOT



In order to generate search areas, a SWOT-matrix was used. This Strengths, Weaknesses, Opportunities and Threats matrix, is used to combine internal qualities or possibilities for improvement, with external influences. The combination of internal and external is made to find search areas. These search areas are then tested for originality, feasibility and how significant the information is, it will present. Based on this testing, search areas are chosen. Potential search areas are shown in blue circles, where chosen search areas are shown in red. These choices were based on a simple and quick rundown of their: Feasibility, innovativeness and expected fit with the stakeholders. The final five can be merged to come up with three design directions

SEARCH AREAS

COLLABORATIVE COLLECTING

“Collaboration enhances learning. Having the visitors work together lets them gain more collective knowledge and enhances the learning environment, while extending the tour duration through the process of sharing”

“Learning is the reason people go to museums, and learning is the primary “good” that visitors to museums derive from their experience.” (Falk & Dierking, 2000, p. 2) This means a major way to enhance the tour experience is by enhancing the learning environment. Bujak et al. (2013, p. 542) argue that learning environments are enhanced by the presence of three general factors: collaboration, contextual relevance, and personal relevance. With the house being the reason for the visit and the context of the tour, contextual and personal relevance is present. Collaboration is lacking completely. By adding a layer of collaboration, the learning environment becomes enhanced, enhancing the overall experience of their trip to the Rietveld Schröderhouse. This collaboration also asks of communication among visitors, to share their information. This sharing of the information would come after the exploration, extending the tour.



THROUGH TIME

“Time travel always has been an interest of many people. Using mixed reality to travel to another time in the virtual world, gives the visitor a better representation of the history in the house, while enhancing the immersion of the present house.”

Both the house and the environment has changed greatly since the house has been built. Residents came and went, the furnishing changed and the environment became completely urbanized. Seeing pictures gives a slight impression of a different time, impressing the visitors. When visiting the house, it is hard to imagine someone had lived there, as it is complete lacking signs of people having lived there. Seeing just a glimpse of the

way it has been used, makes the house seem less static, more alive even. Letting the visitors experience parts of these earlier times through mixed reality, will make the experience more immersive. This immersive new experience can give the visitor a better view of the house itself, how it was used and by who. It can also give an impression of the ways of the world back then, how people lived and how the environment looked.



VARIABLE VISITS

“Every person is different and goes through a lifetime of changes. Having the same tour for everyone at every given time, means the tour cannot possibly fit everyone equally much. Having variable visits can fit more people and accommodate return visits better”

Due to the manufacturing possibilities of today, the amount of available products is very high and many of these products have several versions, supplying ranges of technological and aesthetic specifications. Every person can choose the product best fitting his wishes, as well as his personality. Expressing yourself through products is common in the western world. “There is a growing demand for individualism which speaks to our personality and culture.” (Grant et al., 2013, p. 17) This need and possibility for expression through products, arguably also asks for

expression through services. Having only one tour, to accommodate the wide range of visitors over a long time span does not fit this current need. By using several different narratives, different focus points or even completely different tours, will create a better fit between the tour and the visitor. This also creates more incentive for the visitors to return. In this return visit using a different tour, the visitor can see the house from a different perspective, creating a partially different experience than the first time.



WORKSHOP

For a better understanding of the perspective of Central Museum and Capgemini, a workshop was organized, for the complete writeup see Appendix VI. In this workshop, not only the perspective on the project was formulated, but also the desired outcome and interesting subjects.

This information was gathered through the two stage workshop in a meeting room at Capgemini. The first stage was a short interview, to gain insights in opinions, but mostly reasons for participating in this project, which generated the following reasons:

- Making the experience of the house less static, possibly even to include kids
- To be able to time travel through very modern ingenuities.
- To create an innovative experience, a technological showpiece
- Enrichment for the visitor, a bigger learning experience, more stories and curiosity

The second stage was an open idea generation. Having several employees with years of experience with the Rietveld Schröderhouse, they have valuable insights in the possibilities for improvement. After generating many ideas, these could be clustered into more overarching insights:

- History of the house
- The family and other residents
- The architecture
- For kids
- Opinions and feedback
- Organizational

Overall this workshop generated a more clear view of the needs, wants and ideas of the major stakeholders. These are highly useful for selecting and exploring the search areas.



Figures 7.01: The clustered ideas, generated in the workshop

CHOICE OF SEARCH AREA

To make the choice of the search area meaningful, it is done against several criteria. These five criteria include the main aspect the search areas should adhere to, based on the opinions of Capgemini, the Central Museum and my design intuition.

Technological innovativeness

Innovativeness is an important part for a search area, as recreating something already existing would drastically reduce the edge over other products and services. In extension to this innovativeness comes the technological innovativeness. As Capgemini wants to generate a technological showcase with this project, the innovativeness is very important.

Enrichment of the visitor

The enrichment of the visitor is highly important for the Central Museum. As a museum, enriching the visitor is the main focal point, which should be represented in the search area.

Coherent with Rietveld’s legacy

The main goal of the Rietveld Schröder Foundation (RSF), is maintaining the legacy of Rietveld. So the main subject represented by the product needs to be Rietveld.

Assignment fit

The assignment is a very important base for this project. The search area should be tested against the compliance with the assignment

Designer intuition

How well does the search area spark creativity and how well do the initially perceived possibilities benefit the situation

Assessing these criteria this way is very abstract and complex. For this reason, the assessment is not only based on their score objectively, but also adjusted in their comparison with the other two search areas. This gives a clearer perspective on the comparison between the aspects. The assessment can be seen in the table below.

The total score gives a very clear view of how promising each of the search areas are. Even though all of them have their different merits, ‘Through Time’ fits best with all of the criteria. This does not mean the other two will be discarded. The focus points collaboration between visitors and a change in the way the tour is setup, will be kept in mind in further future development.

	Collaborative Collecting	Through Time	Variable Visits
Technological innovativeness (Capgemini)	+	+++++	++
Enrichment of visitor (Central Museum)	++++	+++	+
Coherent with Rietveld’s legacy (RSF)	++	++++	++
Assignment fit	++++	++++	+++
Designer intuition	++	+++	++++
Total	+++	++++	++

THROUGH TIME

DESIGN BRIEF

The Rietveld Schröderhouse is an architectural masterpiece just outside the Center of Utrecht. Witnessing the changeable partitions on the top floor leave many in awe. For this reason, people from all over the world come and visit the house. To accommodate these many different languages, the tour is given in over half a dozen different languages. The tour guides can not possibly be equipped with mastery over that many languages, so audio tours are there to support them.

The audio tours come in the form of a mobile phone like device, to which the visitor presses his ear. This way the tour is very individual and very static. The way the current tour is done and to adapt to a rapidly developing society, the tour is ready for innovation.

This project is focused on delivering innovation in the form of enhancing the experience of the Rietveld Schröderhouse, through ‘mixed reality’. This added virtual layer, can create a more immersive experience and enhance the learning of the visitor. To give more direction for this enhancement a search area was described and selected. This search area is ‘Through Time’. This search area focuses on showing the history of the house, the residents and the environment, showing extra depth of information in an informal manner.



Why

The house is nearing the age of 100 years old. Much has changed over this long period of time. Not only did many residents come and go, and furnishing go through many changes, but even the environment changed greatly. When the house was built, it was on the complete edge of the city, with just grasslands around, in a time when the T-ford was still in production. Even though it has been built in another century, it still has a very modern twist. A great way to show things and events from other eras is mixed reality, which can show things that have once existed, but are no more. Implementing mixed reality can have great benefit for the immersiveness and learning of the visitor, while being an excellent showcase for the project hosts.

Who

The target user will obviously be the visitors of the house, interested in the house and the story behind it, specifically the students and working visitors, willing to use mixed reality. The retirees showed to have a high chance of being reluctant to use mixed reality. The focus of this project will lie on people of various origin, for who the experience needs to be accessible.

Focus points

The focus of the project will lie on the bottom floor of the house. Adding to the bottom floor gives a lot of room for improvement, while having higher chance of acceptance by the visitor.

The information given will be correct history. Supplying information on Rietveld and the house. The learning that comes with it will be enhanced by mixed reality.

The transfer of information will be through mixed reality, having a double function as a technological showcase, where it should be innovative in showing of the technology.

How

The 'how' is the question which needs to be asked and answered in the next phase.

The biggest constant is 'mixed reality'. This project will be done with the use of that technology. The way it will be implemented will need to be expanded on in the next phase.

So a large part will be prototyping. A lot of possibilities and limits will need to be tested, to be able to generate a fitting result. This will focus on three main points:

- How the visitors respond to the technology.
- How the visitors perceive the content.
- What is needed to create a perceived immersive environment.

Ideation will be done prior but also for a large part parallel with prototyping. This will focus on the content itself, as well as the broader story and the presentation. Broad lines can be sketched at the start of the next phase, which will be honed according to the found possibilities and limits found in the prototyping process.

DESIGN GOALS

The analysis is a base to formulate design goals. These design goals summarize the most important aspects found in the analysis, to give aim to the next phase of the project. These goals are the core goals the final product should adhere to.

“The design should incorporate state of the art mixed reality techniques to create a showcase in which virtual blends in and interacts with the environment.”

“The design should incorporate mixed reality to supply accurate data regarding the history and course of living in and around the ground floor.”

“The user should become onto a dynamic, immersive experience, where the house is used as an informal learning environment. “

Several smaller goals can be derived from the analysis as well, in regard to functionalities and uses the design should have.

- The design should be usable by first time mixed reality users
- The design should be usable regardless of language barrier
- The design should accommodate use by multiple people in a small space
- The design should be handled intuitively

PLAN

The list of goals function as guidedlines for the scope. The upcoming phase will define it even further, being used to set up a program of requirements, to use as a template for the upcoming ideation, conceptualization and prototyping.

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APPENDIX

I. History

The Central Museum (Centraal Museum, n.d.-c)

1830: Start in four rooms in the town hall

1838: Opening for general public

1843: Start of neglect after death of mayor

1874: Restoration and redecoration

1891: Move to Het Hoogeland

1921: Move to current location, merging with several collections, into the ‘Central’ Museum

1930: Discovery of the ‘Utrechtse schip’

1987: Acquisition of management over and Opening of the Rietveld Schröderhouse to the public

1989: Rebuilding the old stables

1999: Restoration and rebuilding, with the creation of a section for kids

2006: Opening of the Dick Bruna house

2013: CM becomes independent with an own board

2015-2016: Transformation of the main building and reopening a rebranded Nijntje museum

The Rietveld Schröderhouse (Centraal Museum, n.d.-c) (Centraal Museum, n.d.-d)

1923-1924: Design and build of the Rietveld Schröderhouse

1925: Moving in of Truus Schröder

1937: Addition of a room on the roof

1957: Removal of the room on the roof

1976: The Rietveld Schröderhouse becomes a monument

1985: Death of Mrs. Schröder

1987: Acquisition of management over and Opening the Rietveld Schröderhouse to the public

2000: Addition of the Rietveld Schröderhouse to the UNESCO World heritage site

Capgemini (Capgemini, 2017-c) (Capgemini, n.d.) (Sogeti, 2016)

1967: Founding of Sogeti

1970: Diversification into consulting and outsourcing

1974: Sogeti acquires CAP and Gemini computer systems

1977: Development of the architecture for the first payment terminal

1980: Creates the first electronic yellow page directory

1985: Floated on the stock market, these go up 25% in 5 days

1985: Wins a prize for best annual report, illustrated with paintings

1987: Acquisition of Sesa, gets into system integration and creating a public data transmission network

1990: Acquisition of Hoskyns computing service

1992: Cap Gemini Sogeti has first annual loss due to crisis but still acquires Volmac and Programmator

1995: Convergence program is launched, focussing on consultancy and IT services

1996: Rebrand to Cap Gemini

2000: Acquisition of Ernst & Young, surpassing 50.000 employees in nearly 30 countries

2002: Relaunch of Sogeti

2003: Establishes in India

2004: Launch of current logo and brand name Capgemini

2010: Presentation of new strategy to conquer more companies, entering Brazil through CPM Braxis surpassing 100.000 employees threshold

2014: PostNL’s cloud service completely run by Capgemini

2016: Launch of Applied innovation exchange

2017: Over 193.000 employees in 44 countries, nearly 54.000 hires a year, with 6.000 clients

II. Interviews

- Where are you from?
- Are you currently a student, working or retired?
- How did you hear about the museum?
- How far did you travel to come here today?
- What was your reason of visiting the Rietveld Schröderhouse?
- What did you find the most interesting in the Rietveld Schröderhouse?
- Did the house live up to your expectations? Why did/didn't it?
- Would you recommend it to other people? Why?
- Have you ever used AR?
- Have you ever used AR/VR glasses?
- Did you like the experience?
- Would you mind to in the future?

III. Mixed reality

The original mixed reality

Augmented reality(AR) and virtual reality(VR) were both already successfully being developed more than 20 years ago (Johnson 2016)(Rouse 2016), with the early prototype of AR even dating back to 1962(Carmi-gniani et al. 2010). At that time, the term ‘mixed reality(MR)’ was first introduced by Paul Milgram(Carmi-gniani et al. 2010):

“The continuous scale ranging which covers all possible variations and compositions of real and virtual objects. The continuum ranges from a completely real and natural environment, to a completely virtual environment.” (Reality Technologies 2016a)

Since that time the definition of AR and VR did not change much, still containing the same principles.

Augmented reality

Augmented reality is augmenting the real world perception of the user, meaning adding an overlay of virtual objects, often in the form of information like a Heads Up Display(HUD).(foundry n.d.)(Jimmy 2017) (ICulture 2017)

Virtual reality

Virtual reality creates a whole simulated environment through computer technology, also making it possible for the user to interact with the environment. By simulating as many senses as possible, the user is immersed in this, seemingly real, artificial world.(Jackson, B. 2015)(Reality Technologies 2016b)

The new mixed reality

20 years ago these different kinds of realities were quite well discernible; AR is an overlay on reality, VR creates a whole new reality and MR includes all of the combinations of real and virtual.

Though AR and VR did not change much, MR underwent some major changes. At this moment the definition is different per person, sometimes also referred to as hybrid reality(foundry n.d.), and often is used without clarity, in an effort to keep it nuanced, even resulting in statements as: “Mixed reality, which lies somewhere between AR and VR”. (ICulture 2017) With recent technological developments, a lot of possibilities became available. One of these possibilities is the combination of the two main components of AR and VR, respectively, the possibility to see the world around you and complete immersion. (Johnson 2016)(Reality Technologies 2016a) In fact MR often refers to adding virtual objects in the real world, where these objects also interact with the world, making MR arguably a specialisation of AR.

So with both AR and MR adding objects into the real world, the difference between AR and MR becomes delicate. By using Pokemon Go, the famous phone based video game, as an example, the definitions become more clear. Some people mistake Pokemon Go as an MR game, because of the moving 3D objects, but seeing these objects do not have a fixed placement in the real world or interact in any other way with the real world, these pokemon are AR. The simplest analogy would be; Seeing a moving 3D pokemon through your camera is AR, seeing a pokemon walk over your table and climbing up your laptop is MR. This also shows MR can be considered a form of AR, but not the other way around.



The image shown above, nicely shows products using one of the realities. From left to right, VR, AR and MR.

So everything was clear and well categorized, until the inventor of the Microsoft HoloLens Alex Kipman, found the terms VR and AR to be obsolete, “This is why, to simplify things, we call all of it ‘Windows Mixed Reality’”, (Robertson 2017) falling back on the term invented by Milgram. His reasoning behind this is his prediction of the future, where real and virtual will be perfectly blended. Even though his prediction is most likely true, at this moment this is not case and combining three similar but still very different technologies into one group makes it very confusing to converse about these three technologies in the coming years.



It has the biggest influence on MR itself. With this inclusion of the other two terms, VR headsets are now also called MR, as can be seen in the image above. Only the left headset adds virtual objects to reality, as the the three headsets on the right are VR, the cameras in the front are only to map out the surrounding, so the user cannot see the real world.

In spite of the confusing use of these definitions, the term mixed reality will still be used to talk about the headset and technology used for this project, instead of augmented reality. Though most papers refer to augmented reality for this technology, using the term mixed reality makes it possible to clearly differentiate between the 3D augmentation in MR and the static 2D augmentation of AR. This makes the definition of Mixed reality: “the addition of 3-dimensional virtual objects into the perception of the real world, where the virtual objects are dynamic and interact with the world around them.” This definition refers to the objective technologic addition compared to augmented reality. For this project, the dynamic nature and added level of immersion is needed to create a modern showcase and heightened experience of the Rietveld Huis.

IV. How it works

The biggest difference between MR and VR, is MR inclusion of the real world environment around the user. So VR only needs to determine the position of the headset and show the video that represents that 3D pose (translation + orientation). MR in turn also needs to map out the environment around the user and to create an overlay over the environment, as it doesn’t show just a video, so it needs to correctly visualize the virtual objects in this real world and show this all in 3D vision in your eyes. These four aspects are all very technical, but having a basic understanding how it works, adds to the understanding of this project.

Mapping out environment in AR

In basic augmented reality application, the mapping of the environment does not always need to be done. Using, for example, a marker, where the camera can recognize the form of the marker, to recognize the model that needs to be added, the location and the orientation of the user compared to the marker.



For mixed reality, markerless tracking is used, where the tracking is done based on the mapping of the environment.

Determining position and mapping out environment in MR (The Verge, 2017) (Xinreality, n.d.)

Even though determining position and mapping out environment are quite different techniques, the software and hardware behind them have some overlap. Determining the position is done through calculations with the combined data of external and internal sensors, so the product does not only know where it is moving, but also where it started.

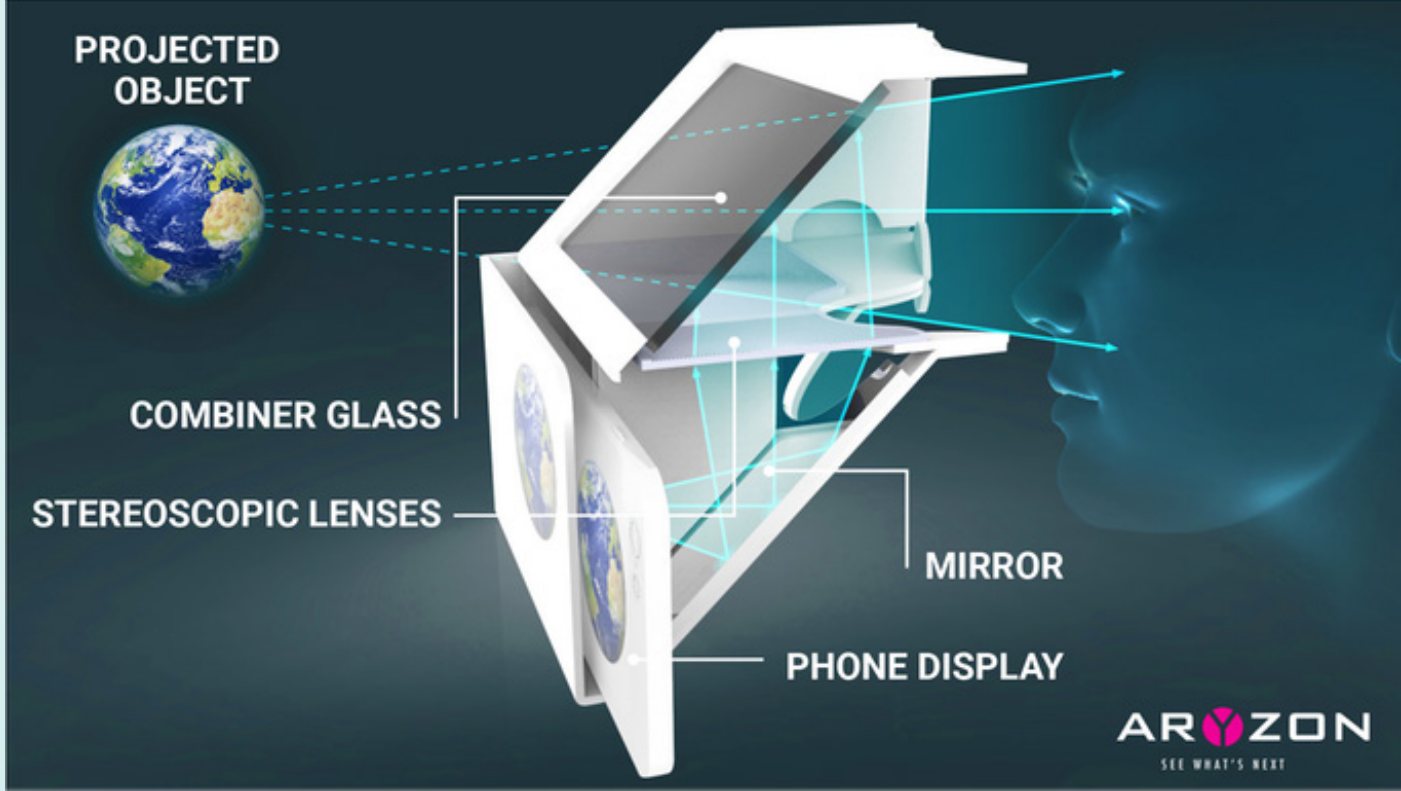
Knowing where the product is moving, mainly asks for accurate internal sensors, like an accelerometer, magnetometer and gyroscope, to register changes in movement, adding other sensors generate more accurate measurements.

Knowing where it started asks of both internal and external sensors. Here VR has an advantage, it just asks for a piece of empty space to walk within, as no interaction with the outside environment is needed.

So here the HTC Vive can use external sensors to triangulate the position of the headset within the grid of sensors. For the the Microsoft Hololens, it gets more complicated, it not only needs to know the location, but also what the surrounding looks like, so virtual objects can be placed naturally in the surrounding. So through the sensing of the surrounding through internal sensors, it is already doing, it can use this to calculate its location in the room. This is necessary for example a reference point for the position of the product compared to the floor, so the user can perceive the floor to be as far away from eye-level as in real life.

So to well determine the position of the MR product, a basic mapping of the environment needs to be done. The true mapping of the environment, typically also mainly gets done by internal sensors. Humans can see depth through stereoscopic vision, where the slight difference in vision between the eyes, create the necessary information for the brain to process depth. For MR, a combination of sensors 'seeing' the environment, can imitate this effect. With the additions of lasers and depth sensors, an accurate estimation of the 3D pose can be made.

In smartphones this estimation of the 3D pose is done with the help of a camera, through which it uses



visual features, and is called visual odometry.

Showing the video, concurrent with the pose and visualising objects. (Microsoft, 2017)

With MR first the video needs to get to your eye. This is often done with the help of mirrors and semi-transparent glass. Both eyes get separate video, so the brain can perceive it as 3D.

For VR, the glasses function as a viewpoint in the virtual world, by knowing the exact pose in the real world, it can be translate this viewpoint to the concurrent location, so the user can see as if standing in that exact location in the virtual world. MR needs to take this a step further; it not only needs to show that same viewpoint, but it also needs to adapt the virtual world, to fit the real world environment. Adapting to the real world starts with representing real world spatial surfaces by triangle meshes. These representations make it possible for the product to view every part in the room and make a virtual representation of it. After this it is possible to create a convincing virtual addition, by using several aspects:

Occlusion

Occlusion is hiding (a part of) a virtual object, as soon as it would spatially be located behind a real world

object, to really make it seem it is existing in the world.

Visualization

A simple visualization of a surface can create better understanding of the environment. With the use of a sample layer or shadows, a clear view of the location and dimension of the surface is created.

Placement

Placement means placing a virtual object on a point on a surface instead of a point in space, where this surface is on a mapped on a real world object like a table.

Physics

Using physics to create a realistic representation of a virtual ball rolling off a table and bounces under a couch, adds greatly to the realism of the simulation.

Navigation

Letting a virtual character navigate freely through a room, like a real person would, through correct mapping of 'walkable' surfaces and changing environments like doors.

V. Trends

Museums

- Extending the Museum’s Age Range: (Vergeront, 2017)
- Inclusion of users outside the original user is sought after
- Awareness of Informal Learning: (Vergeront, 2017)
- Learning is social, object-based and contextual. It can be non-traditional and active
- Collaborative Experiences: (Vergeront, 2017)
- Collaboration works on many scales. It helps engage different perspective, shares expertises and extends resources
- The Power of Place: (Vergeront, 2017)
- Place is more than just the physical, it is an experience.
- Authentic Materials: (Vergeront, 2017)
- Materials tell a lot about a product, especially with today’s digitalization
- Nice + Necessary: (Vergeront, 2017)
- Museums need to be a pleasant place to bring friends. Museums are necessary in strengthening communities and playing a critical role in early development
- Visitor Engagement: (Vergeront, 2017) (NMC)
- Not only working for, but also with your visitors, enriching the experience through new perspective and increased relevance.
- From STEM to STEAM: (Vergeront, 2017)
- Adding arts to a highly technical area, creates a more accessible area, to extend the reach, especially for females, while welcoming creativity in science.
- Maker Spaces and the Maker Movement: (Vergeront, 2017)
- Learning through doing and interacting, with the social engagement in the building.
- Technology Everywhere: (Vergeront, 2017)
- New technology can be used to introduce new subjects or extend existing ones.
- Becoming Places of Research and Evaluation. (Vergeront, 2017)
- Ethical Everything: (AAM, 2017) (AAM, 2016) (AAM, 2015)
- Empathy, civil rights and the reshaping of the world
- Rise of the Intelligent Machine: (AAM, 2017)
- Artificial intelligence and deep learning
- Failing towards Success: (AAM, 2017)
- Trying fast, testing success and adjusting accordingly
- The “Open” Economy: (AAM, 2016) (AAM, 2015) (NMC, 2016)
- Uncontrolled information, available for everyone, easily accessible, with the help of smart devices
- AR and VR: (AAM, 2016) (AAM, 2015)
- Wearable portals to other places and times
- Measuring Happiness: (AAM, 2016)
- Happiness is more than wealth
- It’s Personal: (AAM, 2015) (NMC, 2016)
- Mass personalization
- The Slow Movement: (AAM, 2015)
- Doing it quickly doesn’t mean doing it right
- Cross-Institution Collaboration: (NMC, 2016)
- Sharing and co-creation of collections, exhibitions, and technology (internationally)
- New Roles for Museum Professionals: (NMC, 2016)
- Curators explaining to passive audiences changes into guides for visitors to find their own way and opinion
- Data Analytics for Museum Operations: (NMC, 2016)
- Like big businesses, collect data about the visitor for greater understanding of the audience’s interests and needs, to deliver more focussed information

Augmented Reality areas

- Travel & Tourism (Medium, 2017)(Sood, 2010)
- Get information about current or walk through historic places and monuments
- Customer Service (Medium, 2017)
- Overlay information
- Retail/ E-commerce (Medium, 2017)(Sood, 2010)
- Browsing a virtual catalogue and fitting rooms
- Construction/Architecture (White et al., 2014)(Chi et al., 2013)
- Seeing yet to be built buildings
- Education (Medium, 2017)(Sood, 2010)
- Teaching through interaction and collaboration (Bujak et al., 2013) in an hybrid learning environment(Dunleavy et al., 2008)
- Learning environments are enhanced by three factors: Collaboration, contextual relevance and personal relevance (Bujak et al., 2013)
- Healthcare (Medium, 2017) (Sood, 2010)
- Training and information overlay
- Advertising (Medium, 2017) (White et al., 2014)
- Experience the advertisement
- Production (Sood, 2010) (White et al., 2014)
- Overlay assembly lines
- Emergency Services(Medium, 2017)(White et al., 2014)/ defense (Sood, 2010)
- Information overlay and training
- Businesses
- Hologram conferencing (Sood, 2010)(Chi) and co-creating (Chi)
- Gaming (White et al., 2014)

Augmented Reality Developments

- Rapid advances in mobile computing create large possibilities (White et al., 2014)
- Interaction with virtual objects should be as natural and intuitive as physical objects(White et al., 2014) (Dunleavy et al., 2008)(Chi et al., 2013), as it reduces extraneous cognitive load(Bujak et al., 2013)
- Privacy and security of scanning glasses are a major concern (White et al., 2014)
- AR can enhance visualization and increase comprehension of 3D environments (Chi et al., 2013)
- AR technology detects unique features of scenes to determine the superimposition of virtual objects (Chi et al., 2013)

Augmented Reality In Museums

- Using AR to create an informal learning environment. (Sommerauer & Müller, 2013)
- Museum visitors learn and remember significantly more from augmented exhibits. (Sommerauer & Müller, 2013)(Tsai et al., 2017)
- Visitors perceive it as a valuable add-on to exhibitions and wish to see it more in the future. (Sommerauer & Müller, 2013)
- Experiments show visitors enjoyed having AR as a guide through the Louvre (Miyashita et al., 2016)
- 3D reconstruction of cultural objects through AR is enjoyable by older and younger adults (Capuano et al., 2016)
- Technology based AR has a positive influence on emotion and engagement. (Capuano et al., 2016)
- Not only interaction between human and device, but also between human and content should be taken into account. (Tsai et al., 2017)
- Augmented reality, through bridging the gap between digital and physical, improves interaction between audiences and exhibits. (Tsai et al., 2017)

VI. Workshop

Interview

More return (NL) visitors than expected

What would you say are your mission and vision?

CM: Enriching the visitor with stories of the world
RVH: Sharing Rietveld with the world

What experience do you want to supply the visitor?

Making the experience less static, the tour is now fixed in 1920
Showing the modularity
An unique experience, time travel through very modern inge-
nuities.

What are highlights with the current tour?

The modularity/sliding panels

What would the AR add, what could be considered a better visit?

Emphasis on history
An innovative experience

To what extent will AR overlap with or replace the current tour?

Ideally it would replace it completely
At this moment small steps

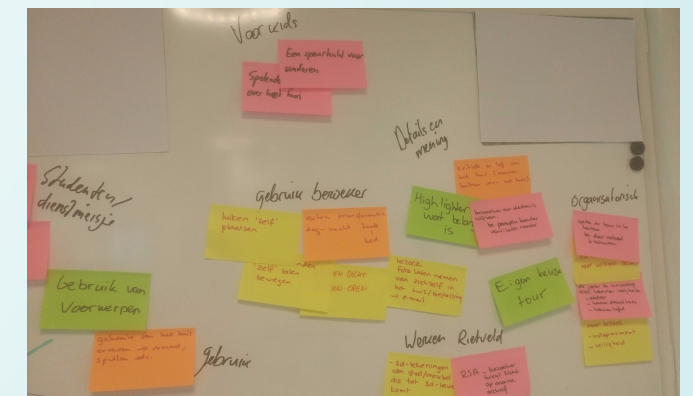
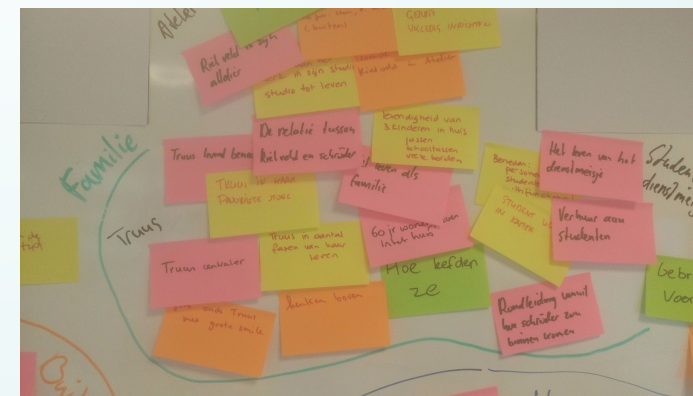
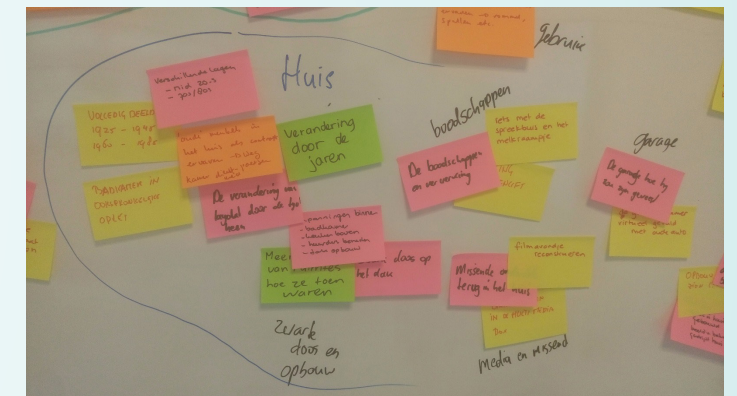
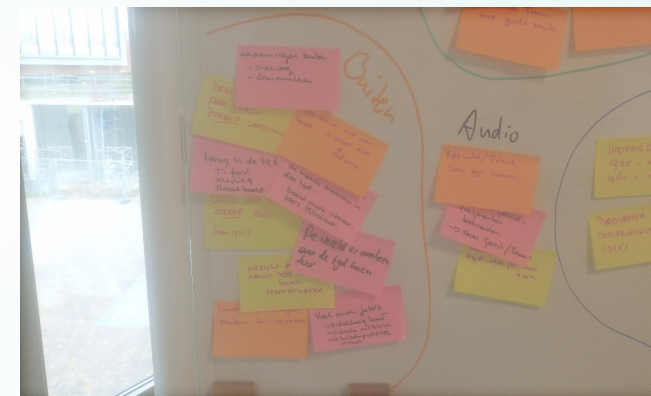
What do you expect of the end result?

- A well working product
- Room for feedback
- Letting the visitor steer their own experience
- Stepping off the 1 dimensional tour
- Visual completion on the house
- Enrichment, a bigger learning experience, more stories and curiosity
- A more dynamic experience
- Include kids
- Recommendations and return visits

Idea generation

Directions

- History/through the years
 - Inside out (seeing what happened in the surroundings)
 - The family, how they lived, and other residents
 - Truus
 - The workshop
 - Family
 - Maid/students
 - The house, what changed and what could have been
 - The top building
 - Groceries
 - Garage
 - Mediabox and missing components
 - The architecture
 - For kids
 - Modularity
 - Opinions and feedback
 - Organisational



VII. Questionnaire for initial test



• AR in RSH •

Name

Please choose the best answer for each of the following.

Aryzon

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The use of the Aryzon is intuitive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is inviting to be used	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I want to use the Aryzon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is comfortable to hold	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is comfortable to walk with	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is inviting to look through	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is comfortable to look through	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Aryzon is pleasant to look through	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The video quality is great	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My view is unobstructed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel like I am staying in reality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker kitchen



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker Maid's room



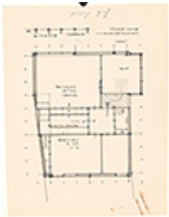
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker Studio Chair



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker Studio Building



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker Study room



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Marker Upstairs



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This marker makes me curious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker bares enough reference to the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker is fitting for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This marker has a positive influence on the room	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Model Kitchen

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why do you like/dislike this model?

Model Maid's room

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Model Studio Chair

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Model Studio Building

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why do you like/dislike this model?

Model Study room

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

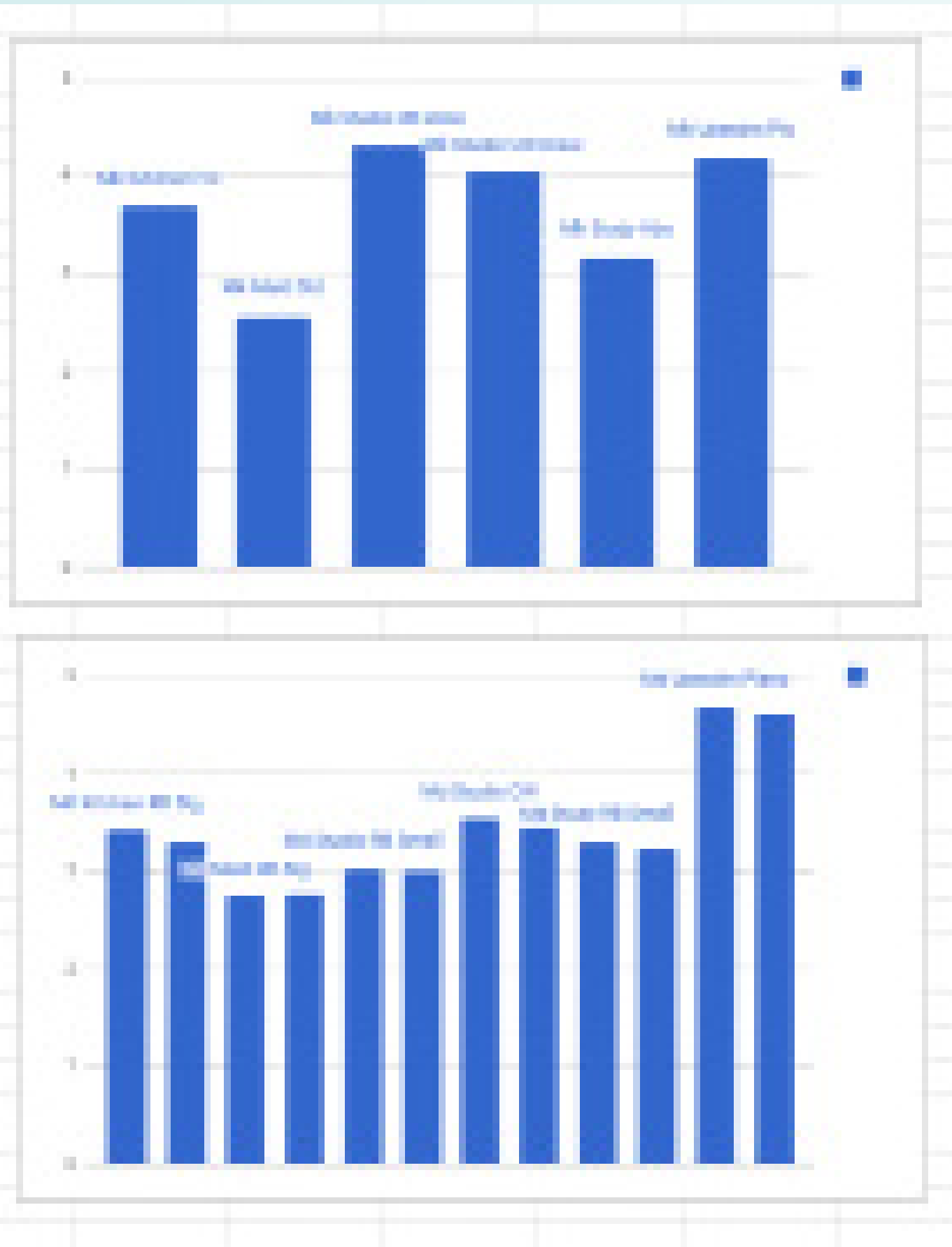
Model Upstairs

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The size of the model is appealing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The size of the model is surprising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This model fits in the context of the experience of the house	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The model is of enough detail to be interesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeing the model in this situation makes me more immersed in my surroundings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like this model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why do you like/dislike this model?

Additional comments

IX. Results initial questionnaire



X. Questionnaire for testing

Visit Rietveld Schröder house

Information

What is your age

- ☐ 18-25
 ☐ 25-40
 ☐ 40-60
 ☐ 60+
 ☐ I prefer not to answer

What is your gender

- ☐ male
 ☐ female

What is your highest finished education

- ☐ High School/Middelbare school
 ☐ Community college/MBO
 ☐ Bachelor/HBO
 ☐ University Master
 ☐ Other
 ☐ I prefer not to answer

What is your current employment status?

- ☐ Student
 ☐ Part time (up to 34 hours/week)
 ☐ Full time (35+ hours/week)
 ☐ Retired
 ☐ Other

Have you visited the Rietveld Schröder House before?

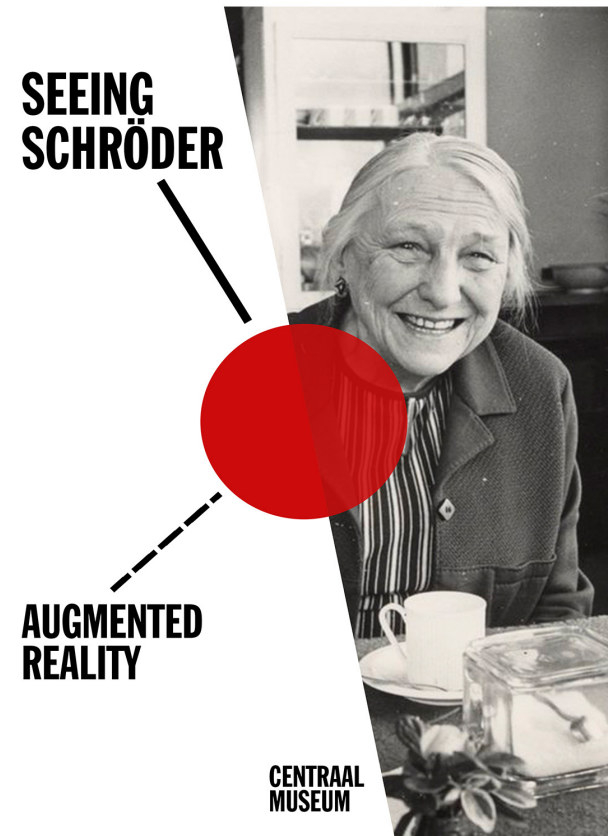
- ☐ Never
 ☐ Once
 ☐ Twice
 ☐ Three or more times

What is your reason to visit the Rietveld Schröder House?

What is your experience with Virtual Reality (VR) and/or Augmented Reality (AR)?

- ☐ Never heard of it
 ☐ I know of it but have never tried it
 ☐ I have tried it
 ☐ I have used it more than a few times

Marker 1



This marker makes me curious

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

This marker fits the situation

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

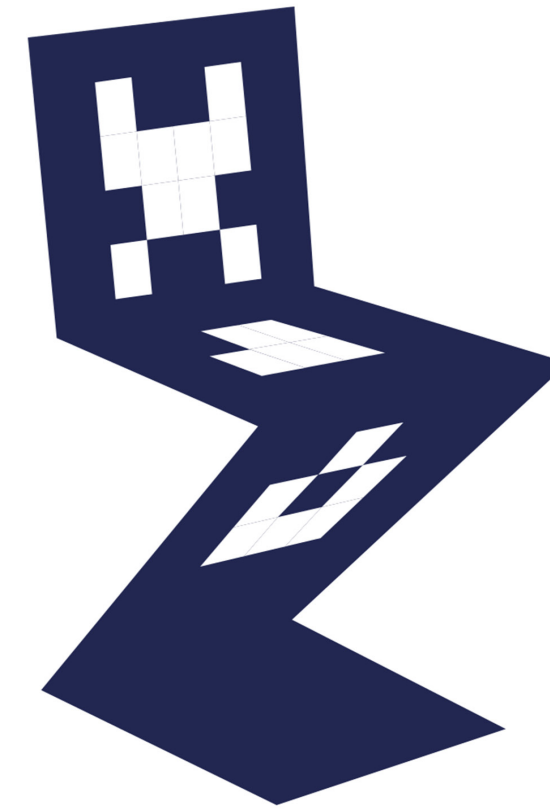
This marker fits the house

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

I think the marker is attractive

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

Marker 2



This marker makes me curious

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

This marker fits the situation

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

This marker fits the house

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

I think the marker is attractive

strongly disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ strongly agree

Visit Rietveld Schröder house

Augmented Reality

I felt comfortable in using the device

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

Using the device was self-explanatory

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

The device invites use

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

The device makes me curious

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

Using the device was fun

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

Using the device was informative

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

The experience is immersive

strongly disagree ○ ○ ○ ○ ○ ○ ○ strongly agree

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Overall

What would you grade this visit?

1 ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ 10

Would you recommend this visit to other people

- ☐ Yes
☐ Yes, but not to everyone
☐ No

Do you have any remarks or comments about the use of the augmented reality device?

Do you have any remarks or comments about the experiment?

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Consent

- ☐ By checking this, I agree I was aware that I was allowed to stop during the experiment at any time for any reason
☐ By checking this, I agree the data from this survey is used anonymously for further development

I would like to get an update on the development of this project (please fill in email adress)

XI. Results test questionnaire



XII. References

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