Augmented Reality;

as Municipal Communication Tool

Benjamin Sprecher | *Chair*

Heidi Carelsberg | *Coach*

Sjoeke Suilen | *4859715*

Author

Sjoeke Suilen

Graduation Comittee

Benjamin Sprecher
Department of Sustainable Design Engineering

Heidi Carelsberg
Department of Human-Centered Design

TUDelft

Delft
University of
Technology

Preface

When I started my "design-career", I desperately wanted to invent cool new gadgets. Yet the more I learned at the faculty, the more I realised that we might not need new gadgets. When initially learning about the Circular Economy, it just clicked. It makes so much sense to me that materials need to be circulated and used for as long a period as possible to lower environmental impact. The world does not need a redesigned toaster every year, but perhaps a redesigned way of managing materials is necessary.

This thesis kickstarted from personal motivation to apply this topic in the realm of Social Design, which recently got my interest. After realising that designers often use very abstract, expensive and unnecessary language to communicate, I wanted to take a shot at achieving the opposite: *How can design be leveraged to Simplify Language?*

Throughout this journey, I learned that it is deceptively difficult and time-consuming to do this. I stumbled often, made mistakes, held wrong assumptions, and got stuck.

Despite these challenges, the community I found at IDE made all the difference. The Faculty is home to many great people, who helped me get up when I fell. I want to thank all of you, and especially my supervisory team; Benjamin Sprecher and Heidi Carelsberg for guiding me throughout this process, providing me with valuable feedback, guidance and lessons that will stick to me for the remainder of my career and life.

Furthermore, I would like to thank my IDE-family who supported me during coffee breaks, sparring sessions and reflections that helped improve the overall designs.

Lastly, I would like to express my gratitude for the inhabitants of Carnisse, and many great initiative-leaders who are situated there. A special thanks to Evelyne Hofman, who gave me a tour through the neighbourhood and showed all of Carnisse's beauty and hospitality. By breaking my bubble, you expanded my world and made all the difference in my research.

You all helped me a great deal, and this thesis would not have been possible without you!

I would like to end this preface with the following quote, which will serve as a guide- and lifeline for my future work:

> *Some people find it classy, tough, and impressive to use fancy words, but it's actually tough, an art, and a gift to use words that reach as many people as possible.*

- Rosetta Leiendecker

I hope you enjoy reading the thesis as much as I enjoyed making it.

Best regards,

Abstract

Addressing climate adaptation is one of Rotterdam's critical challenges as it seeks to achieve a fully circular economy by 2050. However, language barriers and limited literacy levels, particularly in neighbourhoods like Carnisse, prevent many residents from engaging in the city's climate initiatives. This thesis explores the potential of Augmented Reality (AR) as an innovative tool to bridge these communication gaps, making complex Circular Economy (CE) principles more accessible by increasing engagement, comprehension and making the experiences more memorable for residents with lower levels of literacy.

Using the Delft Innovation Method (DIM), this design research iteratively develops and tests two AR prototypes to assess AR's effectiveness in increasing comprehension, engagement, and retention among residents of Carnisse. Apart from the DIM, a mixed-method approach was utilised, including literature reviews, stakeholder interviews and observations. The first prototype translates a municipal website that explains CE-principles into an AR experience, and thus aims to establish whether the technology is suitable for use in Carnisse. The second prototype, The Digital Sustainability Tour, leverages learned lessons from the previous prototype to improve, and expands the scope and generalises the findings to another neighbourhood with a similar profile.

Results from A/B testing and community feedback suggest that AR has the potential to enhance user engagement and understanding compared to traditional text-based methods. Based on these findings, this thesis proposes three strategies that align with municipal goals and capabilities, in which AR can be leveraged effectively to: Improve Communication via Inform & Remember, Increase Participation via Analyse & Apply and lastly enhance self-efficacy via Evaluate & Co-Create. These strategies aim to foster a more inclusive dialogue and empower inhabitant to participate in sustainability efforts.

Glossary

One of the main themes of this report is **communication**, particularly how it can be tailored for individuals with lower levels of literacy. Despite this focus, the report delves into complex terminology, societal issues, and linguistic concepts. To make sure clarity and accessibility are still respected, key terms have been defined and listed below.

Delft Innovation Method (DIM): Design Method developed by Jan Buijs (2012), in which the innovation process is simplified as a circular and continuous loop. The method consists of five phases which merge into each other. Respectively these phases are named: *Product Use, Generate Search Areas, Generate Product ideas, Develop Product* and lastly *Introduce*. The method was conceived to help designers innovate in rigid corporate structures, and helps to structure and communicate the design process.

Circular Economy (CE): The CE refers to a regenerative system in which resources input and output, emissions, and leakage of energy are minimised by slowing, closing and narrowing material streams and energy loops (Geissdoerfer et al., 2017). This can be achieved with the R-strategies which respectively are Refuse, Rethink, Reduce, Reuse, Repair & Maintain, Refurbish, Remanufacture, Repurpose, Recycle and lastly Recover.

Sustainability: The concept of Sustainability refers to the balance between economic performance, social inclusiveness and environmental resilience (Elkington, 1998), to the benefit of current and future generations (Geissdoerfer et al., 2017, Keeble, 1988).

Sustainist Culture: A cultural framework stemming from books like *Sustainism is the new Modernism* (Elffers & Schwarz, 2011) and *Sustainist Lexicon* (Schwarz, 2016) that emphasizes the vocabulary and values needed to promote a sustainable society. It integrates social values such as placemaking, connectedness, locality, commons, circularity proportionality and co-design, locality, guiding towards community-oriented, environmentally responsible, and ethically grounded ways of living.

Boundary Object: A term coined by Star & Griesemer (1989) and is utilised for concepts that can be used by heterogenous parties to cooperate towards the same goal. Like how Sustainability and the Circular Economy are two concepts that strive towards environmental sustainability, but often have supporters from different political wings.

Immersive Technologies: The umbrella term for technologies that expand reality via immersive stimuli in the form of Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR).

Augmented Reality (AR): An Immersive Technology that overlays digital content onto the real-world environment via a smart device, enhancing user interaction.
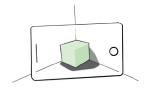
Virtual Reality (VR): A fully immersive experience where users are placed in a completely virtual environment. The technology is often used in the videogame industry, but can also be found in education. A headset is required for the experience.

Mixed Reality (MR): A blend of the real, augmented and virtual worlds, where physical and digital objects coexist and interact in real-time. An example of this is the new Apple Vision Pro.

Digital Twin: A digital counterpart of a real object. Currently trending in city planning, as a digital twin can be used to simulate potential real world scenario's and interventions to see their implications. Digital Twins also pose opportunities for enhanced participation, as inhabitants can be immersed in new plans which helps with imagination.

Self-Determination Theory (SDT): A psychological theory that suggests human motivation is driven by the need to satisfy three psychological needs: autonomy, competence, and relatedness. Autonomy refers to the need to feel in control of one's actions; competence refers to the need to be effective and skilled in tasks, and lastly relatedness is the need to connect with others. According to SDT, satisfying these needs fosters intrinsic motivation, personal growth, and well-being.

Wantivation: A form of motivation where internal pressures like interest and enjoyment drive behaviour. Typically resulting in want-to-do tasks. It is driven by satisfaction.

Mustivation: A form of motivation where external pressures or obligations drive behaviour, typically resulting in "must-do" tasks. Unlike intrinsic motivation, which arises from personal interest or enjoyment, mustivation is often fuelled by external rewards, deadlines, or social expectations.

Bloom's Taxonomy: A framework originally developed by Benjamin Bloom in 1956, in which learning objectives are placed in a pyramid. The Taxonomy underwent some changes in the last decennia, yet the most modern version goes from top to bottom as follows: Remember, Understand, Apply, Analyze, Evaluate and lastly Create. This taxonomy is widely used by teachers to support deep learning and critical thinking.

Cognitive Load Theory: A theory from psychology that states that the human brain has a limited capacity for processing information at one time. And when the brain is overloaded with complex, unstructured and excessive information, learning and decision making can become difficult. According to the theory, Cognitive load can be dissected in: Intrinsic Load, Extraneous Load and lastly Germane Load.

Intrinsic Load: This relates to the complexity of the information itself.

Extraneous Load: This relates to the extra distracting elements that do not necessarily contribute to the understanding of the information, basically noise.

Germane Load: This relates to the extra information that helps structuring the information. These can be supporting visualisations or infographics for example.

Situated Learning: A learning theory based on the work of Jean Lave & Etienne Wenger (1991) that argues learning occurs most effectively when embedded in a relevant, real-world context (Brown et al., 1989; Clancey, 1995).

Multimodal Learning: An instructional approach that integrates multiple modes of learning, such as visual, auditory, and kinesthetic. By engaging various senses, multimodal learning accommodates different learning styles, often leading to improved retention and understanding.

Constructivist Learning: Based on the constructivist theory by Jean Piaget, this approach views learning as an active process where learners construct new knowledge by connecting it to prior experiences. Learning is thus personalized, meaning-making, and exploratory, with an emphasis on problem-solving and critical thinking (Dunleavy & Dede, 2013).

Table of Contents

01

Introduction

This chapter introduces the thesis and gives necessary background information on the situation in the Netherlands, and more specifically Rotterdam Carnisse, within the realm of communication, sustainability and the CE. Afterwards, the problem is defined, and an overview of the project is given.

In this chapter:

1.1 Background

Language is everything. Everything we can imagine, build and design has come from somewhere, and that somewhere most likely started as an idea. That idea was shared with others, and together people were able to turn that idea into reality.

Language, through words, letters, and sounds, has long shaped our path to success and innovation. For many people however, access through this path is not as simple, as evidenced by alarming literacy rates. In the Netherlands, 18% of the population is struggling with lower levels of literacy (Stichting Lezen & Schrijven, 2024). And if we zoom in into Rotterdam's Charlois (in which Carnisse is located), this number is almost doubled to 34% (CINOP, 2018; CBS, 2023) . Apart from the challenges regarding literacy, Charlois struggles with lower-income levels as well (Allecijfers, 2023).

According to Hart & Risley (2003), these phenomena are related. As observed in their "30-million-word gap", children from lower-income households are exposed to 30 million fewer words by age three than their higher-income peers, resulting in limited literacy and reduced opportunities from an early age. As Tim 'S Jongers highlights in Poverty Explained to People with Money, these barriers reinforce social divides, driving a wedge in our society.

Additionaly, this literacy gap makes conversations around complex issues like climate adaptation inaccessible for many. In Carnisse, residents' opinions are often overlooked because they are seen as "uninformed" or "unlikely to contribute." This perception denies them a voice in discussions that impact their neighbourhood and limits not only comprehension but also active engagement in sustainable initiatives.

Today in the Netherlands, challenges like rising polarization (Ministerie van Volksgezondheid, Welzijn & Sport, 2022), the housing crisis (Mouissie & Kraniotis, 2023), and climate adaptation (Rijksoverheid, '2020) have become critical issues. While this project focuses mainly on climate adaptation, it is important to note that all three issues affect both socio-economic and environmental domains. Tackling such interconnected, "wicked" problems requires a careful balance, as changes in one area influence the others (Dorst, 2019). Addressing climate adaptation, for example, presents particular challenges for Carnisse residents. Sustainable products often carry premium prices due to their added social and ecological costs, which limits accessibility (Ingenbleek, 2015). At the same time, responsibility for climate adaptation is shared across multiple stakeholders, making collective action difficult and resulting in a diffusion of responsibility (Przepiorka, 2018). This is further complicated by low levels of trust in government entities to deliver on sustainability- (Gadenne et al., 2011) as well as social commitments, leading to the fact that residents feel unheard (Hoogenboom , n.d.) (Van der Goot, 2024). Declining ecological literacy further boosts this issue, as diminished connections with nature reduce sustainable behaviour (Hempel, 2014, Hilmi et al., 2021).

These barriers make discussions about climate adaptation overwhelming, hindering efforts to promote sustainable behaviours (Fraune & Knodt, 2018; Tranter, 2013), as inhabitants feel it is not worth the hassle.

To get back to the literacy gap that was identified in the previous section and its relation to climate adaptation, it is important to get an understanding of Rotterdam's agenda and vision regarding the topic. Rotterdam has committed to the ambition of becoming a Circular Economy by 2050, and as a leap in the right direction they aim to be 50% circular by 2030, which is soon (Rotterdam, n.d.). Yet these plans, and the expectations the municipality has from their inhabitants, are mostly communicated in text-based media.

This combination of challenges that Carnisse faces fuel the fire of miscommunication and frustration. The 34% that struggles with literacy are indirectly excluded from the conversation about climate adaptation, since the language surrounding sustainability and CE is unnecessarily complicated. Furthermore, there are so many definitions, that engaging with this topic can be extremely daunting (Bulten et al., 2021; Segrave, 2014). This is alarming, because this means a third of Carnisse's population cannot share their voice and opinion, and is that truly democratic?

1.2 The Problem Definition

Based on the background information, one would wonder if there might be a way to simplify communication between the municipality and its inhabitants. This project starts from a desire to do just that, and use Augmented Reality (AR) to make information about sustainability and CE principles more accessible to lower-literate residents in Carnisse. By visually bridging communication gaps, AR could be a valuable tool in the communication arsenal of the municipality, to activate a large portion of their inhabitants to participate.

In past researches, AR has already shown potential to simplify complex topics, especially benefiting users with lower levels of prior knowledge (Katika et al., 2022). This project aims to make climate adaptation a more inclusive dialogue, and is guided by the following research question:
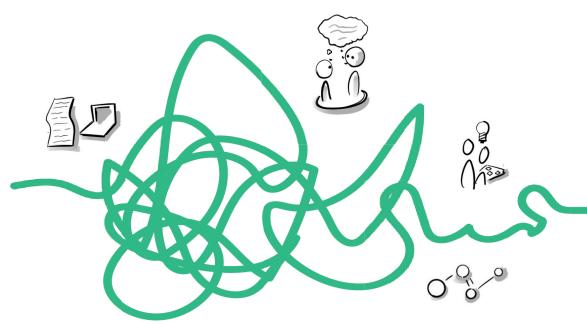
// Can **Augmented Reality** be used to make **Circular Economy Principles** more *engaging*, *comprehensible* and *memorable*, to the households of **Carnisse**? ****

1.3 Project Overview

This thesis spans over both the Integrated Product Design (IPD) and Strategic Product Design (SPD) Master's. To distinguish in what parts of the thesis each discipline contributed to the process, an overview sketch has been made (Figure 1). SPD mostly guided the fuzzy front end, as well as the development of the future directions and strategies, while IPD mostly contributed to the embodiment phase in which concepting, prototyping and testing were most important.

The project kicks-off with a contextual analysis to identify the problem area. This contextual analysis is built on a literature review, interview insights and a stakeholder analysis.

Afterwards, an AR prototype has been designed in the embodiment phase to "probe" the Inhabitants of Carnisse and test if the technology is suitable for the neighbourhood. Based on this information, the design has been improved and a new iteration was designed. This

Fuzzy Front End

Contextual Analysis
SPD

Figure 1: Project Overview Sketch
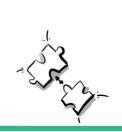
iteration aimed to facilitate a more direct connection between the inhabitants and the municipality.

All the insights gained from the project were distilled in three strategies that can give the municipality direction in creating their own Immersive Experiences to communicate sustainability and CE principles.
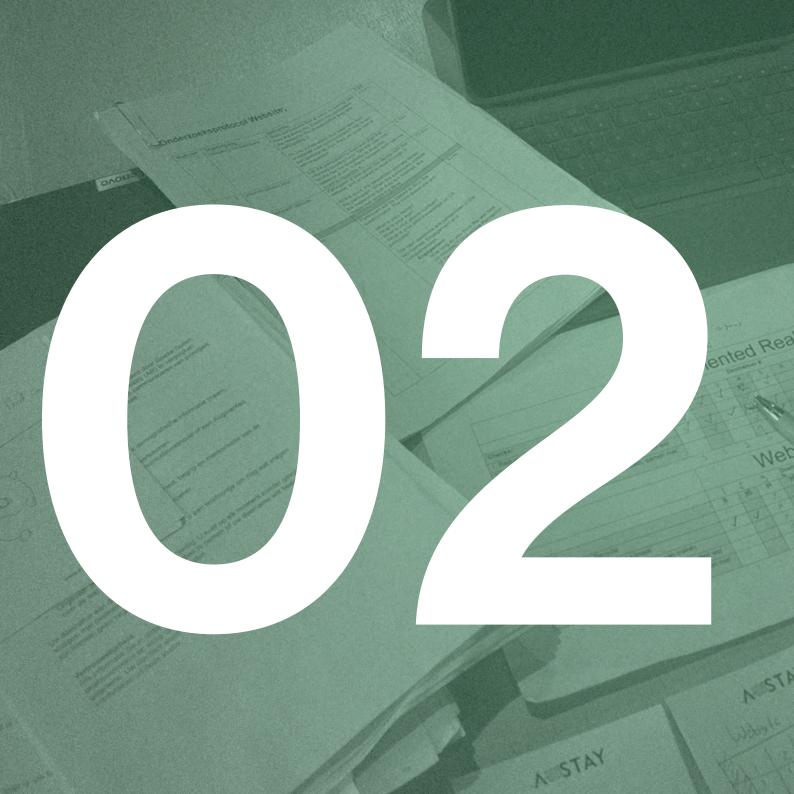
Embodiment Design

Concept-, Prototyping- and Testing
IPD

Strategic Development

Developing Future Vision and Roadmap
SPD

Design- and Research Method

In this chapter, the chosen Design Methodology, Research Questions and employed Research Methods will pass review. For the Design method, the Delft Innovation Method by Jan Buijs (2012) was chosen. For the Research Method, a mix of a Literature Review, Stakeholder Analysis, A/B-tests and Qualitative Interviews were employed.

Before delving deeper into the project's leading question and research method, a light will be shed on the design method that guided this project.

In this chapter:
2.1 Design Methodology
2.2 Research Question- and Method

2.1 Design Methodology

Jan Buijs jokingly said that he serendipitously got infected with the "innovation virus" in 1974. To synthesise his journey, Buijs wrote the Delft Innovation Method as "*his memoirs with a twist*". The developed method reflects his 35 years of helping, learning and teaching to create & innovate in corporate settings.

For this graduation project, the Delft Innovation Method developed by Jan Buijs (2012) will be employed. This iterative method is developed for corporate innovation on both product and service level. An overview of the original method can be seen in Figure 2 below, and the method is signified by its iterative loop. As Buijs notes: "The innovation process is not linear, it is circular and ever continuous". A "product" is never finished and can always be improved.
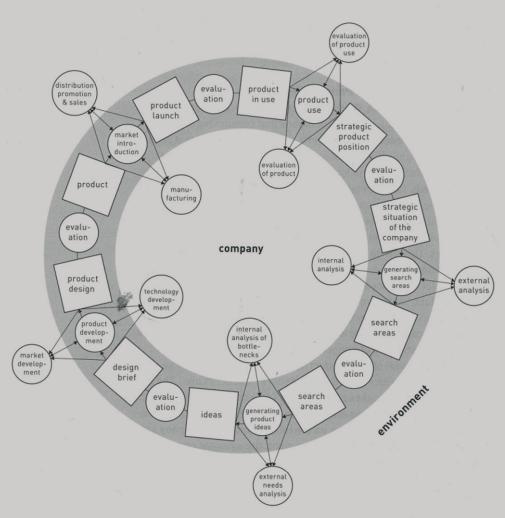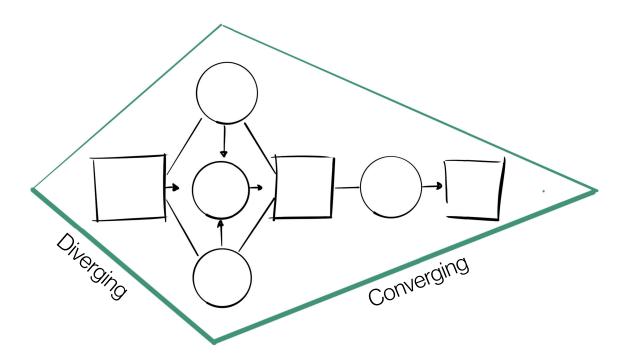
Figure 2: Delft Innovation Method (Buijs, 2012)

Apart from the continuous cycle, the individual phases are conveyed in a Diamond-like shape that diverges and converges, resembling the classical Double Diamond Design process (IDEO, n.d.). Figure 3 illustrates this with an isolated "bit" of the method. This approach ensures that new possibilities are explored while a clear scope and focus are maintained.

Figure 3: Isolated "Diamond-like" bit of the DIM

Jan Buijs' method is crafted with a quick-to-market strategy in mind. Iterations should be validated as soon as possible, to gather valuable feedback early in the design process. As a result, a slight adjustment was made to the method, where each phase is ended with either an experiment, MVP or Prototype. Figure 4 shows a visual interpretation of the adjusted method, in which the quick-to-market strategy is highlighted with a drawing of a vehicle that evolves with each phase.

This analogy is meant to represent the following anecdote in green from the book "Art & Fear" (Wix, Bayles & Orland, 1998).

In a nutshell, the steps of the adjusted DIM are summarized below.

1. **Deconstruction | *Product Use I*:** Analyse current communication methods through desk research, stakeholder interviews, and small experiments.
2. **Scoping | *Generating Search Areas:*** Translate identified needs into search areas for directed ideation.
3. **Ideation | Generating Product Ideas:** Develop various ideas which can be tested and validated.
4. **Conceptualisation | *Product Development:*** Further develop and test the best-suited concept.
5. **Introduction & Distribution:** Test the refined communication concept with a larger sample of the target audience
6. **Validation | *Product Use II*:** Assess and reflect on the concept's impact on the research question.

> " A pottery teacher has two classes and decides to host a little competition. Students from class A are tasked to deliver a single pot at the end of the month, a "masterpiece" so to say. Students of Class B are tasked to build a pot every single day, until the month is over. At the end, the teacher looks at the pots from Class A and B, and notices that class B has booked significant progress in skill and craftsmanship, due to the fact they iterated rapidly and learned from their mistakes. "

2.1.1 Rationale behind the DIM

The municipality of Rotterdam operates as a large, hierarchical organization with a corporate-like structure, which can introduce political and bureaucratic challenges that slow down innovation. The DIM is particularly well-suited for navigating such environments because it provides a structured, iterative approach that encourages creativity within rigid, siloed settings. This makes DIM an ideal fit for engaging with the municipality, as it aligns design's dynamic and iterative nature with the municipality's need for order and accountability.

Where design can be unpredictable and exploratory, corporate and municipal structures prioritize clear steps and defined outcomes. DIM offers a framework that anchors the design process, organizing thoughts, ideas, and concepts in a way that fosters collaboration with stakeholders.

By establishing a shared language, structuring decisions logically and managing expectations, the DIM supports alignment between designers and municipal representatives, facilitating communication and transparency throughout the innovation process.
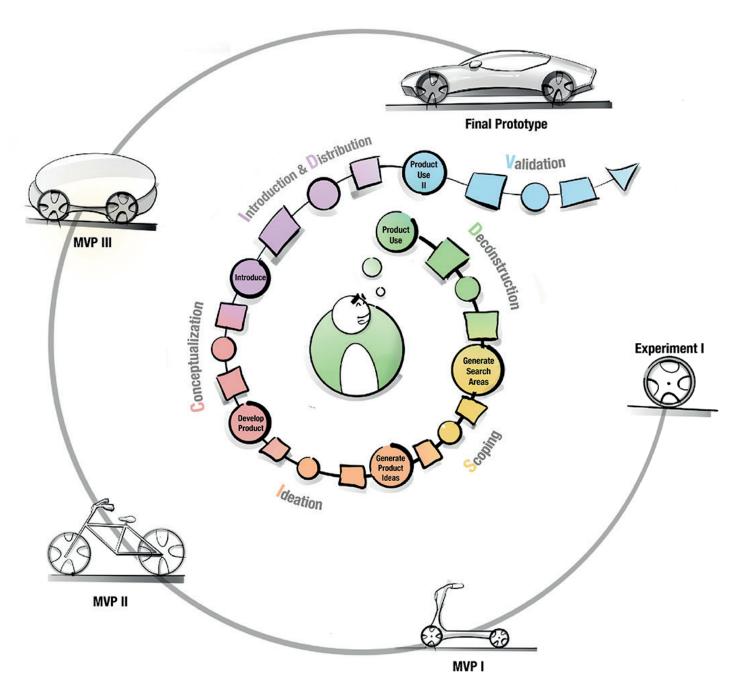
Figure 4: Adjusted DIM

2.2 Research Questions & Methods

In this section, the research questions and methods used to address them are outlined. The goal of this research is to evaluate whether AR serves as an effective medium for communicating CE principles to households in Carnisse. To assess this, two prototypes were developed and tested in sequence.

The first AR prototype was tested against a municipal website, with both evaluated based on engagement, comprehension, and memorization by Carnisse residents. This initial test aimed to validate AR's effectiveness as a communication tool.

Based on insights gathered from the first test, a second prototype was developed and tested in both Carnisse and Leidschendam. Testing across these neighbourhoods with similar profiles allowed for an assessment of AR's broader applicability and effectiveness.

The main and sub-research questions, along with their corresponding methods, are presented in the following sections to provide a structured overview of this study.

2.2.1 The Main Research Question

The main research question and hypothesis for this study are:

RQ: Can **Augmented Reality** be used to make **Circular Economy Principles** more *engaging*, *comprehensible* and *memorable*, to the households of **Carnisse**?

H1: *Augmented Reality can be implemented to improve communication in the domains of comprehension, engagement and memorisation to the inhabitants of Carnisse. Due to AR's immersive nature, it has the power to simplify abstract subjects and turn them into experiences, which will be stored in long-term memory.*

2.2.1.1 Methods for the Main Research Question

As stated in the introduction of this section, two prototypes have been developed and tested. These will be explained with their corresponding method, to start, the first prototype method will be shared.

Prototype 1: AR Website Translation

The first prototype was a translation of a municipal website that explained the Circular Economy. For this prototype, a visual interpretation of a municipal website has been developed which contains the same information. However instead of text, this information is provided through a voice-over and visual support that suits the 3D-AR environment. This prototype was compared to the website through an A/B-test, where levels of engagement, comprehension and memorisation were compared between two groups, one with the website and one with the AR experience.

For this study, these three principles were defined in the following way:

- **Engagement:** According to Attfield et al., the definition of user engagement is the emotional, cognitive and behavioural connection that exists, at any point in time and possibly over time, between a user and a resource (2011). The question is thus to find out to what extent the participant feels engaged to whatever they have experienced.

- **Comprehension:** To what extent is the participant able to understand and recite that what they experienced?

- **Memorisation:** To what extent is the participant able to memorise that what they experienced, and how much of that can they recall later (+/- 14 days after the experience)?

Sampling Strategy

Participants were recruited via purposeful sampling strategies from Patton (2014). The goal of this research was to find out whether AR is suitable for use in Carnisse. As a result, the sampling strategies have been chosen for their ability to get an understanding of group characteristics, so an apt and generalisable conclusion could be made (Patton, 2014). The specific strategies used are shared to the right:

- **Typical Case Sampling:** The average inhabitant of Carnisse will be recruited to get an idea of what works for a typical resident. These participants were found in public spaces (Zuidplein Library and the Amelandseplein) and at events organised by Gouwe (KI)ouwe.

- **Key informant sampling:** Key figures from the neighbourhood were asked to participate and contribute as well. These key informants are the initiative takers of Gouwe (KI)ouwe & Zuidplein Librarians due to their connection with the inhabitants of Carnisse, and insider knowledge on the neighbourhood.

02 | Design- and Research Method

Sample Size

A comparison was made between the existing website of the municipality and the AR translation, and as a result two groups needed to be tested. A total of 16 participants have been asked to participate, equally divided between these two groups (Control Group A: 8 participants, AR Group B: 8 participants).

The sample size was chosen due to feasibility reasons. While a larger sample size would greatly benefit the rigor and validity of the research, time constraints made this difficult. By taking a lean approach, the sample size was smaller, but the feedback and input gathered in this test were implemented in a second prototype. This prototype has been tested again to have a swift iteration loop that improved the overall concept. Next to that, this study is indicative and explorative by nature, and can thus be used to lay the foundation for future, larger quantitative research.

Method

At first, recruits were asked to fill in a consent form, of which an empty version can be found in Appendix B. Next, participants were tasked to go through either the municipal website (Group A) or the AR Translation (Group B). Afterwards, both groups were given the same questionnaires, which can also be found in Appendix B. The participants were then asked to rate the media they went through on Engagement via Likert scales and a Subjective Perception of Time test (SPT-test), Comprehension via open ended questions and Retention through a call at +-2 weeks after exposure. For this, participants had to leave their phone number.

The answers of the questionnaire were compared, and differences in perceived Engagement, Comprehension and Memorization were noted. A more detailed experiment protocol can be found in Appendix C. Next to that, Figures 5 & 6 provide a situational sketch of what the experiment looked like for Group A and B.

Figure 5: Overview sketch of Group A Setup

Materials

The tests were be based on information gathered from the website of the Municipality of Rotterdam. More specifically, the information is based on the following webpage;

🌐 Wat is een Circulaire Economie?

This webpage has been chosen because the following themes were mentioned, which are considered CE principles for this study:

- Why a Circular Economy is necessary?
- Why a greener Rotterdam is desirable?
- What can we do with waste?
- Reuse, Reduce & Recycle
- Rethinking the System in a piecewise manner

All the materials that were used in this A/B test are listed in Table 1.

Control Group A	AR Group B
Questionnaires on paper	Questionnaires on paper
iPad to engage with website	iPad to engage in AR environment
Stopwatch app on phone	Stopwatch app on phone
Voice recorder on phone	Voice recorder on phone

Table 1: List of Materials for the A/B test, categorised per group
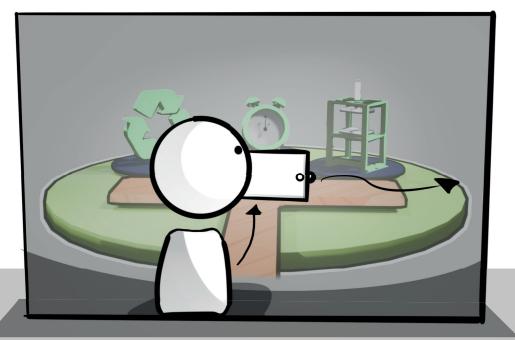
Figure 6: Overview sketch of Group B Setup

Prototype 2: Digital Sustainability Tour

Building on insights from the first prototype, this second version, The Digital Sustainability Tour, was developed. The Digital Sustainability Tour aims to test AR's ability to communicate CE principles across neighbourhoods with similar demographics. To achieve this, participants from Carnisse and Prinsenhof were recruited via purposeful sampling.

Sampling Strategy

Same as with Prototype 1: AR Website Translation, Participants have been recruited via purposeful sampling strategies from Patton (2014). Yet due to time constraints only **Typical Case Sampling** (Section 2.2.1.1: Sampling Strategy) was utilised.

Sampling Size

To validate, a total of 10 participants were recruited, evenly distributed between Carnisse and Prinsenhof. This size was, again, chosen due to the time constraints and limitations of the project. In future studies, it would be beneficial to test reception with a larger sample size, to further enhance the rigor and validity of the research.

Methods

After consent (Appendix D), participants will engage with the new AR prototype; "The Digital Sustainability Tour" and then participate in open-ended interviews and loosely structured discussions, which are guided with the Reflectionnaire (Appendix K). This qualitative approach captures insights on participants' engagement and understanding of the experience. These insights will be used to triangulate AR as a communication tool in neighbourhoods with a similar profile, like Carnisse and Prinsenhof.

Figure 7 shows an overview sketch of the test environment.

Materials

The updated AR prototype has been designed to provide a Digital Sustainability Tour that immerses participants in sustainability concepts. The interviews and questions afterwards will focus on capturing participants' reflections on the experience, aiming to uncover whether AR can be generalised between neighbourhoods with a similar profile.

The full test protocol can be found in Appendix J, and to make the questions more engaging / exciting the participant is given the "reflectionnaire" which can be found in Appendix K.

The list of materials used for this validation test is:
• Consent Form (Appendix D)
• iPad to engage with the Experience
• Reflectionnaire on paper (Appendix K)
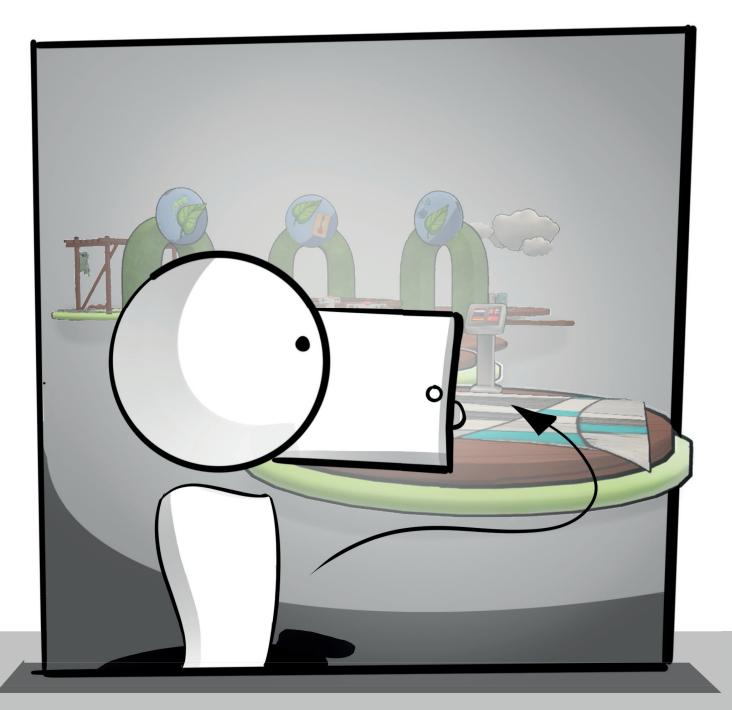
Figure 7: Overview sketches of setup for The Digital Sustainability Tour

2.2.2 Sub Research Questions & Methods

Before answering the main research question, it is essential to build a foundation of knowledge and theory. Understanding how AR can assist Carnisse residents with CE principles requires insights into Sustainability, the Circular Economy, Rotterdam and Carnisse's context, as well as AR's strengths and weaknesses in municipal and sustainability communication. As a result, the following Sub-Research Questions (SRQ's) were formulated.

SRQ 1: What makes sustainability & the Circular Economy such difficult concepts to grasp for inhabitants of Carnisse?

Method;

A literature review in which the Circular Economy, Sustainability and its inherent differences will be reviewed is conducted. Relevant literature on the origins of both concepts will pass review. And the political context of both concepts will be touched upon. Next to that, a light will be shed on what makes the concepts so elusive.

This can be read in Chapter 3.1.

SRQ2: What are the current communication strategies of Rotterdam, and how do these connect with the inhabitants of Carnisse?"

Method;

Stakeholder interviews will be conducted with municipal officials from Rotterdam, experts from Rotterdam Circular, and Inhabitants & initiators from Carnisse. To understand the connection between the inhabitants and the municipality, the community will be "infiltrated". The following strategies will be used to achieve this:

This can be read in Chapter 3.2.

● *Recruitment via Virtual Network Sampling and Snowball Sampling Strategies:* Using LinkedIn and other social networks to connect with key individuals within the municipality and the Carnisse community. Initial contacts will help expand the network through referrals (snowball sampling).

● *Interviews and Focus Groups:* Conducting semi- structured interviews and focus groups with municipal officials, community leaders, and residents to gather insights on current communication methods, challenges, and preferences.

● *Participant Observation:* Engaging in community activities and municipal meetings to observe and understand the dynamics, needs, and challenges from both a top-down and bottom-up perspective.

SRQ3: Why can AR be implemented successfully (or not) within the domain of municipal communication, and what are important considerations when crafting a novel AR experience?

Method;

A brief historical analysis of Immersive Technologies will be reviewed. Afterwards, a literature review on AR and its inherent strengths in the domain of communication and education will be explored. Then, academic case studies that utilised AR in the domain of communication, education and sustainability will pass review. Lastly, experts are interviewed to share their views on AR's use in a municipal setting.

This can be read in Chapter 3.3
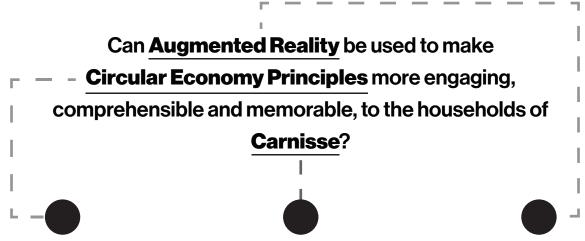
2.2.3 Overview of Research Questions

The Sub-Research Questions are used to build a strong foundation that grounds the main research question in academic research. Figure 8 shows an overview of this relation.

Chapter 3 will explore each Sub-Research Question in detail, providing the background necessary for Chapter 4, which examines the prototypes and presents the study's results.

Can **Augmented Reality** be used to make **Circular Economy Principles** more engaging, comprehensible and memorable, to the households of **Carnisse?**

What makes sustainability & the Circular Economy such difficult concepts to grasp for inhabitants of Carnisse?

What are the current communication strategies of Rotterdam, and how do these connect with the inhabitants of Carnisse?"

Why can AR be implemented successfully (or not) within the domain of municipal communication, and what are important considerations when crafting a novel AR experience?

Figure 8: Overview of foundation for the Main Research Question

The Context; laying the foundation

Building on the research questions and methods outlined in *Chapter 2*, this chapter provides the academic and theoretical groundwork needed to address the main research question. Here, the Sub-Research Questions are explored in depth, with each section designed to clarify the core concepts and challenges of the study.

First, this chapter examines the origins of sustainability and the CE, and discusses the concepts within the context of climate adaptation, language and politics. By dissecting the multi-faceted nature of these concepts, this section will highlight the complexities and potential barriers that arise when communicating these ideas to diverse audiences, setting a common foundation for understanding.

Next, the current sustainability goals and communication strategies used by the municipality of Rotterdam are closely analysed to identify potential misalignments or areas where communication with Carnisse residents may fall short. This review provides insights into the existing challenges and opportunities for improvement within the municipal machine.

Finally, the potential of immersive technologies, specifically AR, as a tool for enhancing communication and learning is evaluated. Beginning with a brief historical analysis, this section explores AR's unique strengths and limitations in communication and education, complemented by an analysis of relevant case studies. Expert interviews provide further insights into AR's applicability within a municipal setting.

Together, the insights from this chapter will support the design of an innovative AR communication concept aimed at conveying CE principles to Carnisse residents in an engaging, comprehensible, and memorable way.

In this chapter:
3.1 The Evolution of Sustainability & the CE
3.2 Communication between the Municipality & Carnisse
3.3 Immersive Technologies and their potential
3.4 Synthesis: Connecting the Dots

3.1 Background

In December 1968, astronaut William Alison Anders captured a historic image during the Apollo 8 mission:" Earthrise". For the first time, humanity saw Earth from space, a fragile sphere floating in the pitch black depths of space.

3.1.1 Defining Sustainability; from Forestry to Frameworks

There is a lot of speculation and ambiguity surrounding the definition of sustainability. Scholars have proposed various definitions of sustainability, with estimates of over 300 interpretations (Johnston et al., 2007). From this, an abundance of concepts ranging from quantitative models like the IPAT equation (Commoner, 2020, Holdren & Ehrlich, 1974) and the Planetary Boundaries (Rockstrom et al., 2009), to more systemic approaches like the Cradle-to-Cradle (McDonaugh & Braungart, 2009) and Resilience theory (Holling, 1973) emerged, making Sustainability difficult to grasp from a uniform perspective. This abundance and variety in lenses further add to the complexity, making them difficult to address for the untrained.

Even though there is a plethora of explanations and lenses, the origin is clear. The word stems from the French verb "Soutenir", which translates to: "to hold up or support" (Brown et al., 1987). The word can be found in forestry and is based on the silvicultural (= the art and science of managing forests and woodlands) principle that the amount of wood harvested should not exceed the volume that grows again (Geissdoerfer et al., 2017). This definition goes back to the 18th century, where it can be found in the "Sylvicultura Oeconomica" (von Carlowitz, 1713).

At its core, sustainability focuses on maintaining balance, a concept that would later evolve into the more encompassing framework of "Sustainable Development," famously defined by the Brundtland Commission as meeting the needs of the present without compromising the ability of future generations to meet their own (UN, n.d.; Keeble, 1988).

"Earthrise" symbolised a turning point, sparking global awareness of Earth's vulnerability and inspiring the early environmental movement, and is often cited as having led to Earth Day (BBC, 2023). It serves as a powerful visual reminder that we are rather lonesome in space, urging us to rethink the way we do things, if we want to maintain our Earth.

The Golden Standard

Today, sustainability is commonly visualized through the "Triple Bottom Line" (Elkington, 1998), which balances social, environmental, and economic factors. This framework (Figure 9) evaluates organizational activities based on their social, environmental, and economic impacts, striving for long-term viability and meeting in the middle all three dimensions, ergo; **Sustainability**.
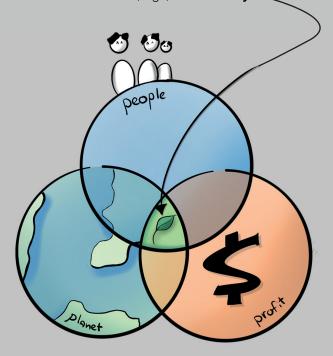
Figure 9: The Triple Bottom Line by Elkington (1998)

3.1.2 Behold, Spaceship Earth

Two years before "Earthrise," economist Kenneth E. Boulding introduced the Circular Economy concept in The Economics of the Coming Spaceship Earth. Boulding argued that Earth's resources are finite, with no "new frontiers" to exploit. As a result, he proposed a closed-loop system where waste becomes the feedstock for new production, a vision that would later shape modern Circular Economy principles.
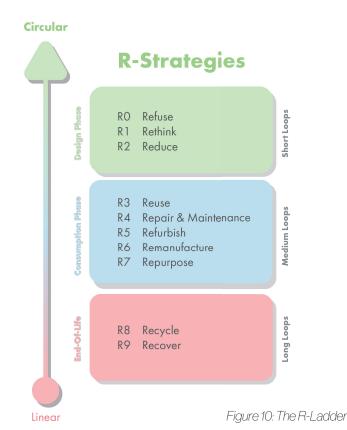
Building on Boulding's ideas, Pearce and Turner (1989) and the Ellen MacArthur Foundation (2013) developed the Circular Economy into a framework that emphasizes resource cycling and regeneration. This approach differs from sustainability by focusing on the logistics and business models that enable a regenerative economy. The Circular Economy encourages local resilience, resource optimization, and closed-loop systems to create a sustainable economic model.

Defining the Circular Economy; from open- to closed Earth
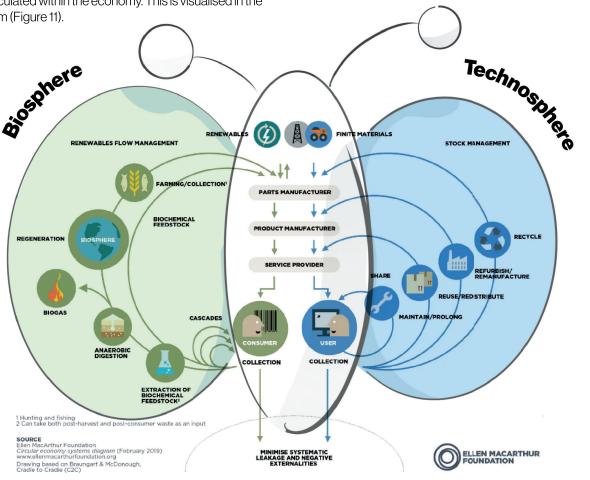
The Circular Economy employs a plethora of strategies to achieve the aforementioned local resilience and resource optimisation. These key strategies are:

The R-ladder: This framework (Figure 10) consists of 10 words that start with the R: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and lastly Recover. The green words are the most circular, and thus can have the most influence on emissions, as they heavily influence the design phase. The blue words influence the use phase, and can be used to lower emissions here. The red words are recapturing value at the end-of-life phase, and have the lowest potential.

R-Strategies

Design Phase		Short Loops
R0	Refuse	
R1	Rethink	
R2	Reduce	

Consumption Phase		Medium Loops
R3	Reuse	
R4	Repair & Maintenance	
R5	Refurbish	
R6	Remanufacture	
R7	Repurpose	

End-Of-Life		Long Loops
R8	Recycle	
R9	Recover	

Circular

Linear

Figure 10: The R-Ladder
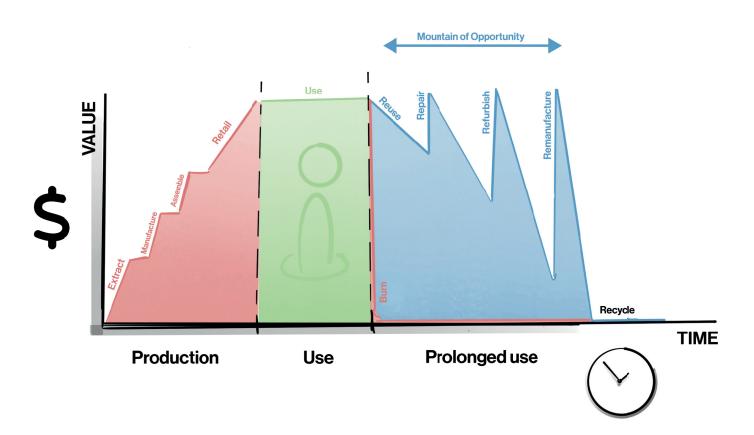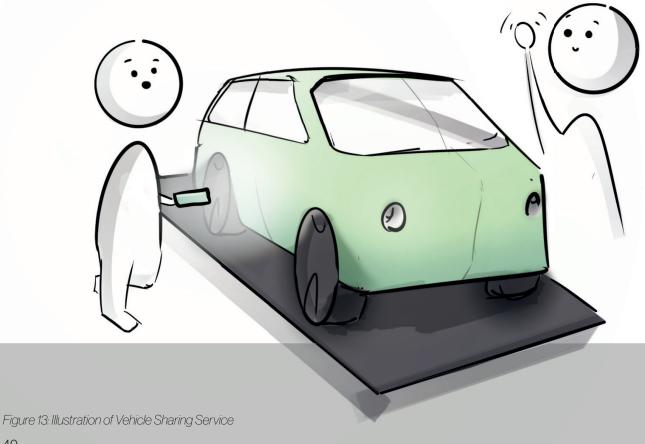
Closing the Loop: Instead of viewing materials as disposable, the Circular Economy emphasizes the importance of reusing, recycling, and repurposing resources to create a closed-loop system. This means designing products and systems with Durability, Reparability, and Recyclability in mind, and ensuring that materials can be continuously circulated within the economy. This is visualised in the Butterfly Diagram (Figure 11).

Figure 11: The Butterfly Diagram (EMF, 2013)

Resource Optimization: The way materials and resources are currently managed need to be rethought. Resources cannot be disposed at the current rate. The CE aims to increase Durability and Recyclability of products. Next to that, the CE vouches for renewable materials and energy, thus minimising environmental impact while maximising value. The CE visualizes this in the Value Pyramid (Figure 12).

Figure 12: The Value Hill

Shifting to Service Models: Another spearhead of the CE is the transition from a product-based to a service-based economy. Instead of owning products outright, consumers access goods and services through sharing, leasing, or subscription models. This not only reduces the demand for new products but also incentivises manufacturers to design products for longevity and durability, as they retain ownership of that what they produce, and are benefitted with longevity, instead of the other way around. A common example is a vehicle sharing service (Figure 13).

Figure 13: Illustration of Vehicle Sharing Service
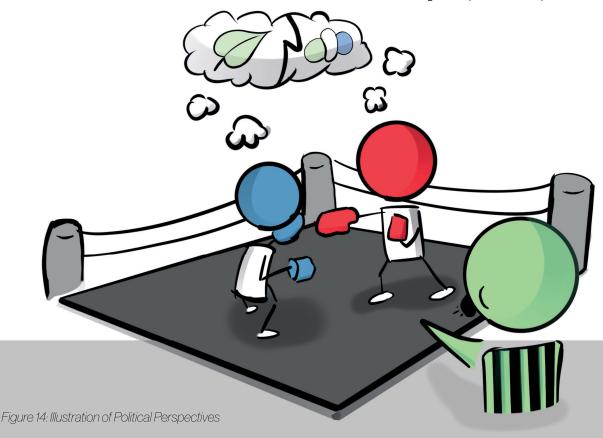
3.1.3 Political Perspectives

It is no coincidence that "Sustainability" often appears on the left of the political spectrum, while the CE tends to resonate more with the right. These frameworks essentially convey the same message, striving for an ecologically stable future, but differ in approach. Generally, left-leaning ideologies align with sustainability through abstract, aspirational goals that emphasize social well-being, equity, and environmental conservation. For many leftists, sustainability supports a vision that tackles inequality and fosters community resilience (Hopwood et al., 2005). However, the term itself can be paradoxical, implying "sustaining" something, when, in fact, it involves efforts to improve current environmental and social systems (Jasanoff, 2010).

In contrast, right parties often frame sustainability through the lens of economic potential. This perspective emphasizes efficiency, profitability, and a "circular" approach to resource management, which combines environmental concerns with a market-driven focus (Geissdoerfer et al., 2017). The CE concept aligns with the emphasis of the right on tangible, actionable solutions, where local sourcing, resource recovery, and durability contribute to economic resilience and independence (Bjørn & Hauschild, 2013). Some argue that CE frameworks align well with nationalist sentiments, given their emphasis on local economies and reduced dependence on external resources (Blok et al., 2015).

The challenge for the public lies in navigating these divergent, and often conflicting messages. Figure 14 illustrates this conflicting message as a boxing match. While political parties may seem to argue different approaches, both sustainability and CE are commonly used as "boundary objects", as defined by Star & Griesemer (1989), for heterogenous parties to cooperate towards the same goal.

Figure 14: Illustration of Political Perspectives

3.1.4 Mixing the Cocktail:
Sensemaking

Synthesising all the previous findings into a cocktail, we can shed a light on what makes sustainability and the CE so difficult to grasp. It is a combination of jargon, a lack of consensus amongst 'experts', politicians who frame the terms differently to highlight opposing views, the abstract long-term and goal-oriented language that is difficult to envisage and lastly the effects of behaviour that feels disconnected from the now.

To address the two latter, AR can be used to bring these long-term goals closer to home, by creating immersive experiences that show the impact of sustainable actions or visualizing data in a more accessible way. To do so, plain language and visualisations can be presented to create a trifecta of communication, integrating audio, text, and visuals to create a multi-sensory experience in a way that is accessible and aligns audience's cognitive abilities.

However, it is important to not see AR as a silver bullet that can bridge the gap between political divides. Rather, it can be used as another tool to convey ideas, educate and inspire inhabitants to engage actively with sustainability and CE goals.

"The Sustainability Sour"

Ingredients:

- 2 oz. Jargon Gin
- 1.5 oz. Expert Disagreement Vermouth
- 0.75 oz. Political Twist Syrup
- 1 oz. Abstract long-term tonic
- 1 spash of Disconnected Action bitters

3.2 Rotterdam, Carnisse & Communication

In translating sustainability and CE goals into local action, Rotterdam faces unique challenges, particularly in neighbourhoods like Carnisse. Despite the city's ambitious targets, the success of these initiatives relies on clear, accessible and actionable communication that resonates with all residents. Carnisse, characterized by its socio-economic diversity and lower literacy levels, exemplifies the need for tailored communication strategies that bridge gaps in understanding and engagement.

This section will deep-dive in how Rotterdam's communication approaches align, or fall short, in addressing Carnisse's specific needs, highlighting the barriers and opportunities for building a more inclusive dialogue around sustainability.

3.2.1 Rotterdam's Big Hairy Audacious Goal & Communication styles

As stated in the introduction, Rotterdam has the ambitious goal to be fully Circular by 2050, and as a stepping stone they committed to being 50% along the way by 2030 (Rotterdam Circulair, n.d.). This ambition requires a drastic redesign of how the city functions, as well as the way in which resources are managed. A much more local strategy will be employed, enabled by local businesses, communities, initiatives and inhabitants.

Transitioning to a CE cannot be achieved overnight. As a result, Rotterdam Circular has written a Vision Document (Rotterdam Circulair, n.d.) in which the three primary goals and priorities from the period 2023-2026 are outlined. These are:

BHAG's are usually used to inspire employees to take action, from "Built to Last" by Jim Collins and Jerry Porras (1994)

1. **A greener and more sustainable Rotterdam:**
   - We prevent or reduce the negative impact on the environment, nature, and climate of all resources, materials, and products we use.
   - We utilize (local) organic resources for a healthy soil and nature restoration.

2. **A more economically resilient Rotterdam:**
   - We reduce our vulnerability to supply risks and prevent resources and products from becoming unaffordable, known as resource poverty, by reusing existing resources, materials, and products in a high-quality manner.
   - We strengthen the local economy and circular business activity by supporting companies that focus on local employment.

3. **A healthier and cleaner Rotterdam:**
   - We reduce the use of toxic substances and promote the use of healthy resources, materials, and products in construction and the production of (consumer) goods.
   - We work towards a cleaner living environment by reducing emissions, pollution, and (litter) waste.
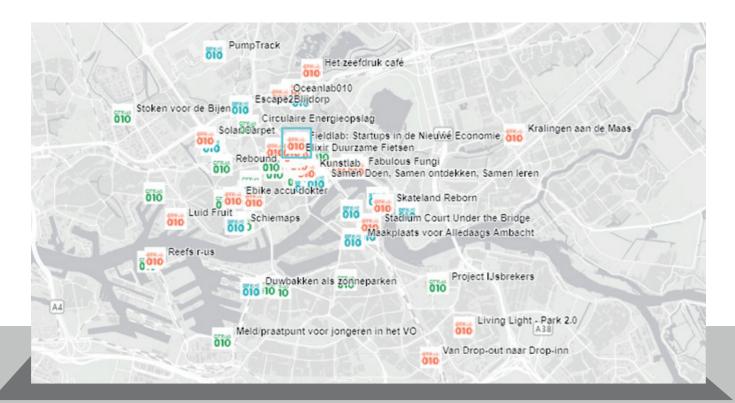
3.2.1.1 Communication Challenges and Opportunities in Carnisse

Apart from the goals, it is mentioned within the document that Rotterdam has the ambition to utilize strategies that are higher on the R-ladder, since it came to the attention of the Planbureau Voor de Leefomgeving (PBL) that the Netherlands are using Recycling as a silver bullet. This is over-reliance is not desirable if we want to design a resilient Rotterdam, and to achieve strategies higher on the R-ladder the municipality needs to activate its inhabitants to Refuse, Rethink and Reduce.

Rotterdam's Circular goals require engagement from all neighbourhoods, but achieving this in Carnisse presents distinct challenges. Interviews with Ingrid Verheij and Jerney Steur from Rotterdam Circular highlighted several barriers specific to Carnisse, including a *lack of biodiversity, limited waste separation*, and the need to *normalize sustainable behaviour*.

Visibility of Circular initiatives is key to connecting residents to these goals. CityLab010's interactive map (Figure 15) aims to showcase initiatives across Rotterdam, but most of these projects are concentrated in the North, with fewer options in the South. This division, strengthened by the physical barrier of the river Maas, makes these initiatives less accessible to residents of Carnisse. If Rotterdam strives for better visibility of Circular Initiatives, there are two simple solutions. Either make the North more accessible, or kickstart and scale-up more initiatives in the South. This latter can be achieved by informing and motivating residents with communication that sticks.

Figure 15: Map of Initiatives in Rotterdam (CityLab010, n.d.)

3.2.1.2 Current Communication Methods and their Limitations

Rotterdam Circular has three spearheads for communication:

- Highlighting success stories – **Inspiring**
- Informing about alternative, more sustainable products – **Spreading Knowledge**
- Enabling inhabitants to start-up sustainable initiatives themselves – **Subsidize and Empower**

Yet these strategies manifest themselves in communication methods that do not stick with inhabitants for a plethora of reasons. Which ultimately means the goals are not achieved. To shed a light on why this is the case, and what specific communication methods do not work, inhabitants of Carnisse were interviewed at multiple locations and events (at the "Zuidplein Library", "Gouwe (Kl)Ouwe", "De Groene Oase" and lastly "de Kunst- en Vliegfabriek"). Many residents expressed distrust toward municipal-branded materials, preferring direct, personal communication instead. Specific challenges per communication channel included:

Paper / Text based Communication Methods

Figure 16: Screenshot of Duurzaam010 (n.d.)

Figure 17: Image of MKB Rotterdam-Rijnmond (n.d.)

Newsletters sent to the addresses of inhabitants (Figure 16) – Are not checked because when something "smells" like the municipality, the inhabitant becomes hesitant and distrustful (Evelyne Hofman, 2024).

Posters – as they are branded with municipal logo's and again smell like the municipality. This results in distrust. Next to that, poster campaign's usually do not reach Carnisse physically (e.g. Municipal Elections of 2022, where politicians decided to skip campaigning in Carnisse. Figure 17 shows an example of a poster from Rotterdam.

Digital Based Communication Methods
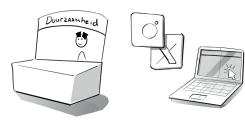
Figure 18: Circulair Loket (Rotterdam Circular Instagram, 2024)

Figure 19: Instagram Feed of Rotterdam Circular (2024)

A digital sustainability counter where inhabitants can pose questions – The turnaround time is too long, it takes approximately 4 weeks to get an answer to your question, and this counter is not really accessible if you do not know about it in the first place. Figure 18 shows promotion of the counter.

Websites & Social Media (i.e. Rotterdam Circulair, Gemeente Rotterdam) – You need to actively follow these channels, and you only do that if you are interested in the first place. As a result, highlighting success stories and sharing information this way is not reaching many people. Figure 19 shows a snippet of the Instagram feed of Rotterdam Circulair.

People-based Communication Methods
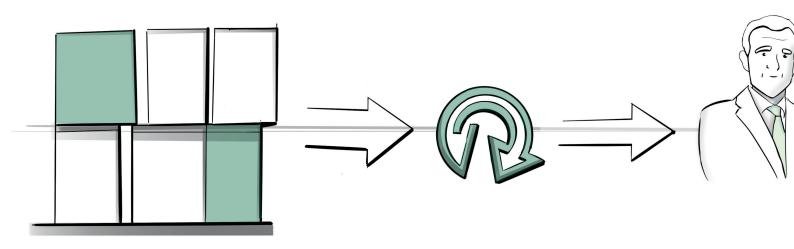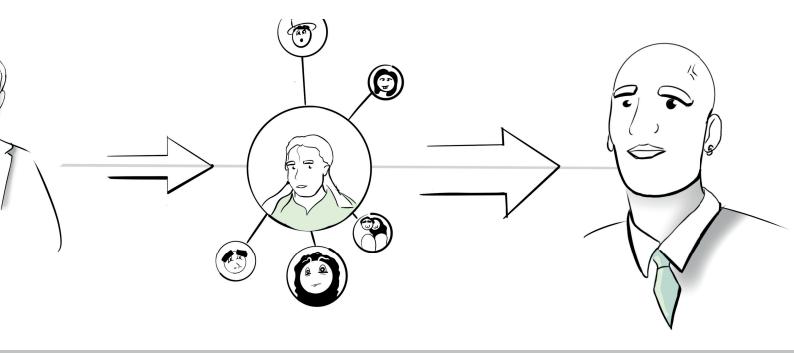
Figure 20: Image by Noorderzon 010 (Bastinck, 2023)

Quartermasters who are key-figures in neighbourhoods. These quartermasters are not quite accessible and rarely have the time to speak to people. Figure 20 shows a quartermaster.

Apart from these methods that do not reach the inhabitants, many inhabitants perceive the municipality is inaccessible. To further elaborate on the 'distance' between the municipality and the inhabitants, an example of a communication pipeline is shared (Figure 21). Communication starts in the Municipality and at Rotterdam Circulair. Afterwards, messages are passed down to the Neighbourhood Manager, then towards the Neighbourhood Networker, and at last they will be passed on towards the inhabitants. Apart from the bureaucratic steps which negatively influence the timeframe of communication, the message also gets diluted with every step. Of course there are protocols that aim to reduce distortion, yet the cumulative effect is often inevitable.

Figure 21: Communication pipeline from municipality to Inhabitant

3.2.1.3 Bridging the Gap

Rotterdam acknowledges this problem, and as a result has started opening more municipal locations within different neighbourhoods (Dagblad010, 2019) to increase visibility and accessibility. Steps in the right direction are made, but these locations now only offer aid on specific topics. These locations could be leveraged more to actively engage with inhabitants.

Additionally, integrating new communication methods that do stick could provide an accessible and engaging way for Carnisse to connect towards Sustainability and CE goals.

3.2.2 Carnisse's Frame

In the previous section we discussed the Circular Vision of Rotterdam, and how it aims to communicate that. However, the section also touched briefly on the fact that these generalised methods struggle to connect with certain communities. Carnisse, with its distinct challenges and demographics, is an example of such a community. In order to understand why the current strategies fall short and how they could be improved, it is crucial to explore Carnisse's unique frame and context in greater depth.

Carnisse is a sub-neighbourhood of the larger "Charlois" [Sjaarloos] (Figure 22). And its history stems back to the Middle Ages. Charlois became habitable after the construction of dikes, leaving a plot of land for settlers to live (SHC Geschiedenis Charlois, n.d.; Vocke, 2024).
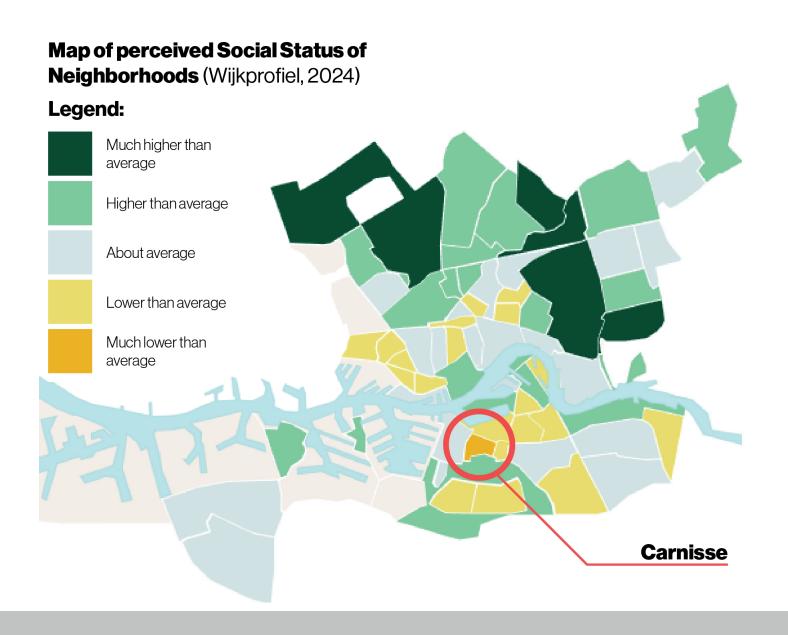
The name can be traced back to the name of "Karel van Bourgondië", who received the land and aptly named it after himself, Charollais. Eventually, transforming into Charlois.

Fast forward to 1899, when the municipality gave a green light to build workers' housing along the Katendrechtse Lagedijk. As a result, the neighbourhood grew between 1900s and 1950s. A major contributor to this was the exponential growth of the port of, and an urgent need to accommodate the new workers that were required. Evolving into a working-class neighbourhood, Carnisse has a rich history shaped by its industrial past and diverse community. According to recent research findings from interviews with inhabitants, many residents express a strong sense of community and pride in their neighbourhoods' resilience. However, concerns

about issues such as gentrification, affordable housing, and access to public services are mentioned. Next to that, inhabitants express their concerns regarding criminality, safety and cleanliness, which can be seen in the safety score index (Wijkprofiel, 2024). Next to that, one inhabitant calls the area "marginal", where he explains that the neighbourhood feels as a balancing act, that is frequently challenged with happenings & events that cross the boundaries of norms and values (OPEN Rotterdam, 2023). Additionally, a report by Citisens (n.d.), that was initiated after the record-low turn-out of voters for the municipal elections, highlights lower levels of trust in the government among residents. This reflects broader socio-political dynamics within the community which can be summarized with the following sentiment:

// **You** *(The Municipality)* **are not doing anything for us.** \\\\

For the municipality, this came as a surprise, but when delving deeper into the matter I found out that not a single politician came to the area to talk about and promote their plans. This gave a signal to the inhabitants that they do not matter and are not worth the time.

Map of perceived Social Status of Neighborhoods (Wijkprofiel, 2024)

Legend:

- Much higher than average
- Higher than average
- About average
- Lower than average
- Much lower than average

Carnisse

Figure 22: Map of Rotterdam, with Wijkprofiel Research highlighting levels of perceived social status of the neighbourhood (Wijkprofiel, 2024)

3.2.2.1 Carnisse's Conundrum

In section 3.2.1, the following challenges were identified: Lack of Biodiversity, the Separation of waste & getting sustainability higher on the agenda. After an interview with Özlem Ates, project leader at Rotterdam Circular who is frequently speaking with Carnisse's inhabitants, it became apparent that Carnisse deals with another very specific challenge;

// *Each day of the week, one can see big bulks of waste piling up on the street.* \\

This is the result of the following phenomenon: The flow of inhabitants is constant and fast, meaning a lot of people move in- and out of the area. This is caused by two things, housing is available, yet expensive. And relative to the price, housing is moderate at best. For the same price, inhabitants can find better accommodation.

When all these people move out, they throw away a large portion of their household items, which shows itself in the streets (Figure 23). These items are considered garbage, while they actually are valuable resources to others. However, if these items are left outside and left to be collected by the waste managers, the items follow their proclaimed destiny and in fact, do become waste.

3.2.2.2 Transforming Trash into Treasure

As a result, the initiative Gouwe (Kl)ouwe has been developed. Gouwe (Kl)ouwe picks up the furniture (Figure 24) and refurbishes them in a workshop location within Carnisse. The refurbished furniture then can be picked-up by another inhabitant of Carnisse, to prolong the life of good quality furniture. As a result, a circular ecosystem within the neighbourhood emerged.

Figure 23: A normal sight in Carnisse (Citylab010, n.d.)

Apart from Gouwe (kl)ouwe, there are a handful of other initiatives in Carnisse. "De Moeite Waard" is an initiative that transforms obsolete fabrics into useful products (i.e. bags and aprons) for inhabitants of the neighbourhood. At "de Moeite Waard", Jannie Spoor helps inhabitants of Carnisse bring their obsolete articles of clothing into bags and aprons. She is a sewing teacher and voluntarily helps inhabitants to upgrade their products, by offering guidance, machinery and a location to be creatively active, enhance social cohesion and help people improve their skills (Rotterdam Circulair, n.d.). The location is financed by a local bar-owner, who has a Circular Heart.

Figure 24: One man's trash is another man's treasure (Citylab010, n.d.)

Café Huisman, *Carnisse Rotterdam*

3.2.2.3 Other Initiatives

Apart from "de Moeite Waard" and "Gouwe (Kl)ouwe), Carnisse is home to some other initiatives with different goals.

"De Groene Oase" (Figure 25) is a community garden located near Zuiderpark. As the name suggests, it serves as a green oasis within the urban landscape of Rotterdam, significantly contributing to the social cohesion of the neighbourhood. It exemplifies a "third space" where residents can meet, relax, and engage with nature, thereby enhancing local ecosystems. "De Groene Oase" supports small-scale urban farming, sells plants, and offers a welcoming environment where everyone is invited to enjoy a cup of coffee (De Groene Oase, n.d.). However, "De Groene Oase" faces pressure from the municipality due to plans for constructing a new high-rise in the area. This development raises concerns about gentrification and fosters fear among residents that their cherished community space may disappear (Based on interview with Harmen Sliep, 2024).

Figure 25: De Groene Oase
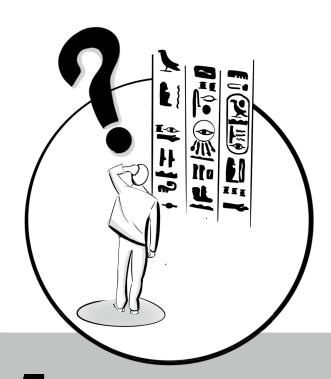
Figure 26: De Kunst- en Vliegfabriek

Lastly, "De Kunst & Vliegfabriek" (Figure 26) is another initiative led by local entrepreneurs and inhabitants, which aims to improve social cohesion through cultural activities. These activities revolve heavily around urban culture, hip-hop & spoken word, speaking mainly towards a younger audience. However, the owner is also a profound enjoyer of boardgames, so boardgame nights are organised as well.

Lepelaarsingel, *Rotterdam Carnisse*

3.2.3 Highlighting Implications: *Sensemaking*

From the previous sections, we can see four clear implications.
These are highlighted below:

1. Abstract ■ Language

The abstract nature and goal oriented language surrounding Sustainability and the Circular Economy make it difficult and confusing for vulnerable groups of society to take part in the discussion about the topic, meaning their perspectives are left out.

2. Scaling-up ■ Initiatives

Rotterdam seeks more community-led initiatives to create standalone Circular Ecosystems, supported by neighbourhood participation, yet this is not communicated properly.

3. Distrust and ■ Neglect

Municipal trust in Carnisse is at an all time low due to a feeling of neglect. Their problems are not prioritized and efforts to make the area more livable are left to initiatives that are not (yet) supported by the municipality. This is extra painful, seeing the Municipality's ambition from point 2.

4. Islandlike ■ Isolation

While Carnisse stands alone, a plethora of initiatives have emerged. There is a strong "us versus them" mentality makes it difficult to find common ground.

59

3.2.4 Inhabitants of Carnisse

As stated in the introduction, in 2022, the municipality of Rotterdam made the estimate that 34% of Charlois's population (aging between 16-65) struggles with lower levels literacy (CINOP et al., 2018). This is a considerable amount, as this is approximately twice the average of the Netherlands is 18% (Stichting lezen & schrijven, 2024). Next to that, the income levels of the inhabitants of Charlois are relatively low. In fact, according to AlleCijfers, households in Charlois have the lowest average income in the whole of Rotterdam (2024).

Despite these challenges, Carnisse remains a vibrant and dynamic neighbourhood, with ongoing initiatives aimed at improving living conditions and fostering community engagement. In the next sections, we will take a plunge into Carnisse's People, and look at the specific Persona's that can be found within the neighbourhood.

3.2.4.1 Personas
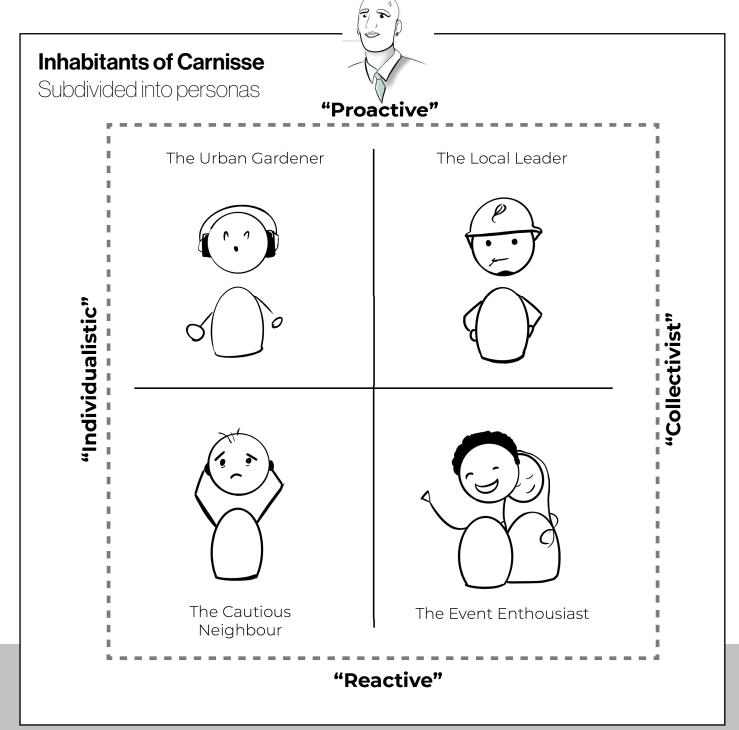
To understand how the community of Carnisse interacts with the communication methods in the regards of sustainability and the CE, it is important to get a better understanding of the mindsets and behaviours of the inhabitants. To map these, personas were made. These personas reflect diverse attitudes towards sustainability, communication methods, and engagement with municipal initiatives. Each persona highlights different communication barriers and opportunities for improvement.

These personas are based on talks with inhabitants of Carnisse during various activities and settings. These include ad-hoc interviews at Gouwe (Kl)ouwe, Zuidplein Library, De Groene Oase, De Kunst- en Vliegfabriek and lastly on the streets.

In order to do something with the information, the different personalities can be positioned in Matrix 1, and are distinguished with the folowing antanyms:

- **Individualistic versus Collectivist (Horizontal)**
- **Reactive versus Proactive (Vertical)**

Matrix 1 provides a visual representation of where each persona falls in relation to one another. Next to that, each quadrant of the Matrix can be used to formulate and target a specific strategy. To illustrate, communicating with the Local Leaders will require a rather different approach than, let's say, the Urban Gardeners. The different personas will pass review in the next pages.

Inhabitants of Carnisse
Subdivided into personas

"Proactive"

The Urban Gardener

The Local Leader

"Individualistic"

"Collectivist"

The Cautious
Neighbour

The Event Enthousiast

"Reactive"

Matrix 1: Inhabitants of Carnisse, subdivided into four different personas

> **//** I have lived in Rotterdam for a couple of years now, and started living here after my studies. I really like the increase in green in the neighbourhood. It reminds me of Berlin, which inspired me. I kind of want to turn the pavement section in front of my house into a garden, a little hub to enjoy the outside in. ****

1. The Urban Gardener

Bio:
This person aims to make their space more liveable by constructing a facade garden or placing plant pots outside. They prefer to work alone due to their timidity but will participate in neighbourhood greening if it involves their immediate surroundings.

My Goals:
I want to create a more liveable green space around my home and inspire others by showing how small-scale initiatives can improve the quality of life

This is how you reach me:
To connect with me effectively, use visual inspiration, like photos or case studies from other cities with vibrant projects. It's important to keep communication simple and to the point, focusing on the direct benefits to my personal environment. I appreciate offers for small-scale projects with low levels of commitment—think of them as low-hanging fruit.

Avoid these when communicating with me:
Please don't overwhelm me with large group projects or complex processes, as they stress me out. Next to that, don't assume I'll take part in long-term collaborations without prior discussion.
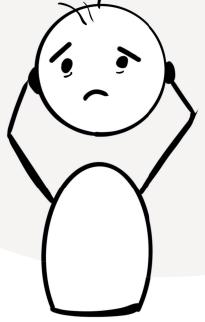
2. The Cautious Neighbour

Bio:
A hindsight thinker, the Cautious Neighbour fears chaos, associating it with nature. When a new green initiative starts, they worry about potential problems, such as maintenance and obstruction of views. However, once the green spaces are established, they appreciate the development and its integration into the street scene.

My goals:
I aim to maintain peace of mind by ensuring all initiatives are safe, regulated, and won't cause unintended issues or accidents. I also want to avoid any personal responsibility for potential problems that could arise from neighbourhood changes.

This is how you communicate with me:
To effectively communicate with me, provide clear, detailed explanations about how projects adhere to regulations and policies. Reassure me that any issues, like maintenance or municipal policy concerns, are addressed. Engage me in low-risk, clearly defined activities that come with minimal personal responsibility. Make regulations and rules easy to find, or ensure it's quick and easy to get a municipal official to check the changes.

This is how you do not communicate with me:
Don't ambush me with sudden changes without ample notice, explanation, and reassurance. Please avoid using vague or abstract goal-oriented language; I prefer plain speech from someone with authority to reassure me.

> We've built a strong network in this neighbourhood, one we're very proud of. Recently, the municipality issued a tender for companies to provide sustainable care packages to residents. A company from outside Rotterdam won, and now they're paid to deliver these packages. But when they struggled to connect with locals, they came knocking on our door. I don't appreciate others benefiting from the network we've worked hard to build. The municipality could have involved us instead. Keeping it local is how we create ecosystems that benefit Rotterdam.

3. The Local Leader
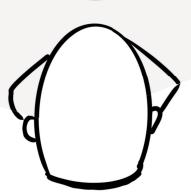
Bio:
An active inhabitant who organizes various activities, the Local Leader often has an entrepreneurial spirit, evidenced by numerous businesses and initiatives they've started. As key figures in the neighbourhood, they are trusted by other inhabitants and experience little difficulty when recruiting help for their initiatives due to neighbourhood-wide support.

My Goals:
I strive to strengthen the community through entrepreneurial ventures, local initiatives, and activities that boost social cohesion. I also want to create a vibrant neighbourhood ecosystem that leverages the capabilities of its inhabitants and keeps value in the neighbourhood.

This is how you communicate with me:
To reach me effectively, keep communications professional but personal—address and acknowledge my expertise about the neighbourhood. Offer collaboration opportunities that align with my goals and community-oriented mindset; don't hesitate to reach out and invite me to meetings, I am very happy to help!

This is how you do not communicate with me:
Please don't bypass my input when planning projects or events; I want to be involved because I can provide valuable insights about the neighbourhood. This can give projects a head start and improve adoption time

> **//** I enjoy spending time with my neighbourhood family. Any activity, you name it, **//** and I'll be there!

> **//** It has been a couple of years since I came back to the Netherlands. Since that time I have been very busy joining different initiatives. I go to the church where they repair clothes, I help with green and I enjoy working on furniture at Gouwe (Kl)ouwe. **//**

4. The Event Enthousiast

Bio:
This is, as the name suggests, a very social person. They love to spend time with others and are always present at neighbourhood activities. These people are like mascots of the neighbourhood, very trusted and familiar.

My Goals:
I want to participate in as many social activities and initiatives as possible while strengthening relationships with neighbours and fostering a sense of community belonging.

This is how you communicate with me:
To connect with me, be enthusiastic and personal—invite me directly to community events or gatherings. Use word-of-mouth to make me feel included and needed. If you use posters or any other form of indirect communication, place them in accessible locations. You can find me in parks, public spaces, and at initiatives.

This is how you do not communicate with me:
Don't rely too much on formal channels of communication like emails or newsletters; I prefer face-to-face or direct invitations. Avoid making events seem too formal or structured—I enjoy relaxed and laid-back events where everyone can just be themselves. When the municipality takes over an event, I can smell it from a mile away. One big tell is that at the start and end of an event, there will be a "Thank-you" bit, where someone picks up a microphone to thank everyone for their participation. Additionally, someone is often taking pictures, which feels fake to me, and I do not like this.

03 | The Context

3.2.4.2 Stakeholder Map

Now we have a better idea of all the players in the field. We discussed the municipality, the inhabitants and the initiatives in Carnisse specifically. These stakeholders can all be plotted on a stakeholder map, which can be found in Figure 27. In this map, the stakeholders are either categorised as Direct, Links and lastly Indirect. Direct referring to stakeholders who experience Carnisse on a daily basis. Links referring to people and/or places that link direct and indirect parties together. Indirect meaning stakeholders who do not experience the neighbourhood on a daily basis. It is also interesting to note that the Local Leaders usually are those who kickstarted a neighbourhood initiative. However, they are an inhabitant first (hence Direct), and initiative taker second (Link).

The Municipality

Rotterdam Circular

Rotterdam Municipality

Neighbourhood Networker

Neighbourhood Manager

The Inhabitants

The Event Enthusiast

The Local Leader

The Cautious Neighbor

The Urban Gardener

The Initiatives

"De Moeite Waard"

"De Kunst- en Vlieg Fabriek"

"Archiklas"

"Gouwe (Kl)ouwe"

Direct

Links

Indirect

Figure 27: Personas, Initiatives and Municipality in Stakeholder Map

67

3.2.4.3 Rotating the Perspective

From this analysis of Carnisse and the Municipality we understand the roles and influence of each stakeholder, it is essential to shift focus away from a birds-eye view of stakeholders to the practical, boots-on-the-ground reality of Carnisse's community. Rather than assuming that stakeholders will work harmoniously, it is crucial to consider the disconnects in communication, trust, and engagement among the Municipality, Initiatives/Local Businesses, and Inhabitants.

In this adjusted perspective, we observe that while the intentions of the municipality may be positive, residents face barriers to understanding and acting upon sustainability messages. The initiatives, positioned as intermediaries, often serve to bridge the gap yet struggle with maintaining sustained engagement. As the initiatives need to have multiple "personalities" when dealing with either the Municipality or the Inhabitants. Perhaps initiatives are a tad overprotective, which hinders collaboration as well.

Figure 28 depicts this dynamic, where the inhabitants are "in the pit," facing challenges that hinder active participation. This sideview highlights that the current structure leads to confusion and disengagement, illustrating the need for more direct and accessible pathways of communication and support between the Municipality and residents.
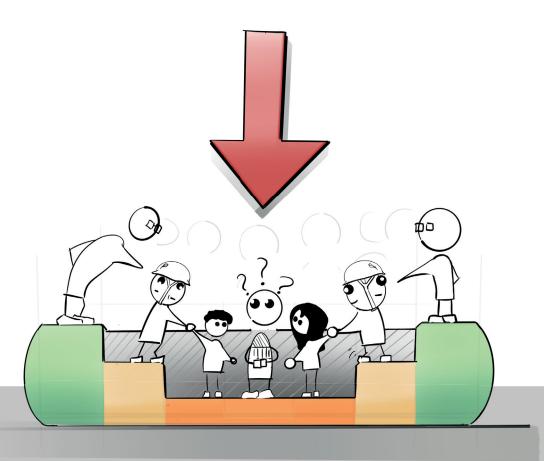
Figure 28: Sideview from Stakeholder Map; Rotating the Perspective

3.2.4.4 Envisioning the Desired State

The visualization in Figure 29 of the desired state shows a more collaborative and connected ecosystem. Here, the Municipality actively supports Initiatives/Local Businesses that are engaged with residents, fostering mutual trust and collaboration. In this model, the focus is on facilitating contact and teamwork across stakeholders. For residents, this creates a more inclusive environment where they feel part of the sustainability conversation.

Bridging the literacy gap with immersive technologies like AR can support this transformation. By making beneficial information that can be put to one's advantage more accessible, and reducing complexity through AR, the Municipality can offer initiatives and residents actionable, relatable information on sustainability, effectively levelling the "playing field". This new approach could make sustainability goals more understandable, and residents would be better equipped to engage actively, resulting in the feeling that the municipality is there to support the neighbourhood.
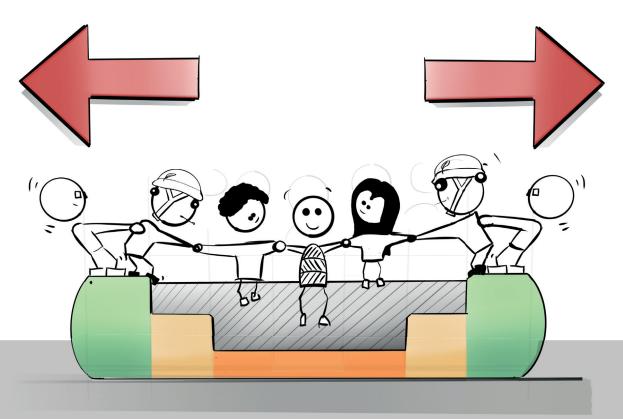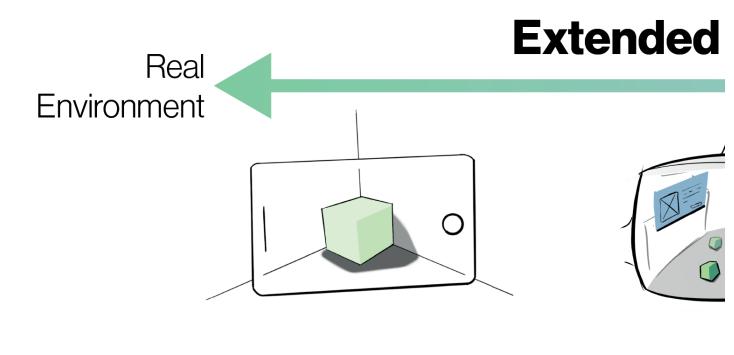
Figure 29: Sideview from Stakeholder Map; Rotating the Perspective

3.3 Immersive Technologies and their role within the Municipality

Currently, Augmented- and Virtual Reality are all the rage. Two tech giants, Apple & Meta are pushing the concept through their line-up of products that enable the technology to be experienced by those interested. Meta with its Quest series (Meta, 2024), and Apple with their newly released Vision Pro (Brownlee, 2022; Aggarwal, 2024; Apple, 2024). Both offer solutions aimed at enhancing productivity and education, extending possibilities beyond the limitations of the physical environment.

Extended

Real Environment

Augmented Reality (AR)

M Re (N

Figure 30: Reality – Virtuality Continuum schematic based on research by Arena et al. (2022)

3.3.1 Defining Immersive Technologies
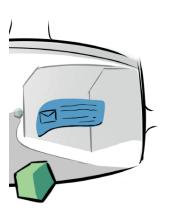
The name "Immersive Technology" refers to a set of contemporary technologies that have the power to create or extend reality by immersing users into a virtual environment. By doing so, they enhance or replicate real-world experiences and can immerse users in new environments.
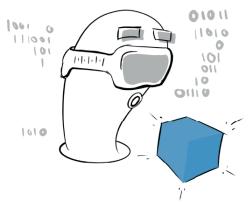
Examples of Immersive Technologies are Virtual Reality (VR), Augmented Reality (AR) & Mixed Reality (MR), and they can be plotted on the Reality – Virtuality Continuum (Arena et al., 2022) (Figure 30). The concepts will be defined in the next sections, and description, example of applications and key characteristics will be shared.

Reality (XR)

Virtual Environment

ixed
eality
MR)

Virtual Reality (VR)

Augmented Reality

AR overlays digital elements (such as images, text, or animations) onto the real-world environment. Users can still see and interact with the real world while experiencing digital enhancements through devices like smartphones, tablets, or AR glasses. Figure 31 shows an illustration of this.

Examples of applications:
- Google with its Wayfinding- and Lens AR application (Google, n.d.)
- Video games like Pokémon Go (Niantic, n.d.)
- City Tours (Niantic, n.d.)

Key characteristics:
- Real world is still visible.
- Digital elements enhance or augment real-world experiences.
- Typically requires a smartphone, tablet, or AR glasses.

Figure 31: Sketch of AR

Figure 32: Sketch of VR

Virtual Reality

This technology immerses users in a completely digital environment, replacing the real world with a virtual one. This is achieved through headsets that block out the physical surroundings and simulate a fully interactive 3D world. The downside of VR is the fact that a headset is required, which can become costly when opting for premium models and makes the wearer less mobile. As a result, use can only be facilitated in a controlled environment. Figure 32 shows a sketch of this.

Examples of applications:
- Gaming in a computer generated environment (i.e. Beatsaber)
- Simulation Training (i.e. with the Simulation Crew (2023))
- •3D modelling in generated environment (i.e. digital sketching with Gravity Sketch (n.d.))

Key Characteristics:
- Real world is fully replaced with a virtual environment.
- High levels of immersion and interaction.
- Typically requires a VR headset (e.g., Meta Quest, HTC Vive).

Mixed Reality

This technology blends the physical and digital worlds, allowing users to interact with both at the same time. In MR, virtual objects are anchored to the real world and respond to its conditions, creating an interaction between the digital and physical environments. This often requires advanced sensors and hardware, like Microsoft's HoloLens and the Apple Vision PRO. Figure 33 shwos a sketch of this.

Key Characteristics:
- Combines real-world and virtual elements in a more interactive and integrated way than AR.
- Users interact with both physical and digital elements in real-time.
- Often requires specialized hardware like Microsoft HoloLens and Apple's Vision Pro.

Examples of applications:
- Remote Collaboration (i.e. creating digital workspaces)
- Virtual Property Tours
- Advertising
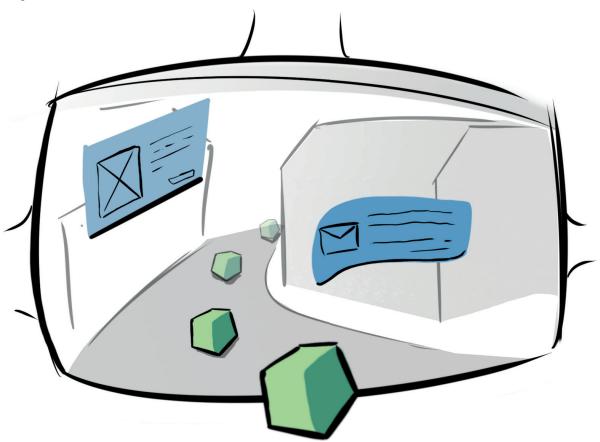
Figure 33: Sketch of MR

3.3.1.1 A Brief History of Immersive Technologies

Although immersive technologies are currently trending, they are by no means a recent innovation. The original idea dates back to 1933, where the concept was conceived in a story by Grauman Weinbaum, called Pygmalion's Spectacles (Figure 34) (Weinbaum, 1935).

The concept was further developed, and in the late 1950s, Morton Heilig made a machine called the "Sensorama", which could deliver multi-sensory experiences to its users (Robinett, 1994). Among the various experiences it offered, the most notable was a simulated motorcycle ride through New York City, which combined visuals, sound, and even scents to create an engaging and memorable experience. While at the time considered revolutionary, it now is reminiscent of modern-day simulator games. Figure 35 illustrates the original Sensorama patent as envisioned by Heilig (1955).

Figure 34: Poster of Pygmalion's Spectacles by Stanley G. Weinbaum (1935)
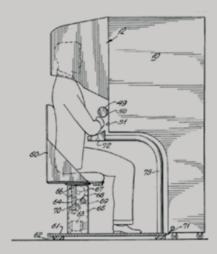
Figure 35: The Sensorama Patent drawing by Heilig (1955)

1935

1955

A couple of years later in 1968, the *Stereoscopic-Television Apparatus for Individual Use (Figure 36)* was built by Ivan Sutherland. This was the first helmet that was equipped with lenses instead of a larger screen, which made it possible to view images that were superimposed into the real world (DuBose, 2020). However, due to the excessive weight of the contraption it had to be mounted to a ceiling, representing the "Sword of Damocles". The uncanny resemblance stuck, and the apparatus was aptly renamed.

One of the first commercially available VR products was Nintendo's Virtual Boy (Figure 37), launched in 1994. Although it was an innovative concept, the hardware limitations—such as its bulky design and awkward interaction mechanisms—contributed to its commercial failure (Boyer, 2009).

Despite these early shortcomings, advances in technology, particularly through Moore's Law, have allowed immersive technologies to evolve. The reduction in size and improvement in performance have led to successful applications in portable gaming consoles and smartphones as well as other technologies. Which were notable in the next years.

Figure 36: The "Sword of Damocles" configuration, developed by Ivan Sutherland (Ismail, n.d.)

Figure 37: The "Sword of Damocles" configuration, developed by Ivan Sutherland (Ismail, n.d.)

1968

1994

From these technological advancements, the first succesfull AR-phone app was conceived in 2016. Pokémon GO (Figure 38) (Niantic, n.d.) was an extreme hit when it came out. It was praised by its ability to morphe outdoor activity with gaming, and showed the world that AR is a viable technology.

Another contributer to Pokémon GO's succes was the fact that it was free to download, meaning it was accesible to millions of people. Users could use the existing hardware they had, namely their phone, to download and play the game.

The year 2016 was not only great for AR, the VR-fans finally could get their hands on the first proper headset named the Oculus Rift (Figure 39). While the machine was already announced many years before, and changed hands from Oculus to META, this VR-machine was able to immerse users in VR videogames for the first time, if you were able to pay the hefty fee.

The Oculus Rift paved the way for the META Quest lineup, which is currently the biggest name in the VR world.

Figure 38: Pokémon GO by Niantic (N.d.)

Figure 39: The Oculus Rift

2016

In 2024, Apple entered the immersive tech market with the Vision Pro, a sophisticated mixed-reality headset. Tech enthousiasts became excited, as usually when Apple joins the party, the technology works well, and the interactions are optimised.

While reviews are positive, the Vision Pro (Figure 40) still deals with teething problems like the front glass breaking quickly, heavy weight, limited app support and a hefty price tag.

The takeaway from this brief history is clear: immersive technologies have evolved from experimental prototypes to mainstream tools that shape how we interact, learn, and work. Today, they are more widespread than ever, with rapid advancements in hardware and software enabling broader adoption and deeper integration into everyday life (Cipresso et al., 2018). As accessibility continues to increase, immersive technologies are destined to further define the way we interact with information, blending physical and digital worlds in ways once only imagined.

Figure 40: Apple's Vision PRO

2024

Future?

3.3.2 Immersive Technologies in the Social Domain

As stated in the previous section, the sector that can be attributed to the rise of immersive technologies is mostly Gaming. They jumped the bandwagon quickly, and already reap the commercial benefits of the new market. To stress again, META, Apple and Microsoft are investing billions in Immersive Technologies (Renganayagalu et al., 2021), and with the recent release of their new products, immersive technologies are not just a fad, they are here to stay.

Apart from the Gaming industry, Immersive Technologies have seen a rise of use in the Military, Healthcare and Blue Collar jobs to be used as training devices (Fonarov, 2024).

Yet, it is interesting to learn how Immersive Technologies can further be leveraged within the domain of Municipalities and Sustainability as education and communication tools, as the technology can provide benefits that aid the social domain as well. To learn more about AR's connection with learning and communication, the next section delves deeper into these psychological concepts. Afterwards, Academic Studies that effectively used AR in the same context will pass review.

3.3.2.1 Theories behind Immersive Technologies

The surge on Immersive Technologies can not only be attributed to the fact that companies pump a lot of money in them. Though the money helps and incentivizes research, there have been a plethora of studies that plea for the standalone positive effects of AR in the field of cognitive psychology. These benefits will be reviewed subsequently.

Cognitive Load Theory

The Cognitive Load Theory, developed by John Sweller (1988), in essence states that the human brain has a limited capacity for processing information at one time. When the brain is overloaded with complex, unstructured and excessive information, learning and decision making can become difficult. According to the theory, there are three forms of Cognitive load and they can be dissected in the following way:

1. **Intrinsic Load:** relating to the complexity of the information itself
2. **Extraneous Load:** relating to the extra, distracting elements that do not necessarily contribute to the understanding of the topic
3. **Germane Load:** relating to extra information that helps structuring the information.

AR can be used as a tool to lower Cognitive Load by presenting information in a real-time, accessible and interactive way. Some ways are shared below:
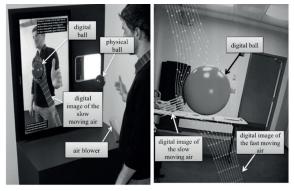
1. **Synchronising Bite-sized information (structuring Intrinsic load):** Rather than providing all the information at once, AR can structure information in a stepwise manner. New information appears when the user is ready.
2. **Reducing Extraneous Load:** AR can highlight specific things in the real world, so that the "noise" becomes less apparent. For instance, if you're learning about plants, AR can highlight and label each plant in real-time, making it easy to understand and remember their functions, isolated from one another.
3. **Enhancing Germane Load:** AR allows layers to be added on reality. These layers can be used to link relevant information in the experience, so the previously mentioned plants can be layered with insects for example. This way the brain can make more links and logical structures and connections.

Cognitive Load Theory in Practice

In the case of Carnisse and Rotterdam, reading competence has become increasingly crucial. Yet letters have a high cognitive load for people struggling with lower levels of literacy, due to being overwhelmed, confused and disoriented. In this case, AR can help to guide the user and make the information more accessible.

Some studies have also highlighted this theory in relation to AR and show how they can be employed to lower the cognitive load, making information more accessible for specific groups. In 2017 for example, Yoon et al. (2017) were able to improve the knowledge of visitors of a science museum on the Bernoulli principle, by allowing them to interact with an AR product (Figure 41). In this study, intrinsic load was structured, extraneous load reduced and germane load enhanced with visual cues and special attention to cause and effects.

Next to that, Lai et al. (2019) designed an AR approach that tied in with a series of geographical learning books. The maps could be scanned with a mobile device, and a 3D geographical formation that corresponds with the map was then loaded. This synergy between Intrinsic Load and corresponding and relevant Germane Load lowered the overall cognitive load of students who read about the subject (Figure 42).
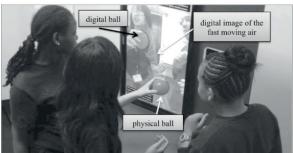
Figure 41: Images of the "Bernoulli Blower" by Yoon et al. (2017)
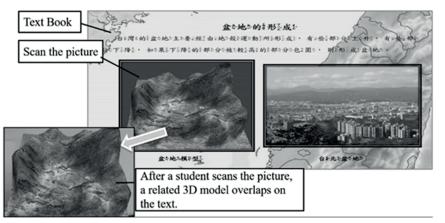
Figure 42: Multimedia AR approach to lower cognitive load of students by Lai et al. (2019)

Situated & Constructivist Learning

In addition to managing cognitive loads, AR experiences align closely with Situated and Constructivist Learning principles.

Situated Learning Theory suggests that learning is most effective when it occurs in relevant, real-world contexts rather than in isolated settings like classrooms, where knowledge may feel abstract and disconnected (Brown et al., 1989; Clancey, 1995). AR can bring learning directly into contextually relevant locations, either by being deployed in real-world settings or by simulating realistic environments, increasing the impact of the learning experience (Dunleavy & Dede, 2014). For example, an AR experience simulating rising water levels could convey the tangible impact of floods, making the concept of flood risk more meaningful, even if the experience occurs in a location not directly at risk.

Constructivist Learning Theory emphasizes the need to situate learners in contexts that connect with prior knowledge, encourage self-directed exploration, and allow active participation. AR naturally aligns with this approach by enabling interactive, context-rich environments where learners actively engage with the content at their own pace, reinforcing their understanding through firsthand interaction (Dunleavy & Dede, 2014).

To design AR experiences that optimize learning, key principles from Constructivist Learning include:

- **Embedding Learning in Relevant Locations:** AR can bring the "classroom" to the learner, embedding learning directly in context.
- **Providing Self-Directed, Active Learning Opportunities:** AR allows users to explore content in a hands-on, self-guided way, reinforcing understanding through personal interaction and discovery.

Multimodal Learning

One of the strongest phenomena in favour of AR is the ability to enrich students and practitioners with a cognitive visual experience next to the ordinary text. In Chapter 3.1.4 this is referred to as the "Trifecta of Communication", but Binytska et al. (2020) goes a step further and connects immersive technologies to the five senses of humans:

*// The effectiveness of the principle of visualization in the use of immersive technologies is confirmed by the fact that of the five organs of human perception today it is possible to use three – sight, hearing, touch. *

- Binytska et al. (2020)

3.3.2.2 AR in Educational Projects

Research shows that AR is gaining traction as an effective tool in corporate training, offering workers essential skills to operate equipment and machinery efficiently and safely (Martins et al., 2023). One key benefit of AR in training is its ability to streamline learning processes with minimal supervision from senior staff, which reduces training costs and resource demands (Ullo et al., 2019).

Martins et al.'s (2023) systematic literature review (SLR) highlights several positive impacts of AR on skill acquisition. For example, AR enhances skill transfer (Pena-Rios et al., 2018), shortens training times (Syberfeldt et al., 2016), reduces cognitive load (Okazaki & Takaseki, 2017), and boosts motivation, ultimately leading to better long-term retention of knowledge (Bacca et al., 2018). These advantages make AR a valuable tool in workplace settings where safety, efficiency, and knowledge retention are crucial.

Beyond corporate training, immersive technologies like AR have also emerged in educational environments. For example, Neumann et al. (2022) found that AR and MR applications, such as SimSchool and the Magic Book (an Augmented Reality Picture Book, or ARPB), have shown potential in classroom learning. AR is particularly popular due to its accessibility compared to VR and its increasing use in ARPBs, which can seamlessly be integrated in current books and methods with a corresponding application. This allows students to interact with educational content in an engaging, hands-on and 21st century way (see Figure 43).

Figure 43: ARPB by Augray (n.d.)

Immersive experiences have also demonstrated the potential to foster empathy in educational settings. At the Central Pacific Institute in Hawaii, students using immersive technology to simulate a homeless person's experience reported a new understanding of the vulnerability associated with homelessness. "Becoming Homeless," (Figure 44) a project by Stanford's Virtual Human Interaction Lab (VHIL), helped students experience the emotional impacts of homelessness, with students and teachers noting increased empathy and positive learning outcomes (Asher et al., 2018).

A similar course about empathy is present in the curriculum of the UMC Utrecht. "Social Medicine in the consultation room" is a series of courses aimed to give students perspective about the situation of patients from a socio-economic class. These lessons gained traction in social media, and their importance is underscored by the fact that most students come from middle- and upper-class families and have little clue about the social situation of patients (Dalila, 2024). Currently we see more initiatives emerging that leverage VR's ability to function as an empathy tool (Vogelzang, 2022).

Figure 44: Frame of Becoming Homeeles, an immersive experience aimed to foster empathy for the Homeless in Hawaii (Asher et al., 2018)

Figure 45: Medicine Students with VR-glasses, picture by Volkskrant (Van der Geest, 2017)

3.3.2.3 Immersive Experiences in Sustainability and CE projects

Apart from attention amongst tech giants, Immersive Technology has garnered attention in academia, especially within environmental subjects like climate change and biodiversity loss (Cosio et al., 2023). From 2017 to 2020 alone, over 1,100 articles were published on the topic, comprising roughly 56% of total research within this domain during that period (Abad-Segura et al., 2020).

Cosio et al. conducted a systematic review of 80 papers exploring the application of Immersive Technologies for Environmental Sustainability and concluded that these technologies hold significant potential to bridge the gap between people and complex environmental issues. Immersive Technology can enhance self-efficacy, providing individuals with a sense of empowerment in addressing these issues (Erika et al., 2020) and can also promote behavioral change (Ahn et al., 2013). These qualities make it an intriguing tool for municipalities, as it provides a means to educate and engage inhabitants on complex social topics. However, there is still no clear consensus on best practices for implementing the technology effectively.

One practical example of AR in municipal context regarding sustainability and the CE is a 2022 study in Greece. In this study, AR was used to support community engagement for a CE. The study introduced an innovative AR tool (Figure 46) that allowed citizens to engage with CE principles interactively. Participants could scan a QR code, place a virtual tree in their environment, answer quiz questions on CE principles, and view saved locations on a map. This experience was shown to enhance social cohesion and inclusion, bringing the benefits and principles of the Circular Economy into public focus (Katika et al., 2022).

a)   b)   c)   d)
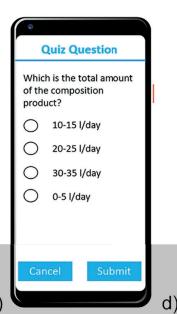
Figure 46: UI of participatory AR tool (Katika et al., 2022)

Going more towards visualising sustainable (or lack thereof) behaviour, another Stanford VHIL project demonstrated ocean acidification's effects on coral reefs at Punahou International University. By incorporating elements of gameplay, the project allowed students to interactively experience the degradation of coral reefs due to human actions (Figure 47). Students expressed disappointment and concern about environmental harm, noting that the immersive experience intensified their connection to and concern for the ecosystem (Fauville et al., 2021).

After the research was conducted, the VR experience was uploaded to videogame platform Steam under the name: *The Stanford Ocean Acidification Experience*, where it can be downloaded and experienced for free.

The Stanford Ocean experience was picked up by Pimentel et al. (2019), and they added a new level to the experience. Their VR prototype named: "Climate change on your plate" (Figure 48), where users could compose their favourite seafood on a plate, was added after the Stanford Ocean Experience. The idea was that the food users selected would deteriorate in their hand, symbolising the increased ocean acidification from the Stanford experience.

Figure 47: Frames of Crystal Reef, a VR experience that visualises CO2 in Coral Reefs (Fauville et al, 2021)

Figure 48 "Climate change on your plate", a VR experience that builds upon the Stanford Ocean Experience (Pimentel et al, 2019)

Some other VR-studies have been done that aimed to bring the long-term effects of climate change closer to home.

Huang et al. (2019) aimed to bring sustainability and climate adaptation closer by visualising a forest in VR. A tool was developed in which ecological data (from LANDIS-II software) could be visualised in VR. The tool is interactive and aims to show users what effects climate adaptation has a forest in Northern Wisconsin under two climate scenarios (Figure 49). The tool was able to transform abstract LANDIS-II Data into clear visualisations that could be communicated towards laymen, making the information more accessible.

Figure 49: Visualising a forest in two scenario's (Huang et al, 2019)

Figure 50: Visualising water levels in Portrane (Xu et al, 2019)

Apart from visualising the effects on ecosystems, Immersive Technologies can also be used to visualise rising water levels. Xu et al. (2022) have designed an awareness tool that was able to visualise floods at the beach area of Portrane in VR (Figure 50). The floods would generate based on DEM (Digital Elevation Model) data from the year 2021 to 2100. This data was turned into an interactive animation, that immersed the users in a flood. Currently, this application is turned into an AR experience, as the accessibility is higher.

3.3.2.4 AR & VR in Dutch Municipalities

In the Netherlands, municipalities have begun exploring Immersive Technology for urban planning and citizen engagement. The Municipality of Arnhem, for instance, recently piloted a Virtual Reality (VR) program designed to help residents visualize new city plans. By creating a "Digital Twin" of several city areas, they have provided a virtual environment where real-world development plans can be overlaid and experienced by inhabitants. This allows citizens to engage directly with proposed changes, such as experiencing a planned park through VR at a public event, rather than merely viewing static representations like posters and pictures. This immersive approach has helped make plans more tangible, enabling earlier and more effective co-creation between the municipality and residents, as they can express their feedback at preliminary design stages. An image of Municipal officials from Arnhem tinkering with VR can be found in Figure 51.

In an interview with project leads Arjuna Snoep and Alex Kramer, they highlighted the promising results of this pilot. Beyond supporting urban planning, the Digital Twin concept could also advance fields like traffic simulation and water management, illustrating its potential to optimize city planning comprehensively.

Figure 51: VR Pilot in Arnhem (Arnhem Direct, 2018) (Picture by Zefanja Hoogers)

Rotterdam has similarly explored Immersive Technologies under the "De Digitale Stad" initiative. The final report from this initiative proposed the development of an Open-Urban-Platform, with a Digital Twin to support simulations in areas such as crowd safety, logistical challenges, sustainability impacts, and noise levels at the port (Eindrapportage de Digitale Stad, n.d.). Key objectives from this report can be seen in Figure 52, and included:

• Leveraging Immersive Technology to co-create with residents
• Visualisation of future plans
• Building a Digital Twin to simulate urban dynamics, including but not limited to urban traffic, noise and water simulations

However, despite the successful pilots, Roland van der Heijden, Program Manager of "De Digitale Stad", expressed concerns regarding adoption challenges. He noted that a resistance to change among some officials, who may favour maintaining the status quo, has stalled further implementation. Additionally, the technical nature of the prototypes requires expertise and preliminary explanations, limiting their accessibility to a broader audience.

To address these challenges, it was concluded that new designs are needed to simplify and clearly communicate AR applications, making the technology accessible, tangible, and self-explanatory for officials and residents alike. Such an approach would address both voiced and unvoiced concerns, increasing the likelihood of adoption and long-term engagement.

Yet it is interesting to see that in the beginning of November 2024, the Rotterdam Municipality has decided to present the vision document to the public, soft-locking themselves into this new direction. Roland van der Heijden noted on this release that:

We have deliberately chosen a concise narrative. This means that the actual elaboration on the Rotterdam challenges has only been partially developed. There is still plenty of work to be done!
- Roland van der Heijden (2024)

Figure 52: Development of Open Urban Platform with Digital Twin (Eindrapportage de Digitale Stad, n.d.)

3.3.2.5 Battle of Immersion: *AR vs VR*

The examples discussed above demonstrate the rising adoption of Immersive Technologies, within communication, education, sustainability, CE and municipal contexts. Once mostly associated with video games and corporate training, these technologies are now having a foot in the door of Municipalities, with cities experimenting with "Digital Twins" to create immersive urban models that can be used for simulation and engagement.

Although both AR and VR are increasingly adopted, VR remains the most prominent. This trend is partly fuelled by VR's aforementioned high-tech image, where substantial marketing investments promote the Metaverse, thus positioning VR as a technology that powers the future. However, it is important to note that while VR offers full sensory immersion, there are definite drawbacks that need to be considered. The hardware is expensive, requires substantial training, and impairs user movement. In some cases, VR can induce nausea or a sense of isolation for users (Carter, 2023). These limitations make VR less accessible for large-scale, public-facing projects, especially where ease of use and inclusivity are paramount.

In contrast, AR is accessible through common, portable devices like smartphones and tablets, reducing both cost and the need for extensive user training. Familiarity with the mobile interface, whish is based on touchscreens and intuitive gestures, makes it more inclusive, enabling a broader range of users to participate comfortably. This accessibility makes AR a powerful tool for public spaces and community engagement initiatives, as citizens can participate using personal devices without specialized equipment. Additionally, AR tends to produce less nausea compared to VR, making it more suitable for longer, repeated interactions in public settings, especially where users may be of diverse ages and tech comfort levels (Carter, 2023).

It is important to consider the trade-offs as well. With AR, processing power is, at the moment, limited to the hardware of the mobile device. While AR works fast on flagship phones, performance can be laggy on budget alternatives. Next to that there is AR fatigue, the discomfort from holding a device at an optimal viewing angle, which can set in over prolonged use. This is a limiter of session length.

Next to that, there is AR fatigue. Holding a smart device so you can properly see requires a special stance that makes your arms become sore after a period of time.

Each technology serves unique functions: while AR facilitates seamless integration of digital information into real-world contexts, VR excels at creating entirely immersive, controlled environments. Municipalities could benefit from adopting both technologies in a complementary manner. For instance, using VR for detailed visualisations of complex or conceptual projects, where a single headset can help give specific stakeholders an idea of space. On the other hand, AR can be used for public engagement events in which a portable, cost-effective, and easily accessible tool is required to have the widest reach possible.

Given the accessibility and minimal investment required, AR presents a practical solution for municipalities like Rotterdam to engage citizens in a way that is both accessible and impactful. By allowing residents to participate using their own devices, AR democratizes access to information and encourages broader community involvement in sustainability efforts. For this project, the focus will therefore remain on AR, aligning with Rotterdam's goals of fostering an informed, engaged, and inclusive community.

3.3.3 AR Toolbox

Currently, there is no standard recipe to make an AR experience. Lessons from the previous researches and studies have been used to produce a well-considered pipeline. The next section will shed a light on programme selection. Afterwards, "Design Principles" have been shared to act as an anchor throughout the prototyping stage, but these might also prove useful for practitioners who want to make AR experiences but do not yet know where to start.

3.3.3.1 Programme Considerations and Production Pipeline

Currently, a wide range of programs are available for creating AR experiences, each varying in ease of use, functionality, and cost. Generally, more user-friendly software provides a streamlined interface but may offer fewer advanced features. However, all AR production pipelines require two core elements: a program for creating 3D models and another for implementing interactions. This section outlines the considerations involved in selecting the most suitable modeling and AR software for this project.

Some commonly used modeling tools for AR and VR include Blender, Maya, and Cinema4D. Yet there are numerous other programs are available, any software that can export 3D models in an .OBJ format is compatible. Blender, an open-source platform, is widely adopted for 3D modeling and animation due to its flexible workflows and, notably, its cost-free access. Maya and Cinema4D are both powerful, industry-recognized alternatives that offer extensive functionality, although their licensing fees are relatively high (PCMag, 2022 [1,2]). Based on prior experience with Blender and its cost-effectiveness, Blender emerged as a clear choice for this project.

Regarding AR development software, three options were evaluated: Unity, Adobe Aero, and Trace AR. Unity is a robust platform well-suited for developing complex AR and VR experiences but comes with a steep learning curve. Its capabilities are enhanced by its support for custom code scripts, which adds flexibility but increases technical difficulty. Adobe Aero, by contrast, provides a more accessible user interface, particularly for those familiar with the Adobe Suite. Aero's feature set, while more streamlined than Unity's, is comprehensive enough to support a relatively large AR experience and offers geographic pinning options. Moreover, Aero allows for QR-code generation, enabling broad accessibility by linking the AR experience to a simple scan.

The third option, Trace AR, offers a plug-and-play AR creation tool that enables users to drag and drop assets from a pre-existing library. While Trace AR holds promise for a future where AR creation is accessible to a wide audience, its primary limitation is its reliance on users installing the app to view experiences. Additionally, as Trace AR is still in beta, access requires an invitation from its development team. Given my limited experience with coding and familiarity with Adobe software, Adobe Aero presented the optimal balance between functionality and ease of use, making it the most suitable choice for this project.

Figure 53 summarizes the production pipeline. The process begins with initial sketching and storyboarding, followed by 3D modeling in Blender, and finally, interaction design and deployment within Adobe Aero. This streamlined approach ensures an efficient workflow while allowing for the creative flexibility required for this project's AR application.

Augmented Reality production Pipeline
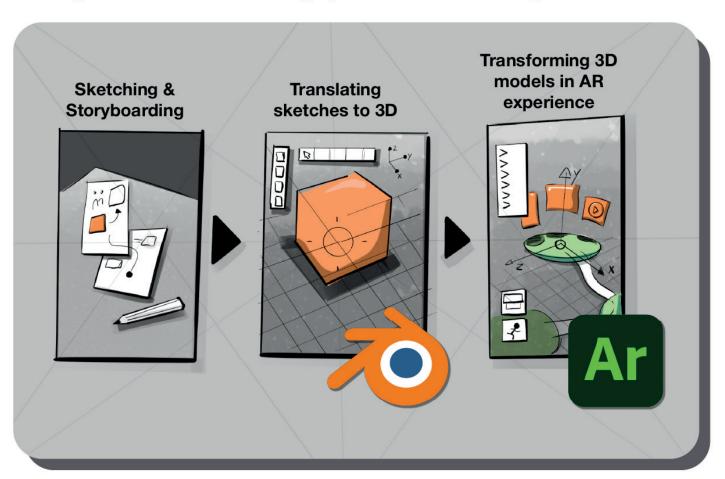
Figure 53: AR Production Pipeline

3.3.3.2 Design for AR Principles

Based on the previous information, an AR toolbox can be crafted which can be used as an anchor and guide when building an experience. The following "principles" followed from a multimedia analysis, that identified tips & tricks from content creators online, as well as own insights when tinkering with the software pipeline. These principles are shared below with a short description and implementation tips.

There is a total of 12 principles, and they have been subdivided equally in three groups which are explained below:

• **Interaction Guidelines (1-4):** These are guidelines to keep in mind that improve interactions between the users and the experience. These are important to keep in mind, as they can make the experience fun and satisfying instead of frustrating.

• **Practical Guidelines (5-8):** These are guidelines to keep in mind when designing and programming the experience. These guidelines are mostly important for the designer, as they cover a range of practical tips that make building and loading the experience quicker. However, there are also some accessibility guidelines here.

• **Abstract Guidelines (9-12):** The last guidelines are more abstract, and mention designerly ways of thinking that can help when building the prototype.

1 Tutorial Island

■ INTERACTION
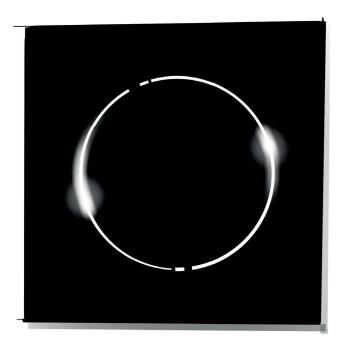
Introducing users to the AR experience through a controlled tutorial environment helps them become familiar with the interface and interactions before they engage with the full experience.

Implementation Tips;
1. Design a simple, isolated area where users can learn the basics without pressure.
2. Use this space to introduce core mechanics and visual cues in a straightforward manner.

2. Interactivity = Glow
■ INTERACTION
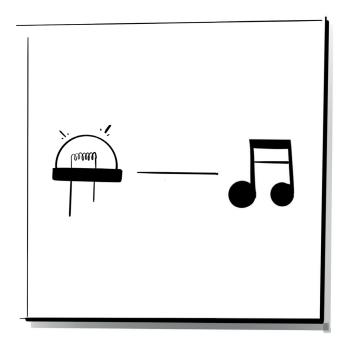
3. Feedback Mechanisms
■ INTERACTION

In traditional websites, interactions are simple, usually involving the mouse. In 3D AR, interactions need to be communicated differently as there is no mouse. Interactable items should grab users' attention through visual cues like glow, bounce, or arrows.

Implementation Tips:
1. Use consistent visual signals for interactive elements.
2. Test different cues to ensure they are noticeable and intuitive for users.

Multi-sensory feedback mechanisms are vital. For example, when a button is pressed, it should activate something, move slightly, and perhaps make a sound. This feedback ensures users know their actions have an effect, preventing confusion and frustration.

Implementation Tips
1. Implement subtle movements or sound cues when users interact with AR elements.
2. Ensure feedback is consistent across different interactions to build user confidence.

4. Context
■ INTERACTION

Context awareness in AR ensures that elements harmonize with the user's environment, enhancing realism and usability.

Implementation Tips
1. Consider environmental factors like lighting, colour schemes, and physical space. Next to that, it is important to be considerate and make experiences so that they do not hinder traffic and pedestrians for safety reasons.
2. Design AR elements to adapt to or complement the surrounding context

5. Proximity & Scale
■ PRACTICAL
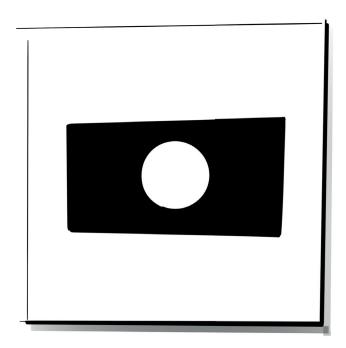
In AR, spatial awareness and the correct scaling of elements are crucial for creating an immersive and seamless experience. Proper placement and sizing of AR elements ensure they integrate naturally into the user's environment, enhancing the sense of presence and usability.

Implementation Tips
1. Regularly test and iterate to find optimal placements.
2. Utilize simple 3D blocks to prototype spatial arrangements before finalizing designs.

6. Contrast
■ PRACTICAL
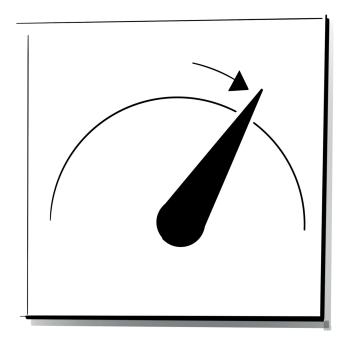
7. Optimization
■ PRACTICAL

Contrast is essential for guiding users' attention. It serves as a crucial tool for wayfinding and creating a clear and navigable AR world.

Implementation Tips
1. Consider the environment where the AR experience will take place and adjust colours and contrast accordingly.
2. Use backdrops or background planes that contrast with the real environment to enhance the visibility of key AR elements.
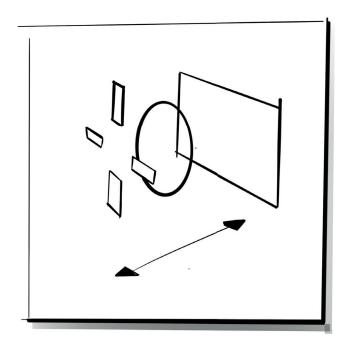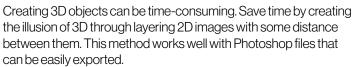
Optimization ensures that the AR experience performs well across different devices and conditions, providing a consistent user experience

Implementation Tips
1. Optimize assets and 3D models to reduce load times and processing demands. Do this by keeping the number of vertexes and information in the models low. Make strategic use of shading as well. Cell shading (The shading style used in my prototype) is excellent for this.
2. Test the AR experience on various devices to ensure broad compatibility and performance stability.

8 Depth & Layers
■ PRACTICAL

Creating 3D objects can be time-consuming. Save time by creating the illusion of 3D through layering 2D images with some distance between them. This method works well with Photoshop files that can be easily exported.

Implementation Tips
1. Leverage tools like Photoshop to design layered 2D assets.
2. Experiment with the distance between layers to enhance the 3D effect.

9 Skeuomorphism
■ ABSTRACT

Using metaphors and skeuomorphisms helps make the AR experience more literal and straightforward, reducing confusion and frustration. This approach turns abstract AR elements into familiar, real-world objects.

Implementation Tips
1. Introduce familiar objects and metaphors to ease user interaction.
2. Avoid over-reliance on skeuomorphism; blend it with novel AR-specific design elements to create unique experiences.

10. AR Lens

ABSTRACT

11. Iterative Cycle

ABSTRACT
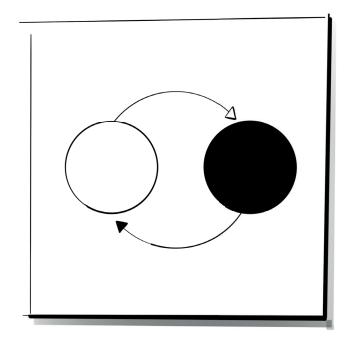
AR is a medium that enhances reality, offering opportunities for creativity and innovation beyond the constraints of the physical world. Designers should trust their intuition and push the boundaries of what is possible.

Implementation Tips
1. Encourage creative thinking and experimentation within the AR environment.
2. Balance this creativity with user accessibility and comprehension in mind. MAYA (Most Advanced, Yet Acceptable) is an important principle to consider
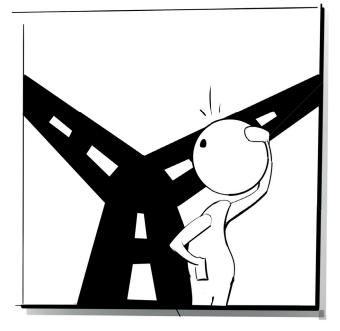
The iterative design process is crucial in AR, allowing for continuous improvement and refinement based on user feedback and testing.
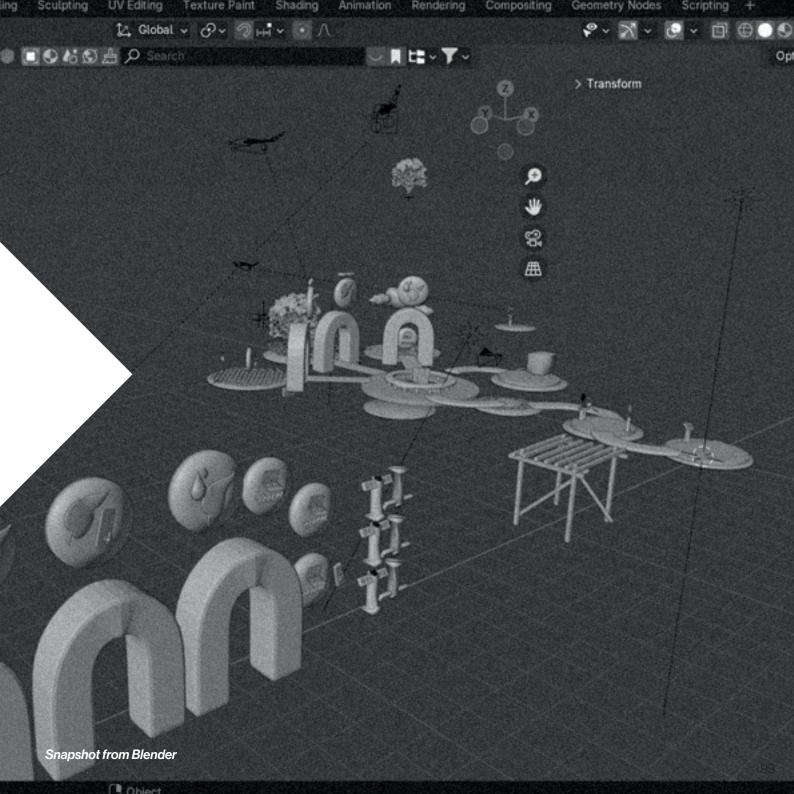
Implementation Tips
1. Incorporate user feedback and testing data into each iteration, test quickly with peers and test scale with yourself.
2. Stay flexible and willing to adjust designs based on real-world testing outcomes, this also translates to your 3D modelling production pipeline. Be flexible and keep changes adaptable. By making lots of backups and organizing work, one can save a lot of time retracing steps when necessary and save heartache when software crashes

12. User Journey & Wayfinding

ABSTRACT

A well-structured user journey in AR ensures that users can navigate the experience intuitively, with clear paths and transitions.

Implementation Tips

1. Map out the user journey and identify key interaction points.
2. Design intuitive transitions and wayfinding aids to guide users through the experience. Test the flow to ensure it aligns with user expectations and minimizes frustration.

Global

Search

> Transform

Z

Y   X

Snapshot from Blender

Object

3.4 Synthesis; *Connecting the Dots*

With insights gathered across the previous domains, the following synthesis connects each facet to create a pathway forward, demonstrating how integrated communication strategies and immersive tools can strengthen sustainable engagement in Carnisse.

3.4.1 Building the Backbone

Having established the potential of immersive technologies, specifically AR, as a powerful learning tool, incorporating structured learning frameworks like Bloom's Taxonomy (Figure 54) offers a logical next step for transforming passive information sharing into active, participant-driven engagement. Bloom's Taxonomy, developed in 1956, provides a structured approach to organizing learning goals and objectives, progressing from basic understanding to more complex cognitive skills. This framework helps not only to clarify the "why" behind the transfer of knowledge but also to design educational modules that facilitate active, meaningful engagement with content (Armstrong, 2010).

In this framework, AR can become a dynamic medium that moves beyond traditional modes like websites, posters, or letters, transforming learning into an interactive, layered experience. Immersive experiences can tell stories to be remembered, explain concepts to be understood, create interactions where knowledge is applied and analysed, and lastly visualise new scenarios that students can evaluate or even improve upon when creating new ideas.

The framework is the backbone that enables inhabitants to progress from understanding to applying sustainable practices in a way that resonates with their day-to-day experiences, as opposed only accessing information and then doing nothing with it.
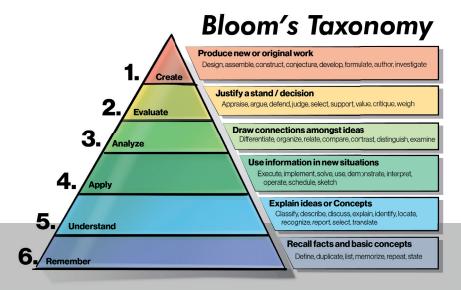
Figure 54: Latest version of Bloom's Taxonomy (Armstrong, 2010)

3.4.2 Consciously Communicating

If this future is to be envisioned, a shift from passive- to active learning is required. Passive learning is very much synonymous to the current "one-way-street" style of communication currently employed by the municipality essentially pushes information onto residents without inviting interaction (Figure 55). When residents attempt to engage, they face a Kafkaesque bureaucratic process, making it extremely difficult to voice their opinions. This issue is compounded by the lower literacy levels in Carnisse (Wijkprofiel Rotterdam, 2024).

The antonym is Active Learning, where learners construct knowledge interactively, with guidance from the teacher (Figure 56). Active learning promotes more engagement and interaction, and research suggests it leads to better understandability and memorization (Keep, 2021).

The problem with Active Learning is that it is difficult to setup. A good teacher is required, who actively asks questions and engages with its classroom. Preparation time for these 'lessons' increase cost. This is problematic, regarding the fact that the municipality is already struggling with time and manpower.

As a result, active interaction can be simulated with AR (Figure 57). Immersive experiences that are tailored towards the inhabitants of Carnisse can be crafted to lower the Cognitive Loads when assimilating information. It provides another flavour to choose from, and due to the novelty can become something that is spoken about with neighbours, family and friends, thus sparking a movement. Next to that, the interactivity element builds upon choice, inhabitants can choose what they want to learn, strengthening self-governance and self-efficacy.
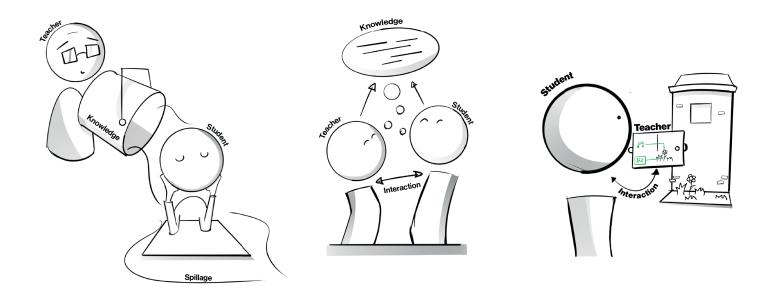
Figure 55: Passive Learning

Figure 56: Active Learning

Figure 57: ImmersiveLearning

3.4.3 Measuring Motivation

Currently, the municipality's approach relies on residents' intrinsic motivation to stay informed and engaged. However, there is a clear misalignment between the municipality's expectation of self-efficacy and the actual willingness of inhabitants to participate (Sociaal en Cultureel Planbureau, 2020; Burmanje, 2022). A structured approach to motivation could bridge this gap and foster stronger engagement. Self-Determination Theory and the Motivation Continuum (Visser, 2017) (Figure 58) provide a valuable framework for shifting from externally driven motivation to intrinsic, value-driven motivation, thereby encouraging sustained involvement'.

This framework differentiates between "wantivation" (intrinsic, personal value-driven motivation) and "mustivation" (extrinsically motivated by obligation). By aligning AR experiences with residents' values and emphasizing direct benefits, AR can foster "wantivation" that is rooted in residents' sense of value and interest. For instance, AR experiences that visualize a cleaner, greener neighbourhood not only illustrate the impact of sustainable behaviours but also appeal to personal and community benefits, thus encouraging intrinsic motivation. Over time, this approach can drive a deeper connection to sustainability and CE principles, enhancing residents' self-efficacy and willingness to engage in ongoing municipal efforts.

The Motivation Continuum

Context	Extent to which basic psychological needs (of autonomy, competence, and relatedness) are satisfied					
Type of motivation	**Amotivation** Feeling unable and unwilling, finding nothing interesting or important	**Controlled motivation** "mustivation"		**Autonomous motivation** "wantivation"		
		Extrinsic motivation		Internalized motivation		Intrinsic motivation
Reason for behavior	**Inactivity** Passivity, avoidance, oppositional behavior	**External pressure** Doing something because of external pressure (punishments, rewards, threats)	**Internal pressure** Doing something because of internal "musts" and expectations	**Usefulness-driven** Doing something because experienced usefulness, relevance	**Value-driven** Doing something because it fits with one's own deeply held values	**Interest-driven** Doing something because it is interesting or enjoyable
Effects	Insecurity, fear of failure, resistance, apathy	Tension, anxiety, little engagement and persistence, dissatisfaction	Feelings of guilt, shame, low sense of self-worth	Sense of volition, pleasure, energy, persistence, deeper learning, performing well, gratification		

© 2017. Translated version adapted from Visser, C.F. (2017). Leren & presteren. Just-in-Time Books.

This figure is based on the work by Richard Ryan and Edward Deci and many other researchers in the field of Self-Determination Theory. The terms mustivation and wantivation were coined by Maarten Vansteenkiste.

Figure 58: Motivation Continuum by Visser (2017)

By applying Visser's proposed strategies that frame information as *Usefulness-*, *Value-* and *Interest Driven*, self-efficacy as well as motivation can be strengthened. This relation is illustrated in Matrix 2, and is also outlined in self-efficacy theory by Albert Bandura (Lopez-Garrido, 2023). It is also interesting to note that self-efficacy can be strengthened by Imaginal Experiences (=basically portraying goals as achievable, and the most likely outcome) (Maddux, 2013). This further supports the case for using AR, as immersive experiences can be designed to facilitate these imaginal experiences, reinforcing both motivation and self-belief.
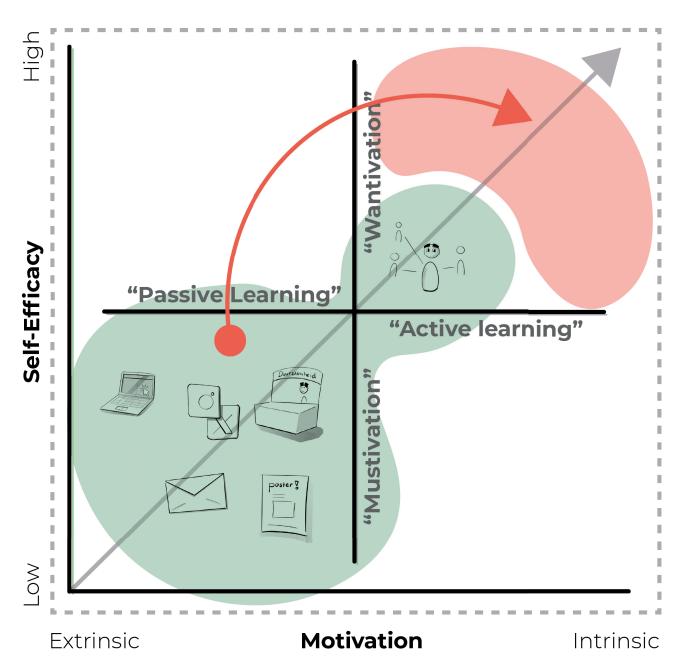
Matrix 2: Self-Efficacy and Motivation

3.4.4 Establishing the Framework

When combining the Motivation Continuum, Self Efficacy, Active & Passive Learning and plotting the Municipality's current communication methods, we get Matrix 3.

This matrix highlights where communication gaps currently exist and gives direction on how to continue. By considering "Active Learning" and fostering "Wantivation", self-efficacy can be improved. AR can be leveraged to bridge this gap, and create communication channels that resonate with the inhabitants while teaching them a thing or two.
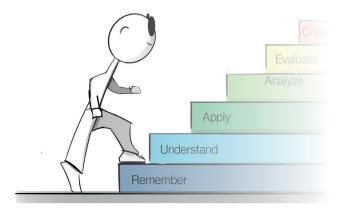
Matrix 3: Overlaying Motivation & Self-efficacy Matrix with plot of Paradigms

3.4.5 Summarising the Lesson:
Sensemaking
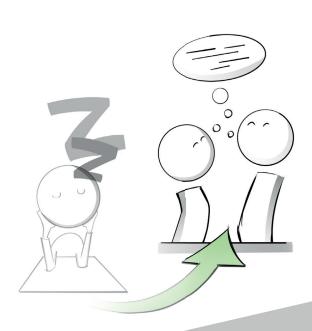
To conclude this chapter, the scope goes beyond communication and incorporates learning as well communication. By broadening this scope, lessons and strategies from Bloom's Taxonomy, Self Determination Theory and lastly Active vs. Passive learning can be used to create actionable design strategies. These strategies are shown below.

1.
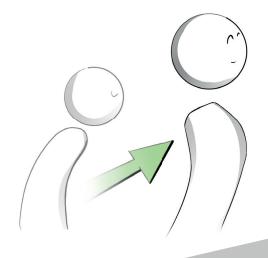
Bloom's ■ Taxonomy

When sharing information, keep the taxonomy in mind. Focus first on Remembering and Understanding, explain ideas and concepts. Afterwards move towards to applying that knowledge, analyzing the world with this newly gathered knowledge, forming an own opinion by evaluating and lastly creating new original work. **This progression ensures that residents become active participants rather than passive receivers of information.**

2. Active vs. Passive ■ Learning
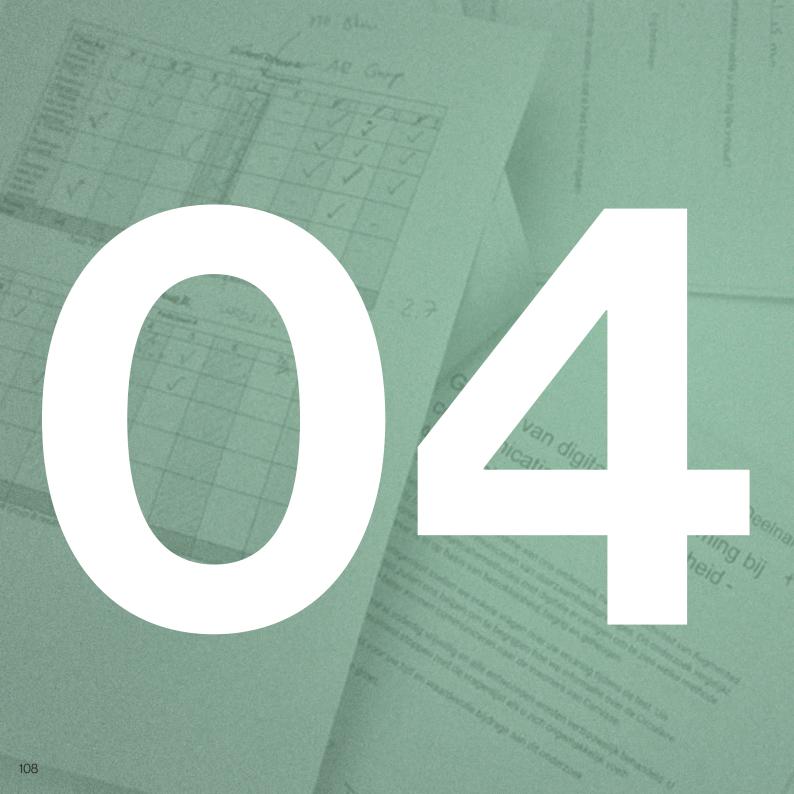
Create immersive learning experiences that move away from the one-way street style of communication. **Create interaction and a way that facilitates Feedback Loops**. AR can facilitate this shift, making abstract concepts tangible and interactive.

3. Self Efficacy & Determination ■ Theory

Go towards Intrinsic Motivation, or "Wantivation", by making the information that is shared:

- **Usefulness driven:** Make sure that the information becomes actionable and useful in day to day life. How can the inhabitants leverage the absorbed information to make their life more fulfilling and gratifying? And how can they use the gathered motivation immediately instead of letting it fade away?

- **Value Driven:** Make sure that the information provided fits with the beliefs and values of the inhabitants of Carnisse. Speak their language. For instance, show the benefits of more green in a visual way and plain way, that is in line with municipal policy. This way, the "Cautious Neighbour" can see what something looks like and mentally prepare. Make sure their questions are answered.

- **Interest Driven:** Make something enjoyable, and highlight personal and community benefits, such as improved quality of life, social cohesion and shared responsibility.

04

Results

The theoretical framework from the previous chapter needs to be put to the test. As a result, this chapter will delve deeper into the developed prototypes and their corresponding tests. This chapter will function as practical evidence on the effectiveness of AR as a communication tool in Carnisse, and eventually Leidschendam.

To start, the first prototype will be reviewed, and the executed A/B test results will be shared. Afterwards, the improved prototype will be shared alongside the small-scale validation and triangulation test.

The insights from the aforementioned prototypes and tests have been used to develop a Future Strategic Direction in the form of a Roadmap.

Based on this test and its results, an iteration was designed that incorporated improvements and is validated in Rotterdam Carnisse and Leidschendam Fluitpolderplein, two areas with similar profiles. The results were triangulated to see if generalisation for the application of AR was possible.

Furthermore, three strategies with the learned lessons from this thesis will be shared.

And to conclude, a summarisation of the design process will be shared in the form of a Design Evolution. This evolution will link back to the Delft Innovation Method, and give more insight in executed experiments and the design process.

In this chapter:

4.1 Prototype 1: AR Website Translation

The first AR prototype, *The AR Website Translation*, was developed to test AR as a communication medium by translating the content of the municipal website "Wat is een Circulaire Economie?" into an interactive experience. The two media formats were then compared in an A/B Test. The prototype was built on insights from the AR Toolbox discussed in Chapter 3.3.3 to align with cognitive load principles and optimize user engagement.
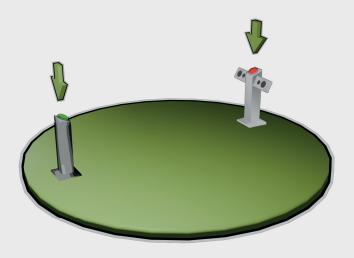
To enhance user comprehension, the prototype presented information in a linear path supported by audio narration and visual aids, designed to reduce Extraneous Load and maintain focus on key concepts. By synchronizing audio and visual elements, it aimed to increase Germane Load, allowing users to concentrate on the most relevant information without cognitive overload. The following sections detail each stage of this prototype's development. All stages of the prototype are shared below.

4.1.1 A Green Start

This stage functioned as a gateway to AR, and provided the users with a short tutorial that learned participants the ropes of what interactions were necessary to complete the tour. Users were tasked to press the red button, look around to find the green button and press that, and eventually continue to the next stage. The isolated stage can be found in Figure 59.

4.1.2 The Essence of Circurity

After finishing the tutorial, a wooden deck appears that guides the user towards the first content-related stage. Here, it is explained what Circularity means for Rotterdam, and recyclability and durability are highlighted. This information is synchronised and starts from left to right, as to not overstimulate the user. Figure 60 shows an isolated view of this stage.
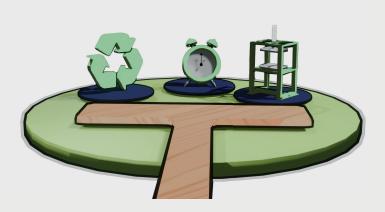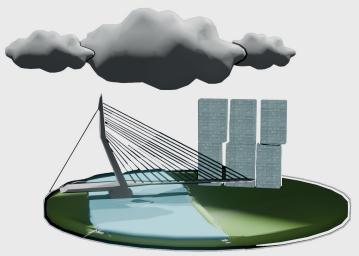
Figure 59: Overview of "A Green Start"

Figure 60: Overview of "The Essence of Circularity"

4.1.3 City in Movement

In the "City in Movement" stage, the user is greeted with a miniature of the Erasmus Bridge, the "de Rotterdam" building, and the Nieuwe Maas River. This stage aims to demonstrate why sustainable behavior within a circular economy is essential. Climate change impacts our society, and fluctuations in water levels must be considered to build a resilient city. Since these challenges can feel distant, AR is used to bridge the psychological distance, bringing the issue closer to home. Figure 61 shows an isolated view of this stage.

4.1.4 Transforming Trash into Treasure

The next path appears, and the user is tasked to walk towards the hydraulic press. This machine is a visual metaphor for the transition of waste becoming products. Plastic bottles are compressed, and as the press rises, a new bottle emerges. This stage aims to shed a light on the production process that is usually kept in the shadow outside of the inhabitants reach. Figure 62 shows an isolated view of this stage.

Figure 61: Overview of "City in Movement"
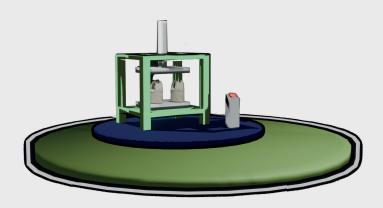
Figure 62: Overview of "Transforming Trash into Treasure"

4.1.5 Balance for the Planet

This stage aims to simplify the Planetary Boundaries principle by showing a simple supply and demand graph that relates to materials. The user is greeted with the Reuse, Reduce, Recycle strategies on top of a table, and can press the corresponding button to see the effect these strategies have over the supply of materials.

This stage aims to put the user in a position where they can directly see what effect these strategies have on the grander scheme of things, and make this concept more tangible. Figure 63 shows an isolated view of this stage.
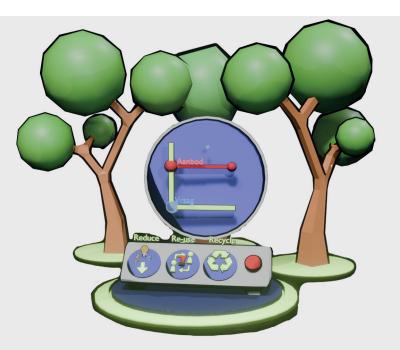
Figure 63: Overview of "Balance for the Planet"

4.1.6 The Sustainable Path

Lastly, the user is shown a television and a closing message that acknowledges that this transition is a daunting task. Yet by tackling it in a stepwise manner a change can be made. Apart from being difficult, this transition can also be fun, adding more green makes cities more liveable. Engaging with neighbours improves social cohesion and quality of life. Sharing has the power to lower costs, which means money can be spent elsewhere. There is light at the end of the tunnel, and the journey is part of the destination, which is why we all should contribute. Figure 64 shows an isolated view of this stage.

Figure 64: Overview of "The Sustainable Path"

4.1.7 The Total Overview

Figure 65 shows the total overview of the immersive experience, that has been made to fit in the Zuidplein Library as well as the Amelandseplein within Carnisse. A pilot test has been executed with this prototype, which can be found in Appendix E.

Figure 65: Total Overview of Prototype

4.2 Test Results AR Website Translation: *A/B Test*

In this section, the results of the AR Website Translation proto-type A/B Test are shared. A total of 16 participants have been tested, 8 in control Group A and 8 in AR group B.

The data has been collected using paper questionnaires, and these results can be found in Appendix F. As explained in the method, quantitative data has been collected via Likert Scales and answers to the questionnaire. In addition, Qualitative data

has been gathered via open-ended questions and loosely structured interviews with the participants after the tests.

These interviews provided deeper insights into participants' experiences and helped identify latent needs, which can be leveraged in future iterations of AR tools for Municipal use. First, the Quantitative Results will be reviewed, followed by the Qualitative Results.

4.2.1 Quantitative Results
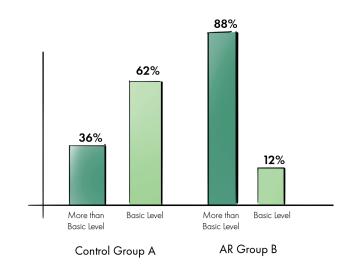
This section will discuss the Quantitative Results gathered from the A/B test. Tables containing the summarised results will be shared here, but for the complete tables Appendix G can be consulted.

Respectively, results covering the introductory questions, Engagement, Comprehension, and finally Retention & Memorization will be shared.

4.2.1.1 Introductory Questions

The introductory questions helped organize the experiment, with the question "How much do you know about sustainability?" serving as a gauge for the accuracy of the results. Notably, 38% of Control Group A reported a "more than basic" understanding of sustainability principles, whereas 88% of AR Group B did (Graph 1). This difference needs to be considered when interpreting the results.

Participants were recruited from the same locations (Zuidpoort Library and Gouwe (Kl)ouwe) and at similar times (14:00 – 17:00), though on different days. Ideally, prior knowledge levels would be comparable across groups to avoid potential biases, but due to time constraints and recruitment challenges, participants were not selected based on this prior knowledge.

Graph 1: Comparison of prior knowledge levels bvetween groups

Testlocation, *Zuidplein Library / Theater Zuidplein*

4.2.1.2 Engagement

To assess engagement, participants completed a Likert Scale evaluating engagement, control, and trust. Additionally, participants estimated the duration of the test, which was used in a Subjective Perception of Time (SPT) test—a scientific method reflecting the idea: "time flies when you're having fun".

The results reveal that AR Group B reported higher average engagement scores (5,75, 5,50 , 6,63 > 4,38, 3,25, 5,75) and lower standard deviations compared to the control group. These findings are summarized in Table 2. Furthermore, participants in AR group B perceived the test duration as shorter, with SPT-test results presented in Table 3.

	Control Group A		AR Group B	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
Engagement	4,38	2,2	5,75	1,39
Control	3,25	1,75	5,50	1,51
Trust	5,75	1,2	6,63	0,74

Table 2: Means and Standard (std.) Deviations comparing engagement

Control Group A		AR Group B	
Average Perceived Time	**Real Time**	**Perceived Time**	**Real Time**
7m56s	6m18s	13m41s	18m49s

Table 3: SPT-Test Results

4.2.1.3 Comprehension

For this part of the study, the answers of the participants to the questions below were compared to specific keywords that represented concepts that participants were exposed to. The questions asked were:

• Can you recite verbally what you experienced during the test?
• Can you explain what a circular economy is?

Points were awarded based on the ability to mention something akin the following relevant keywords and concepts:

1. Reuse, Reduce, Recycle
2. The Climate is changing
3. Waste, we can do something with that
4. Material demand is challenging the supply
5. It is a daunting task, but we can tackle it in a stepwise manner

A summarisation of the results can be found in Table 4. From this table, it can be seen that Control Group A scored lower (mean=1) as opposed to AR Group B (Mean=2,25), suggesting AR can help with comprehension.

	Control Group A		AR Group B	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
Correct Answers	1	0,76	2,25	1,04

Table 4: Summary of Comprehension Results

4.2.1.4 Retention & Memorisation

The Retention & Memorisation test was designed to evaluate the participants' ability to recall and retain information presented during the experiment. This aspect of the study was particularly crucial as it directly relates to the effectiveness of the learning experience facilitated by AR versus the municipal website, and simulated "long-term" memory by calling participants at +-2 weeks after the initial exposure.

The results revealed that participants in the AR Group B exhibited an almost twice as high average retention score (mean=2,71) compared to those in the Control Group A (Mean=1,50).

These summarised results can be found in Table 5.

	Control Group A		AR Group B	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
Retention score	1,50	0,837	2,71	1,38

Table 5: Summary of Retention & Memorisation Results

4.2.2 Qualitative Results

Apart from the Quantitative insights, participants were loosely interviewed. Insights gathered from these conversations and observations are shared in this section.

4.2.2.1 Introductory Questions

When participants were working on the introductory questions, an interesting phenomenon related to the collection of phone numbers and photo consent emerged.

While two participants from Control Group A were uncomfortable sharing their phone numbers, all but one participant from the AR group (who did not own a phone) were willing to provide theirs. Additionally, website participants expressed discomfort with

having their pictures taken and did not consent when asked, which contrasts with the AR participants' greater willingness to engage. These observations suggest that AR might build trust through immersive and interactive experiences, enhancing user confidence and willingness to participate. This trust-building capability could be further investigated in further research, as this evidence is only indicative and not yet concrete.

4.2.2.2 Engagement

Regarding engagement, qualitative insights reinforce the quantitative findings from Chapter 4.2.1.2. Participants expressed enthusiasm for the new technology and noted that the AR experience, despite its longer duration, made time seem to pass more quickly, as reflected in the SPT-test.

Participants valued the interactive elements of AR, which enhanced their immersion and connection to the content. Participants also highlighted AR's benefits for those who struggle with language barriers or limited imagination. They preferred AR over VR due to AR's integration with the real world and its facilitation of interaction with others. Notable quotes include:

- P1: "I liked the concept and understood what happened. *Especially the changing water levels in Rotterdam struck me.*"

- P3: "I like the interactions AR offers. I follow tech trends closely, so I think I would like to see AR on more places, even though it sometimes can be a tad childish, *I just think it's more fun.*'

- P5: "*Such a concept could work well for a big group of people, namely those who struggle with imagining what certain things will look like.*" Quote 2: "However, be cautious of a digital world, Virtual Reality can really suck people into their own bubble, and it becomes difficult to have interactions with them, that's what I like about your variant, as *it still shows the real context and things happening, meaning you are not fully closed off.*"

- P8: "I am the kind of person that finds it difficult to look around and explore whilst listening closely to information. I can focus on one thing thing. Even though the story is quite simple and easy to follow, sometimes I struggled with that. *That's why I liked the fact that you can click buttons multiple times, and you can listen to the parts again.*"

Anonymised Participant, *Zuidplein Library / Theater Zuidplein*

4.2.2.3 Comprehension

The higher comprehension scores in AR Group B from Chapter 4.2.1.3 seem to suggest that AR can be used to enhance understanding of complex topics. The interactive and immersive nature of AR facilitated better engagement with the material, leading to improved comprehension. AR allows users to see and interact with information in a more dynamic and context-rich environment, which according to Cognitive Load theory helps in reinforcing key concepts and principles.

It is interesting that the municipality has opted for a website doctrine that utilises little to no visual aid. This offers little context, and when combined with difficult language this makes the Cognitive Load high, asking a lot of brainpower from the participants.
This became apparent with the following quotes from participants from Control Group A:

- P1 & P2: "We come from Turkey and had trouble with the text. *We did not properly understand it, even though we speak Dutch quite okay.*"

- P4: "*The text felt like I was thrown into a theme without an introduction.* I already knew what Circular means, but a specific context or intro would be nice. *Next to that, the texts do not read that well.*"

- P5: "*I am a language coach at the Zuidplein Library, and I think the written text is too complicated*. *Simple language is key if you want the message to stick to everyone, even those with lower levels of literacy*"

It was interesting to note that P4 experienced the website as topics that were loosely connected. Within AR group B, no participants mentioned this issue. This can stem from the fact that the AR Website translation shared information piecewise in islands, and therefore this might be subconsciously perceived as separate pieces of information. The overarching theme of Sustainability & Circularity connect them, which is visually represented in the path.

The last interesting observation was perceived in the independe of the participants. AR participants went their way with the questionnaire, whereas multiple participants from Group ' clarification on the questions.

4.2.2.4 Retention & Comprehension

The quantitative results suggest that the immersive and interactive nature of AR may contribute to better retention of information. Throughout the test, it was interesting to note that even on the phone, participants from Group B took a stepwise approach when answering the questions. Participants thought aloud and said things in the like of: "At first, I walked here, then I saw this..." etc. On the other hand, participants from group A were in most cases not able to recall specifics, and did not operate in a structured way.

Next to that, it is notable that multiple participants from Group B mentioned that the exaggerations left a lasting impression. These participants were able to recall the specifics of the interactions, and mentioned that it left them thinking about the situations.

Test Desk Setup, *Zuidplein Library / Theater Zuidplein*

4.2 Prototype 2: *Digital Sustainability Tour*

This section focuses on the next iteration of the AR prototype, where the previous insights have been incorporated into the design. Key improvements include the addition of more interactive elements, a stronger narrative flow, enhanced accessibility features, and the introduction of a physical touchpoint that bridges the gap between residents and the municipality. The prototype has also been gamified more to leverage AR's unique strengths, making the experience more engaging and enjoyable.

Through visualizations, a detailed storyboard, and descriptions of the key features, this section will walk through the design process of the new prototype, explaining how it was developed to address the communication challenges identified in previous sections. *The Digital Sustainability Tour* is introduced, offering residents interactive content on Biodiversity, Heat Stress, and Water Floods, chosen for their relevance to the community.

4.3.1 Key Changes

After testing the initial prototype, it became apparent that AR can be a valuable addition to the Municipality's Communication Toolbox. Both quantitative, qualitative and observational insights from the

A/B test informed key design adjustments for this new iteration, which will refine the user experience and communication strategy.

Key changed include:

Exaggerations of long-term effects and visualizations of the impact of certain behaviours resonated with participants. These aspects will be maintained or expanded in the next version to reinforce understanding and engagement.

Interactive elements, such as buttons that affect the digital environment, were highly appreciated by users. Therefore, more interactions will be added to encourage active participation.

To create a consistent starting point, an object that bridges the physical and digital worlds was considered necessary. Research shows that the "disconnect" between residents and the municipality makes dialogue difficult. To address this, a municipal touchpoint, represented by a ballot box, is introduced, offering a space for both information sharing and gathering feedback. This links back to the need for dialogue-based communication, rather than one-way information delivery (Chapter 3.2.1.2)

AR Fatigue , has been taken into account. This phenomenon takes place when participants hold the device for AR for a longer period of time. This can cause cramps and discomfort. As a result, the time the test and experience take should be taken into account.

The language used in the first prototype was identified as overly complex. To improve accessibility, ***a B1 language checker was used to simplify the text.*** Additionally, the narrative flow was described as inconsistent, though not overly distracting. Still, adjustments have been made to streamline the story and maintain focus, ensuring clarity.

In terms of ***Diversity and Inclusion***, the AR experience should mirror the accessibility functions of websites, such as adjustable font sizes, voice recitation, and language selection. A personalization console will be added, allowing users to customize their experience, further aligning with the principles of inclusion and accessibility.

Gamification: AR presents a unique opportunity for gamification, which remains underexplored in previous iterations. This potential has further been leveraged to make the experience more enjoyable and interactive *(see Interest-Driven Motivation in Chapter 3.4.3)*.

Call to Actions have been used to greater effect. By digitally linking relevant webpages from the municipality in the AR experience, participants can immediately access information necessary to start an initiative for themselves. This makes it easier to do something relevant with the discovered information.

4.3.2 The Digital Sustainability Tour

A Digital Sustainability Tour was created, offering basic information about Rotterdam's CE ambitions and three relevant subtopics: Biodiversity, Heat Stress, and Rising water levels. These topics were selected due to their importance to the residents, linking back to the concept of Usefulness-Driven Motivation). Additionally, the experience was designed to be more en-gaging, contributing to Interest-Driven Motivation, with the ultimate goal of fostering intrinsic motivation in users *(see Chapter 3.4.3)*.

A new feature was introduced to connect the physical and digital worlds; a municipal touch-point. In this case, the touchpoint is a ballot box, where participants can leave their feedback, symbolizing a communication channel between the residents and the municipality. This idea stems from the preliminary research, which highlighted that the residents of Carnisse often feel unheard *(see Chapter 3.2.3)*. This manifested itself into a Ballot Box (Figure 66), which can be seen as a municipal touchpoint.
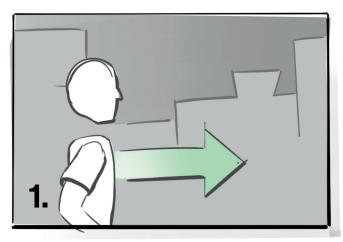
Figure 66: Ballot Box used as starting point and Feedback Mechanism
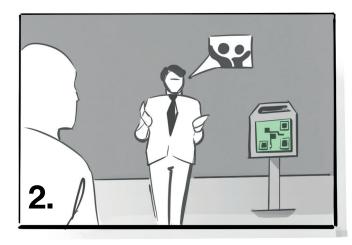
4.3.2.1 The Storyboard

A storyboard (Figure 67) was used to develop this new iteration. The following steps highlight the gist of this new iteration. Afterwards, an overview image of the full iteration is shared in Figure 68.
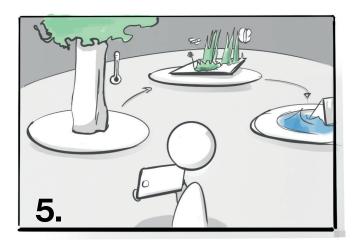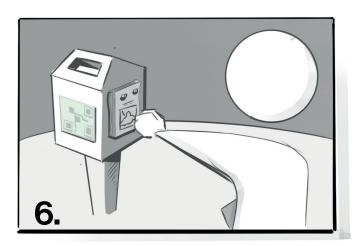
Arrival at the Ballot Box: The participant walks towards the ballot box.
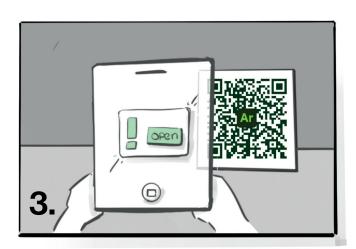
Introduction by a Municipal Official: The first time the ballot box is introduced, a municipal official explains the project.
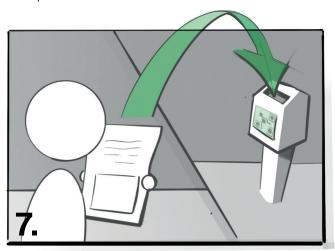
Immersive Journey: The participant walks through the experience, engaging with the content in the order they chose.
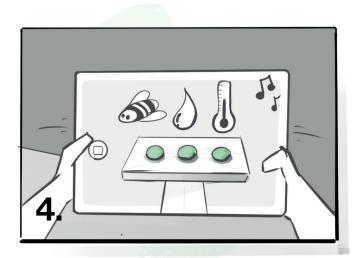
Reflection Form: The participant is given a form to reflect on their experience and share their opinions.

Figure 67: Storyboard Drawing of the Digital Sustainability Tour

3.
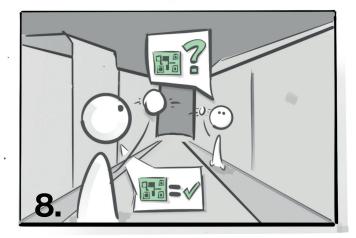
Scanning the QR Code: The participant uses their own smart device to scan the QR code. This grants access the AR experience.

4.

Element of Choice: The user is introduced to the Circular Economy and the municipality's plans. They can then choose to explore one of three subtopics: Biodiversity, Heat Stress, or Rising water levels.

7.

Ballot Submission & Feedback mechanism: The participant drops their feedback in the ballot box, which will remain at the location for approximately two weeks to encourage further participation.

8.

Community Engagement: Local Leaders and Event Enthusiasts (as identified in Chapter 5) are expected to act as early adopters. Through word-of-mouth, they will spread awareness and encourage others to participate, creating a wave of community interest.

4.3.2.2 Overview of The Digital Sustainability Tour

The new iteration was built using Adobe Aero, and a detailed overview can be found in Figure 59. The steps outlined in the storyboard are expanded upon, showing how each stage functions. Full images of the iteration can be found in Appendix H, including the text that is recited to participants at each stage. Below, all stages of the new iteration are shared and numbered. The numbers correspond to the numbers on the overview image to the right.

Another notable change in the design is the replacement of the ballot box with a door. This door acts as a portal to the digital information and was chosen because it sparks curiosity more effectively than a ballot box. To illustrate, the ballot box is quite logical, it is used to gather opinions. However, when there is a random door, people will wonder: "What is this door for?" and investigate. Next to that, the door can still retain the functionality of collecting feedback through a mailbox, so no functionality is lost.

This prototype was also pilot tested, of which the results can be seen in Appendix I.

Rundown of Stages:

1. **Diversity, Inclusion, & Accessibility:** Personalization options, such as adjustable font size and language selection, will enhance the experience for all users, ensuring that the AR platform is accessible to individuals with varying needs and preferences.

2. **Tutorial Island:** A new feature designed to guide first-time users through the AR experience, ensuring they understand how to interact with the system and navigate the various features smoothly.

3. **What is a Circular Economy?:** This section introduces participants to the basic concept of the Circular Economy, explaining how it differs from traditional economic models and why it is important for creating sustainable communities.

4. **Why do we need a Circular Economy?:** This segment expands on the necessity of adopting a Circular Economy, illustrating its potential to reduce waste, promote resource efficiency, and contribute to a more sustainable future for Rotterdam.

5. **How can we make Rotterdam more biodiverse?:** This topic focuses on Biodiversity and explores ways to increase green spaces and protect local ecosystems, emphasizing the importance of a healthy, diverse environment in making the city more resilient.

6. **How can we combat Heat Stress?:** In this section, participants learn about Heat Stress and its growing impact on urban areas, particularly in Rotterdam. The content includes strategies for reducing heat-related risks through urban design and community action.

7. **How can we combat rising water levels?:** This part addresses the challenge of rising water levels and flooding, providing insights into Rotterdam's water management strategies and actions residents can take to contribute to flood prevention efforts.

8. **Closing Message:** A final message to reinforce the importance of community involvement and continuous feedback in shaping the future of Carnisse, encouraging participants to engage with sustainability initiatives and share their thoughts with the municipality.

Access to Prototype:

If you want to test out the prototype for yourself, scan the QR-code on the right page. To do this, you need to install the Aero viewer app in the App- or Google Play store. Make sure you have enough space, and always beware of your surroundings!

4.4 Test Results Prototype 2: *Carnisse & Fluitpolderplein*

This section discusses the final validation test, conducted at the Zuidplein Library in Carnisse and the Fluitpolderplein Library in Leidschendam. A total of ten participants, five from each location, engaged with the Digital Sustainability Tour prototype, followed by a loosely structured interview or reflectionnaire. The goal was to determine whether reception toward the prototype remained consistent in neighbourhoods with similar profiles.

The results of the interviews are detailed in Appendix L, where filled-in reflectionnaires and interview notes can be found. Although the reflectionnaire was initially intended as a written questionnaire, it was more effective to discuss the questions verbally with participants, using the form to document their responses.

4.4.1 Key Findings

The Key Findings from this final experiment will be shared in this section, subdivided in comments about Engagement and Perceived Value AR has in Communication. Then, speculations and considerations of Participants on future use-cases are shared.

Afterwards, Contextual Relevance will be reviewed. Next to last, the interaction and accessibility will be reviewed and lastly key considerations in the form of Action Points are shared.

4.4.1.1 Engagement and Perceived Value

Overall, participant engagement remained high across both locations, with users describing the experience as interactive, visually stimulating, and informative. The inclusion of gamified elements and an emphasis on choice within the AR environment kept participants curious and motivated to explore further. Notably, participants in both Carnisse and Leidschendam valued the novelty and interactivity of AR, often expressing that it was more engaging than a traditional website or printed material.

Participant 1 (Carnisse) found the visual and interactive elements compelling, noting that AR could enhance learning for complex topics in high school settings. *They were especially interested in seeing AR applied at local landmarks, such as Erasmus Bridge, to visualize floods in real time*: *"I would be curious to see AR come to life at contextually relevant locations in Rotterdam, like at the Erasmus Bridge, for example, so you can see a flood in real-time."*

Participant 1 also appreciated the engaging format, stating, *"It is always fun to receive information in a visual and animated way. Next to that, exploring the content at your own pace and discovering everything is nice."*

Participant 3 (Carnisse) *highlighted AR's versatility and portability, saying, "It is cool that AR can be used in any space."*

Participant 5 (Carnisse) noted the usefulness of AR as a novel technology to share information. She expressed gratitude that this important subject was gaining attention among younger generations: *"Such a clear explanation is very useful. Done intelligently. A lot is covered, but it remains well-organized".* and *"Finally, I just want to say that I'm glad to see a younger generation working on something I've always felt was important, but in which I often felt quite alone. Fantastic!"*

Participant 7 (Leidschendam) valued the gamified interactions, explaining that AR's cause-and-effect elements effectively conveyed information. *They suggested that AR would be particularly valuable in educational settings where complex Cause-Effect relations can be explained visually and interactively.*

4.4.1.2 Envisioning an Immersive Future: *in an educational and public setting*

Participants across both locations saw clear potential for AR in educational settings, such as schools, libraries, and museums. They expressed that the visualizations made abstract or complex topics more tangible, especially in subjects like history, social studies, and the environment. The prototype's format allowed users to explore topics at their own pace, which several participants noted as a key strength of AR for learning environments.

Participant 3 (Carnisse) saw value in using AR at museums or monuments, where history could be brought to life: *"It would be*

interesting to use AR in different contexts, like on monuments or during history classes, to let the past come to life. Next to that, it would be fun to use in social studies classes."

Participant 8 (Leidschendam) suggested that AR could be a meaningful addition to town halls, where residents in waiting rooms could engage with sustainability content. *They also envisioned using AR to show future urban situations, turning city planning into participation and giving a voice back to the inhabitants.*

4.4.1.3 Contextual Relevance: *Bringing Sustainability towards your doorstep*

While Carnisse participants were engaged with the Rotterdam-centered content, some in Leidschendam expressed a desire for the experience to include more locally relevant information. This finding highlights the importance of contextual relevance in AR experiences to create a more personal and meaningful connection for users. Participants suggested tailoring the content to specific neighbourhoods, such as highlighting relevant subsidies or projects in Leidschendam.

Participant 9 (Leidschendam) found the visuals captivating but *felt they would have connected more deeply if the content was tailored towards Leidschendam*. They suggested adding

practical steps residents could take in their own neighbourhoods, like setting up façade gardens or applying for subsidies, specifically for Leidschendam.

Participant 10 (Leidschendam) noted an increased interest in sustainability after the experience, wanting to apply similar practices in Leidschendam: *"I'd like to know more about how we can do similar things here (in Leidschendam)".* This feedback indicates that while AR content can have a broad appeal, contextually relevant information makes the information actionable and more urgent.

4.4.1.4 Interactions and Accessibility

Feedback on usability was generally positive, though several participants noted that the experience could be further enhanced with additional interactive elements. Minor usability challenges included some difficulty with orientation within the AR environment, suggesting the need for a tutorial feature to guide first-time users.

Participant 3 (Carnisse) experienced some *"AR fatigue"* when using a tablet, indicating that a shorter or more modular experience might reduce user fatigue. Yet also mentioned a preference for the openness of AR over VR, noting that AR allowed them to remain engaged with their surroundings.

Participant 6 (Leidschendam) appreciated the simplicity and clarity provided by the visualizations, which helped maintain focus on key messages without overwhelming them with text. *They also emphasized the benefit of using imagery and analogies to convey complex ideas, further reinforcing the accessibility of the AR experience.*

4.4.1.5 Lessons Learned: *Action Points for Improvement*

The results indicate that AR can be an effective tool for engaging and educating residents on sustainability topics, with both Carnisse and Leidschendam participants responding positively to the format and interactivity of the Digital Sustainability Tour. Key considerations from this test include:

● **High Engagement across Contexts:** The gamified elements and interactive design of the AR experience were well-received by participants, maintaining their interest and encouraging exploration of sustainability concepts.

● **Potential for Broader Educational Applications:** Participants from both neighbourhoods expressed enthusiasm for seeing AR in schools, libraries, and public spaces. This supports AR's applicability in municipal and educational contexts where active learning could enhance public understanding of sustainability topics.
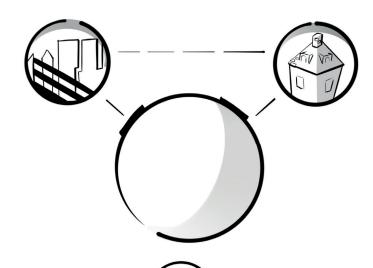
● **Importance of Local Relevance:** To optimize impact, AR experiences should include location-specific content. While Rotterdam-based content was effective in Carnisse, Leidschendam participants wanted information relevant to their neighbourhood, suggesting that localized adaptations may facilitate deeper personal connections and encourage action. From a logistical point of view, generic models can still be used, but it is important that a level from the experience refers to something of contextual importance.

● **Usability and Accessibility considerations:** Feedback on interaction flow, AR fatigue, and user orientation suggests that AR experiences can be improved. The tutorial should be more clear, and visual cues that support wayfinding and interactions can be leveraged to a greater effect to make the experience more accessible to a larger audience.

● **AR as a kickstart to Action:** Participants across both locations felt that AR facilitated a better understanding of how they could take concrete steps toward sustainability. Linking the experience to real-world actions, such as subsidies and neighbourhood initiatives, was particularly valued, as it provided immediate pathways to action.

Figure 69: Comparison between Rotterdam and Leidschendam

Fluitpolderplein in front of Library, Leidschendam

4.5 Future Strategic Direction

Building on the insights from the previous chapters, this chapter outlines three strategic directions that can be used to implement AR in a way that not only informs, but also involves and empowers residents as well as municipal officials in shaping their community's future.

These strategies are based on Bloom's Taxonomy *(Chapter 3.4.1)* and follow a structured progression through Inform & Remember, Analyze & Apply, and finally Evaluate & Co-create. This approach aims to deepen residents' learning and partic-ipation, evolving from basic awareness to active involvement and ultimately to collaborative creation through AR. These strategies are designed to accommodate varying levels of knowledge and engagement, addressing different personas within the community.

With the ultimate goal of improving levels of proactiveness and collectivism amongst inhabitants, resulting in higher levels of self-efficacy and the emergence of more citizen-led initiatives.

4.5.1 Incorporating AR in the Municipality

In Chapter 3.3.2.4, it was stated Immersive Technologies are slowly gaining a foothold in municipalities. Both the municipality of Rotterdam and Arnhem have executed pilots with AR and VR respectively to immerse inhabitants in new municipal plans (Snoep & Kramer, 2024; Van der Heijden, 2024). Rotterdam has even gone one step further, and they have set up the "De Digitale Stad" subdivision, which released its new vision document at the time of writing this thesis (Rotterdam in Transformatie, 2024). Within this document, an Open Urban Platform has been discussed, highlighting the possibilities and advantages a Digital Twin can have on the city.

Within this document, AR, VR and XR are identified as opportunities for Rotterdam, and the Open Urban Platform, that basically functions as a digital hub for inhabitants. Within this platform, the vision is that inhabitants become creators and can share information about for example services that can be delivered but also participation. The first version of the platform will be released in 2025. In this version, data from the real world (like locations of buildings, trees etc.) will be shared in a digital environment. In the future, the Open Urban Platform should become a portal in which inhabitants can become active as well. Inhabitants could make profiles, explore the "digital" city, or apply for permits. The municipality embraces the idea of the "Citiverse", where it is possible to visualise new building plans in real-time, and simulate the effects. And they envision the following:

❧❧ In the Citiverse, it will be possible to calculate these plans in real time and comprehensively assess their effects, with various visualisation options: through holo-tables for resident participation, via augmented reality at the physical construction site, and through the 3D city model accessible from any location (and in any form). ❧❧

The "Rotterdam in Transformatie" document paints a bright picture for Immersive Technologies, yet all these plans are only still that, plans. Still a plethora of challenges before this becomes a reality. The document is still visionary, and there is not yet a list of actionable steps. As a result, the following three strategies could be used to guide and help municipal officials create immersive experiences that connect with inhabitants.

4.5.2 Three Proposed Strategies

As stated before, the three strategies build upon Bloom's Taxonomy. Next to that, the strategies have been formatted into a "roadmap-like" structure, that has been made in accordance with the "Design Roadmapping" book by Lianne Simonse (2024). Yet instead of having multiple horizons that are sequential, the proposed strategies can be executed simultaneously. The individual strategies have independent end-goals, that relate to the personas from *Chapter 3.2.4.1* The strategies include:

1. Inform & Remember
Digital Sustainability Tour

2. Analyse & Apply
Walk-Through Participation

3. Evaluate & Co-Create
Democratising Open Urban Platform

4.5.2.1 Strategy 1: *Inform & Remember*

The accessibility and visibility of sustainability and CE goals can be improved by adding Digital Sustainability Tours. The primary aim of this strategy is spread the message to the inhabitants of Carnisse in a way that resonates with them. Making minimal use of letters, the tour aims to immerse users in information that is usefulness-, value- and interest driven. Figure 69 shows an impression of this.

By placing these tours in public locations like the Zuidplein Library, Amelandseplein or Gouwe (Kl)ouwe, the information becomes visible and community driven, as opposed to letters, posters and websites which usually are targeted towards the individual.

This strategy enables the shift towards a more collectivist mindset by providing easy-to-access AR experiences that everyone can understand and engage with. Due to this, residents are more likely to view sustainability as a shared responsibility, rather than an isolated, faraway goal. The communal learning experience unlocks a sense of togetherness, building the foundational idea that sustainability benefits the entire community and requires collective effort. This desired shift is visualised in Figure 70.
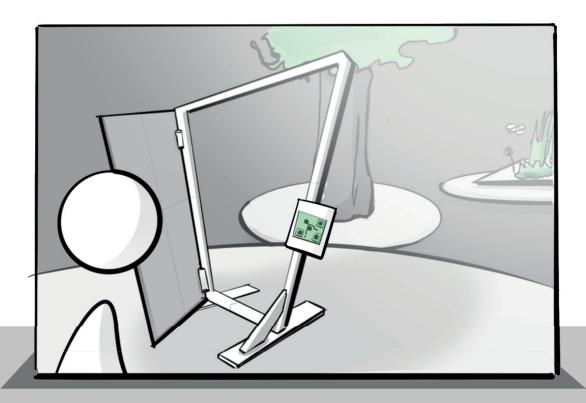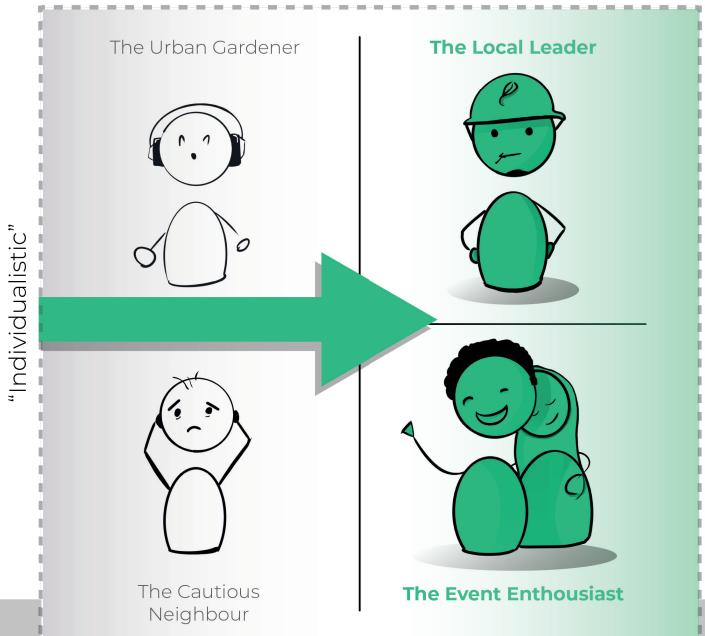
Figure 69: Visualisation of Strategy 1: Inform & Remember

"Proactive"

The Urban Gardener

The Local Leader

"Individualistic"

"Collectivist"

The Cautious Neighbour

The Event Enthousiast

"Reactive"

Figure 70: Desired effect of Strategy 1 on personas of Carnisse

4.5.2.2 Strategy 2: *Analyse & Apply*

Basic Sustainability and CE knowledge can be used to analyse the current situation in the neighbourhood. In this scenario, AR can be used during participation events. Participants are given access to preset models that come with sustainable innovations referring to, but not limited to biodiversity, heat stress and water management. These models can then be placed in the real environment, and instead of having participation events in conference rooms, the event takes place in the neighbourhood. Figure 71 shows an impression sketch of this.
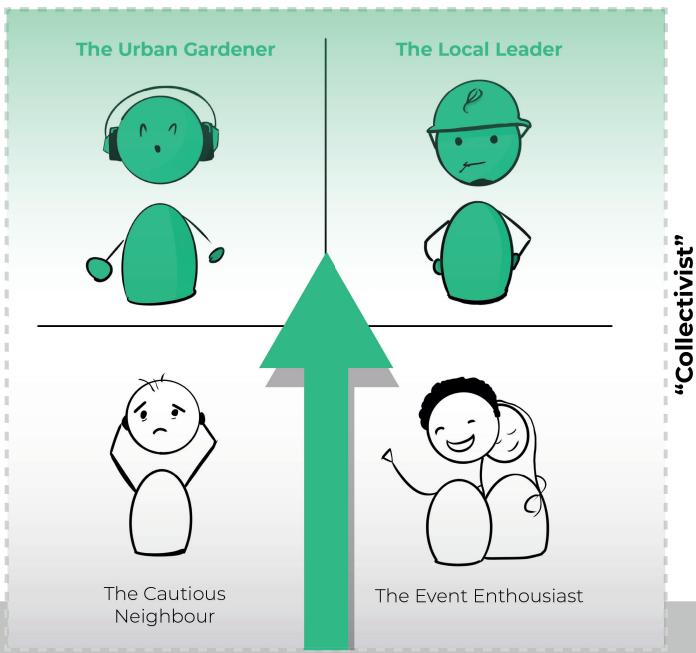
This enables the shift to a more Proactive Mindset, while the municipal officials show effort by coming to the inhabitants and giving them the tools to "design" their own streets. This desired shift can be found in Figure 72.

Figure 71: Visualisation of Strategy 2: Analyse & Apply

"Proactive"

The Urban Gardener

The Local Leader

"Individualistic"

"Collectivist"

The Cautious
Neighbour

The Event Enthousiast

"Reactive"

Figure 72: Desired effect of Strategy 2 on personas of Carnisse

4.5.2.1 Strategy 3: *Evaluate & Co-create*

The last strategy is also the most futuristic. With an Open Urban Platform as suggested by the Rotterdam in Transformatie (2024) document, inhabitants can upload their own ideas for improvement. Others can support ideas they like via voting systems or comment sections, and as a result the Municipality of Rotterdam can act accordingly. Figure 73 shows an impression of this. More residents are empowered to launch their own initiatives, driven by an enhanced understanding of sustainability and the CE principles, possibilities are communicated in a clear way, and increased trust is fostered through the Open Urban Platform, where it can be leveraged to turn inhabitants into "architects" of their own neighbourhood, instead of just being bystanders.

This enables the shift towards a more Proactive and Collectivist mindset. Inhabitants are given the tools to become architects of their own community, and have a platform to share their visions of how the neighbourhood of the future looks like. This desired shift can be found in Figure 74.
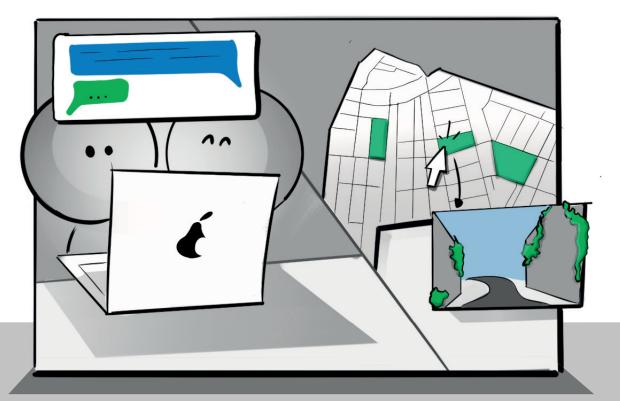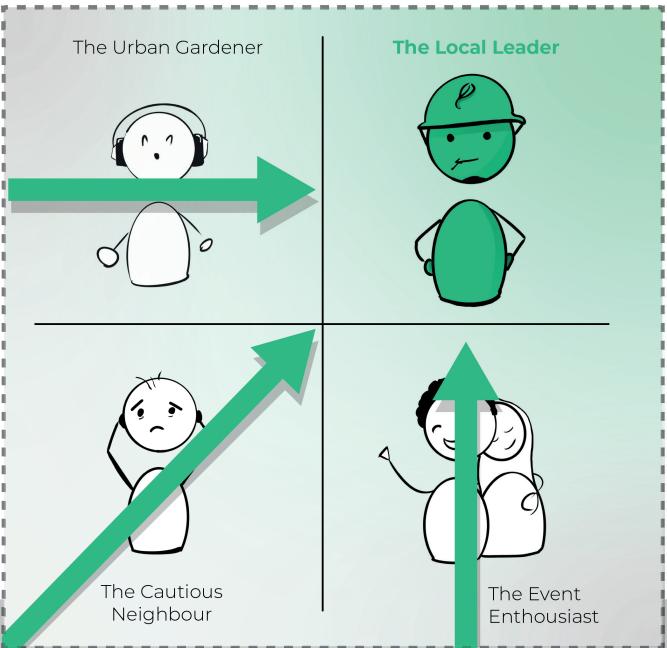
Figure 73: Visualisation of Strategy 3: Evaluate & Co-Create

"Proactive"

"Collectivist"

"Individualistic"

The Urban Gardener

The Local Leader

The Cautious
Neighbour

The Event
Enthousiast

"Reactive"

Figure 74: Desired effect of Strategy 3 on personas of Carnisse

141

04 | Results
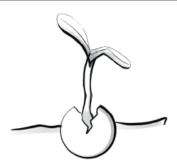
4.5.2.4 Overview of Strategies

The overview of these strategies can be found in Figure 75, and each strategy will be explained in more detail in the next pages. Within the overview, the analogy of a garden is used. In the growth phase, plants require tender, love and care consistently. Only after the plant has established a strong network of roots, can it thrive.

Goal:
What should we achieve by when?

How?
Some pointers in how to achieve this goal

So;
Summarizing Visualisaiton

1ST Strategy
Inform & Remember

2ND Strategy
Analyse & Apply

3RD Strategy
Evaluate & Co-create

"Planting the Seed"

"Watering the Plant"

"Fostering a network of Strong Roots"

Improving **Accesibility** and **Visibility** of sustainability goals via AR tours, placed in friendly neighborhood locations. These expereiences are used to **Inform** inhabitants about sustainable practices to be **Remembered**.

Using Sustainability and CE knowledge to **Analyse** the current situation of the neighbourhood, and **Apply** this information to voice an opinion during participation events.

Leveraging the **Open Urban Platform** to give inhabitants a voice so they can share **Co-Created** ideas and **Evaluate** the ideas of others.

- Provide AR experiences where your target audience is, in contextually relevant locations (ie. at Libraries, Town halls or initiatives)

- Use simplified language (B1) and clear visualisations

- Make the content usefulness-, interest- and value driven.

- Host AR-enabled community events where residents can place prebuilt 3D-models of sustainable innovations in real-time and see what they look like in the neighborhood with AR.

- Give inhabitants the freedom to respond. Either during the event, or at a later date digitally.

- Make the Open Urban Platform user-friendly and accesible for inhabitants.

- Pay close attention to motivated inhabitants, and reach out to them. Provide them with information that can help them set up their own initiative, and make everything as easy as possible.

Figure 75: Overview of Strategies

143

4.6 Design Evolution

In Chapter 2.1, the Delft Innovation Method was introduced. Throughout this project, this specific method has been used with some adjustments. Figure 76 shows an illustrated Design Evolution, which gives an overview of different tests, experiments and iterations that were made before eventually coming up with the AR Translation and The Digital Sustainability Tour.

In order, the experiments, MVP's and Prototypes were:

Experiment 1: Testing a simple AR experience, where a QR code was used to pin a small television which could play an animation. From this prototype, I got my first experience with tracing and locking AR objects into the real world.

MVP1: In MVP 1, simple tiles with a tree and a bench were made. These tiles could be placed within the environment, and were a proof of concept that showed the potential of AR. This MVP was tested with David de Zwart, a municipal official from Leidschendam. From the talk, it became apparent that AR has the power to visualise things that are not really there, a beneficial strength that can be leveraged in participation sessions.

Due to the realistic nature of the models used, the experience was rather slow and sluggish. Meaning a different approach to modelling was required.
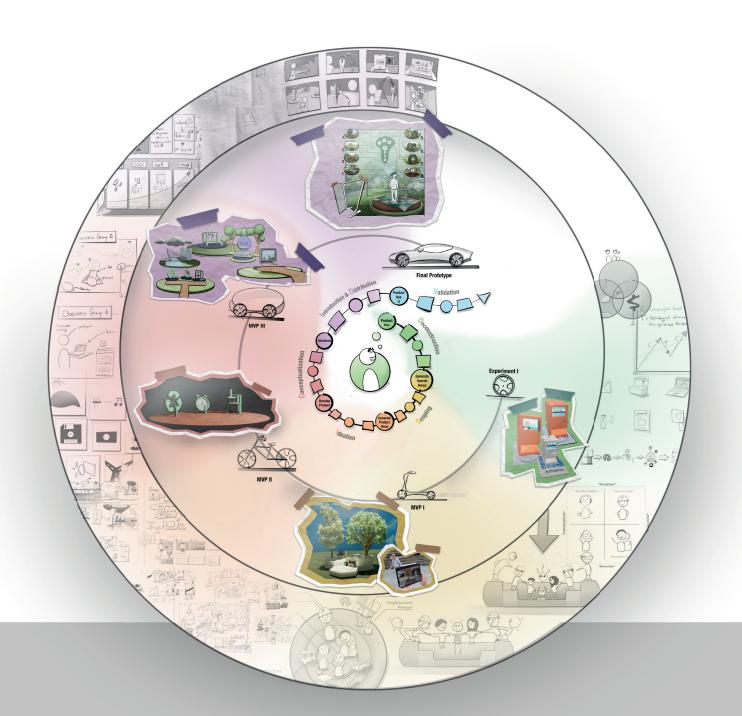
MVP 2: Building on MVP1, MVP2 introduced "islands" where abstract sustainability and CE concepts could be explained in a playful, cartoonish style using cell-shading. This technique reduced processing demands, addressing the performance issues encountered in MVP1 and allowing a smoother experience while adding a distinct and memorable style.

MVP3: This MVP essentially became the AR Website Translation, this prototype was tested with 16 participants on engagement, comprehension and retention versus a municipal website. In this iteration, I learned to improve immersive experiences with the Cognitive Load Theory in mind. By synchronising information and tackling the production process with a pipeline that resembles videography, information could be delivered in a synchronised and simple way, making it easier for people to follow.

Final Prototype: This became The Digital Sustainability Tour, and was used in a validation exercise with inhabitants of Carnisse and Leidschendam. The final prototype is a standalone sustainability tour about Rotterdam and its ambitions and strategies to work towards a CE. While the tour is portable and can be used everywhere, its effectiveness is probably highest in Rotterdam, as the tailored attention to recognisable models like the Erasmus bridge and "De Rotterdam" positively influences the distance between the problem and the user. Meaning the message hits closer to home.

Figure 76: Design Evolution that visualises the process

05

Discussion

This section discusses key limitations of the study and provides recommendations for future research. The study's exploratory nature and use of prototypes offered insights into the AR as a tool for municipal communication on Sustainability and CE principles. However, several methodological constraints, participant dynamics, and procedural choices influenced the outcomes. These factors offer valuable lessons for future reference, to help and avoid facing the same pitfalls.

In this chapter:

5.1 Limitations of the Study

Sample Size and Group Distribution
The findings of both the first as well as the second test were based on a relatively small sample size of respectively 16 and 10 participants. Additionally, in Prototype Test 1, the groups were not evenly distributed when looking at levels of prior knowledge of sustainability and CE principles amongst participants. Although a prior knowledge question was included, it was not effectively used to dictate group assignments. Future studies should consider appointing participants based on their initial knowledge levels to achieve balanced group distribution, which would enhance the reliability of comparative results.

Novelty Effect of AR Technology
A potential novelty effect, or "wow-factor," may have positively influenced participants' responses. AR technology, being relatively new, may have led participants to rate the experience more favourably due to its novelty rather than its intrinsic qualities as an effective learning tool. This effect could diminish over time, transforming AR from an engaging experience into a perceived gimmick. It is essential to acknowledge this possible bias in interpreting results and consider that future iterations of the tool might need to incorporate sustained value to remain engaging over time.

Technical and Accessibility Barriers
While AR shows promise in enhancing engagement, it may pose technical challenges or accessibility barriers, especially for users with low digital literacy levels. It is important to note confusion could arise while navigating the experience, as well as device-related limitations in the performance of hardware, which is especially relevant in Carnisse when taking into regard the fact that it is a lower-income neighbourhood. The inhabitants must not be expected to have flag-ship phones to see the experiences. These challenges can hinder broader adoption in not only Carnisse, but the whole of Rotterdam South. Therefor it is recommended to situate AR experiences in within accessible locations like public libraries, community centres or town halls, where on-site assistance as well as hardware could be available to guide users through the experience.

Time allocation in Contextual Analysis Phase
The extensive contextual analysis of Carnisse provided valuable insights, but has diverted time and resources that could have been used for deeper collaboration with Municipal stakeholders. Although interviews with subdivisions from the municipality like Rotterdam Circular and De Digitale Stad provided some insights, establishing a more direct partnership with the Municipality of Rotterdam could have offered a clearer understanding of municipal needs for an AR communication tool. More intensive collaboration with the municipality probably would have enhanced the practical relevance and potential scalability of the tool, from the perspective of the municipality.

Recruitment Challenges and Testing Methods
The study initially aimed to conduct random sampling in Carnisse; however, interactions with residents proved challenging, and some negative encounters led to adjustments in recruitment strategy. Testing was subsequently conducted in more controlled environments, such as public libraries and the Gouwe (Kl)ouwe initiative, which limited the representativeness of the sample. Testing in familiar public spaces likely created a more comfortable environment for participants but may have reduced the diversity of perspectives. Future studies should consider recruiting participants from varied locations across Carnisse to achieve a more representative sample.

5.2 Recommendations for Future Studies

Partnering with Organizations for increased Authority
A recommendation for future projects is to begin with a partnership with a recognized organization, such as Rotterdam Circular, the Municipality of Rotterdam, or a local library. Collaborating with established stakeholders could streamline the project, facilitate participant recruitment, and provide greater authority for planning focus group sessions and prototype tests. Alternatively, collaboration with social design agencies like Zeewaardig or Muzus could enhance credibility and allow for structured, professionally guided testing events. Collaborating with an organization could also alleviate some of the communicational challenges faced in this study, such as difficulties in securing meetings and recruiting participants.

Larger Scale Pilots
Partnering with an organisation, as mentioned before, could open doors for larger scale pilot tests. It would be interesting to conduct a pilot test within the municipality, to measure doubts and questions of municipal agents. Next to that, pilot tests can be executed across different neighbourhoods in Rotterdam South to provide additional data on scalability, and could be used to identify areas for improvement. Lastly, it would be beneficial to see whether the municipality has the resources to develop AR prototypes in-house, perhaps within the division of De Digitale Stad, as this could save costs and give the technology a foothold within the municipality.

Conducting Group-Based Testing
Testing individual inhabitants provided qualitative insights, but was a timely endeavour. Conducting group-based tests, preferably as part of community events or workshops, could provide rich data on how AR experiences are received in social contexts. Next to that, it would allow for more participants in a shorter duration of time. Lastly, it would be interesting to see whether participants engage in collaborative learning and / or discussion.

Random Sampling and Recruitment in Public Spaces
For more robust and generalisable findings, future studies should explore random sampling across various public locations in Carnisse. Interactions in public spaces can be unpredictable and uncomfortable, sampling from a diverse set of (random) locations would provide a more accurate reflection of the neighbourhood's perspectives. To allow this, the presence of multiple researchers could create a safer and more structured setting for testing, resulting the whole of Carnisse of Rotterdam South can be reached instead of just libraries and initiative locations.

Exploring AR beyond Inform & Remember
Apart from Inform & Remember, it would be interesting to build and test AR-prototypes that incorporate Analyse & Apply as well as Evaluate & Co-Create functionalities, to see what the response is towards different activities that can be facilitated with AR. The hypothesis being that co-designing one's own neighbourhood is an activity that enhances trust, gives a sense of pride & ownership and increases Social Cohesion within the area. According to Wijkmonitor (n.d.), this especially is desired in Rotterdam South.

Long-Term Memory and Retention Studies
It would be interesting to have studies that take long-term memory into account. Perhaps another A/B test can be conducted in which an improved AR prototype is compared with a website, and participants are asked to recall information +-2 months after exposure. It would be interesting to see what sticked.

All-in-one Experience
Lastly, it would be beneficial to turn the AR environment in an all-in-one experience, meaning that no extra steps, apart from scanning the QR-code with a smart device are necessary to complete the tour and establish communication. This would make the concept easier to scale, and would integrate everything nicely in a single package.

06

Conclusion

This research started with the question of whether and how AR can be used to make CE principles more engaging, comprehensible and memorable for the households of Carnisse. The study started off with a contextual analysis kickstarted to answer why sustainability and the CE are such elusive concepts, how Rotterdam currently communicates and what their pitfalls are when reaching Carnisse and lastly to learn if and how AR has been used in past cases, and what its strengths and weaknesses are in communication.

On top of that foundation, two prototypes were developed to compare the effectiveness of AR versus a municipal website, and assess if reception towards AR can be generalised between neighbourhoods with a similar profile.

This chapter concludes this graduation thesis, and the main- and subsequent sub-research questions will be answered.

In this chapter:
6.1 Answering the Main Research Question
6.2 Answering the Sub-Research Questions

6.1 Answering the Main Research Question

" *Can Augmented Reality be used to make Circular Economy Principles more engaging, comprehensible and memorable, to the households of Carnisse?* "

The results of the A/B test indicate that AR can indeed enhance engagement, comprehension, and memory retention among households of Carnisse regarding CE principles. This outcome can largely be attributed to principles from Cognitive Load Theory: in this specific research, the prototype was designed to optimize Germane and Extraneous Load, while minimizing Intrinsic Load by delivering synchronized information in manageable, segmented bits. Participants rated the AR prototype higher on *Engagement*, *Comprehension*, and *Retention* than the municipal website, suggesting that AR could be an effective tool for conveying complex information.

After the initial test, the prototype was improved to respect the rules of the Motivation Continuum by Visser, as well as improve upon points of feedback mentioned by participants. *The Digital Sustainability Tour* contained information that was useful for participants, aligned with their values and was made more interesting through gamification and the novelty of AR. Allowing information to be presented in a different flavour than plain text. Amongst the participants that were tested in Carnisse and Leidschendam, this Immersive Experience was received positively.

In Rotterdam, inhabitants suggested that it would be interesting to see Immersive Experiences at famous landmarks. This could speak to imagination more, yet the downside would be that the experience is bound to a specific location, lowering potential for scalability. Par-

ticipants envisaged the Immersive Experience as well suited for use in libraries, schools, during participation events and lastly at monuments or museums. At all of these locations, AR could be used as an engaging storytelling device with the potential to teach and reach.

In Leidschendam, participants expressed a desire to see more contextually relevant highlights. The Digital Sustainability Tour was still tailored towards Rotterdam, and for participants from Leidschendam this felt further away. While a tailored experience would be preferable, participants still were excited about the idea, and saw the experience working in schools, libraries, but also in a town hall, where participants can immerse themselves in an experience while waiting for their appointment and learn something in the process. Next to that, it was noted that AR can work at asylum seeking centers, where language barriers can be bridged with Immersive Storytelling.

In conclusion, participants were optimistic about AR's potential for public engagement and foresaw its use in various settings. Ensuring that AR experiences incorporate contextually relevant content, such as local landmarks or familiar "insider knowledge", would establish a sense of connection and help ensure that the message resonates. While further refinements in interactivity and local contextualisation are necessary, these findings suggest that AR could serve as a valuable tool in sustainability and CE communications.

6.2 Answering the Sub-Research Questions

SRQ1 〃 *What makes sustainability & the Circular Economy such difficult concepts to grasp for inhabitants of Carnisse?* 〃

Sustainability and CE concepts are inherently complex, often conveyed through specialised terminology and abstract, long-term perspectives. For residents of Carnisse, this language can feel disconnected from their immediate concerns. Those with lower literacy levels may particularly struggle to engage with text-heavy, goal-oriented explanations. Additionally, the political framing of these topics adds another layer of confusion, as Sustainability is often associated with left-leaning values, whereas CE concepts may seem more appealing to the right. Integrating AR, which provides a way to experience these ideas more concretely, offers a promising solution for bridging these comprehension gaps.

SRQ2 〃 *What are the current communication strategies of Rotterdam, and how do these connect with the inhabitants of Carnisse?* 〃

Rotterdam currently relies on various communication strategies, text-based materials such as newsletters, websites, and posters are meant to inform residents about sustainability goals. However, residents in Carnisse often view these channels with suspicion or lack of interest, there is an "allergic reaction" towards things that "smell" like the Municipality due to previous negative interactions (or lack thereof). Next to that, there is a strong disconnect between the municipality's expectation of Self Efficacy levels of inhabitants versus the reality, which drives a wedge in expectations. Municipal messaging is largely top-down and filtered through a bureaucratic structure that dilutes messages and hinder timely and clear communication. Although recent initiatives have sought to increase local engagement, a more context-sensitive and accessible approach is needed to establish a genuine connection with the community. AR technology has the potential to work around some of these limitations by providing a direct, interactive way for residents to engage with sustainability and CE content, creating goodwill and showing effort towards the inhabitants of Carnisse.

SRQ3 *❯❯ Why can AR be implemented successfully (or not) within the domain of municipal communication, and what are important considerations when crafting a novel AR experience? ❯❯*

AR holds promise for successful integration into municipal communication due to its ability to make complex information more accessible and engaging. As seen in previous studies, AR has been used effectively to reduce Intrinsic and Extraneous loads, while improving Germane Loads, ultimately lowering the Cognitive Load of learning. Next to that, AR has the power to facilitate Situated Learning experiences, that strengthen effective learning in contexts that may otherwise feel remote. Connecting these findings with Self-Determination Theory, AR has the potential to unlock intrinsic motivation, or "wantivation".

For residents of Carnisse, AR offers a way to visualize and interact with sustainability and CE concepts, bringing abstract ideas "close to home." Essential considerations for implementing AR include ensuring contextual relevance by incorporating local settings or references. Furthermore, AR experiences should be intuitive and accessible, as overly complex interfaces risk overwhelming users. Practical design choices, such as simplifying interactions and aligning content with residents' values, can optimize AR's effectiveness in municipal communications. While further iterations and testing will be necessary, this research suggests that AR could be a powerful tool for enhancing engagement, understanding, and action related to sustainability and CE initiatives.

References

Abad-Segura, E., González-Zamar, M.-D., Luque-de La Rosa, A. L. L., & Morales Cevallos, M. B. (2020). Sustainability of Educational Technologies: An Approach to Augmented Reality Research. Sustainability, 12(10), 4091. https://doi.org/10.3390/su12104091

Aggarwal, P. (2024, February 25). The Rise of Metaverse: Unveiling the Future of Virtual Spaces. Medium. https://medium.com/@pratiksha098/the-rise-of-metaverse-unveiling-the-future-of-virtual-spaces-497f14763218

Ahn, S. J. (Grace), Le, A. M. T., & Bailenson, J. (2013). The Effect of Embodied Experiences on Self-Other Merging, Attitude, and Helping Behavior. Media Psychology, 16(1), 7–38. https://doi.org/10.1080/15213269.2012.755877

AlleCijfers. (2024, August 4). Ranglijst van het hoogste en laagste gemiddelde inkomen per inwoner van de wijken in de gemeente Rotterdam (8 april 2024 bijgewerkt). AlleCijfers.nl. https://allecijfers.nl/ranglijst/hoogste-en-laagste-inkomen-per-wijk-in-de-gemeente-rotterdam/

Apple Vision Pro. (2024 Apple. Retrieved May 31, 2024, from https://www.apple.com/apple-vision-pro/

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An Overview of Augmented Reality. Computers, 11(2), Article 2. https://doi.org/10.3390/computers11020028

Armstrong, P. (n.d.). Bloom's Taxonomy. Vanderbilt University. Retrieved September 25, 2024, from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Arnhem Direct (2018, April 5). Virtual Reality expeditie in Arnhem Zuid. Arnhem-Direct.nl. https://www.arnhem-direct.nl/berichten/virtual-reality-expeditie-in-arnhem-zuid/

Asher, T., Ogle, E., Bailenson, J., & Herrera, F. F. (2018). Becoming homeless: A human experience. ACM SIGGRAPH 2018 Virtual, Augmented, and Mixed Reality, 1–1. https://doi.org/10.1145/3226552.3226576

Ates, Ö (2024). Interview about the Municipality of Rotterdam, the subdivision Rotterdam Circular and initiatives in Carnisse.

Bacca, J., Baldiris, S., Fabregat, R., & Kinshuk. (2018). Insights Into the Factors Influencing Student Motivation in Augmented Reality Learning Experiences in Vocational Education and Training. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.01486

Bastinck, J. (2023, November 3). 'Circulair is meer dan recyclen alleen' — Noorderzon 010. https://www.noorderzon010.nl/duurzaam-in-noord/circulair-is-meer-dan-recyclen-alleen/

BBC. The 1968 photo that changed the world. (n.d.). Retrieved September 12, 2024, from https://www.bbc.com/future/article/20230511-earthrise-the-photo-that-sparked-an-environmental-movement

Benjamin Keep, PhD, JD (Director). (2021, May 14). When Active Learning Goes Right (And Wrong) | How Learning Works [Video recording]. https://www.youtube.com/watch?v=6EZ8rN5NJXw

Binytska, K., Bilyakovska, O., Yankovych, O., Buchkivska, G., Binytska, O., Greskova, V., Ocheretna, I., Burov, O., & Lytvynova, S. (2020). Implicit Potential of Immersive Technologies Implementation in the Educational Process at the Universities: World Experience: Proceedings of the 1st Symposium on Advances in Educational Technology, 264–274. https://doi.org/10.5220/0010930700003364

Bjørn, A., & Hauschild, M. Z. (2013). Absolute versus Relative Environmental Sustainability. Journal of Industrial Ecology, 17(2), 321–332. https://doi.org/10.1111/j.1530-9290.2012.00520.x

Blok, V., Gremmen, B., & Wesselink, R. (2015). Dealing with the Wicked Problem of Sustainability: The Role of Individual Virtuous Competence. Business & Professional Ethics Journal, 34(3), 297–327.

Boulding, K. E. (1966). The Economics of the Coming Spaceship Earth. Johns Hopkins University Press., H. Jarrett (ed.) 1966. Environmental Quality in a Growing Economy, pp. 3-14. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.

References

Boyer, S. (2009). A Virtual Failure: Evaluating the Success of Nintendo's Virtual Boy. The Velvet Light Trap, 23–33. https://doi.org/10.5555/vlt.2009.64.23

Breng, haal of ruil spullen en planten bij pop-up winkel De Moeite Waard -. (n.d.). Retrieved April 30, 2024, from https://rotterdamcirculair.nl/nieuws/de-moeite-waard-een-circulaire-winkel-voor-en-door-de-buurt/

Brown, B. J., Hanson, M. E., Liverman, D. M., & Merideth, R. W. (1987). Global sustainability: Toward definition. Environmental Management, 11(6), 713–719. https://doi.org/10.1007/BF01867238
Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning.

Buijs, J. (2012). The Delft Innovation Method A Design Thinker's Guide to Innovation. Faculty of Industrial Design Engineering, Delft University of Technology.

Bulten, E., Hessels, L. K., Hordijk, M., & Segrave, A. J. (2021). Conflicting roles of researchers in sustainability transitions: Balancing action and reflection. Sustainability Science, 16(4), 1269–1283. https://doi.org/10.1007/s11625-021-00938-7

Burmanje, S. (2022). De Erkenningsmethode | TU Delft Repository. Retrieved November 14, 2024, from https://repository.tudelft.nl/record/uuid:aaa6d3c4-95bc-4a89-bd61-aeadcb52ee16

Carlowitz, H.-C. von. (1732). Sylvicultura Oeconomica Oder Haußwirthliche Nachricht und Naturmäßige Anweisung zur Wilden Baum-Zucht Nebst Gründlicher Darstellung Wie ... Dem allenthalben und insgemein einreissenden Grossen Holtz-Mangel, Vermittelst Säe- Pflantz- und Versetzung vielerhand Bäume zu rathen ... Worbey zugleich eine gründliche Nachricht von dem in Churfl. Sächß. Landen Gefundenen Turff ... Befindlich. Bey Johann Friedrich Brauns sel. Erben.

Carter, R. (2023, July 3). XR Today's Guide to Stopping VR Motion Sickness. XR Today. https://www.xrtoday.com/mixed-reality/xr-todays-guide-to-stopping-vr-motion-sickness/

Centraal Bureau voor de Statistiek (2023, July 7). De mate van geletterdheid in de gemeente Rotterdam [Webpagina]. Centraal Bureau

voor de Statistiek. https://www.cbs.nl/nl-nl/maatwerk/2023/27/de-mate-van-geletterdheid-in-de-gemeente-rotterdam
Cinema 4D Review. (2022, October 17). PCMAG. https://www.pcmag.com/reviews/cinema-4d

Cipresso, P., Giglioli, I. A. C., Raya, M. A., & Riva, G. (2018). The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.02086

CityLab010, Alle initiatieven. (n.d.). Retrieved November 7, 2024, from https://www.citylab010.nl/initiatieven

Clancey, W. (1995). A tutorial on situated learning. Proceedings of the International Conference on Computers and Education (Taiwan). Collins, J. C., & Porras, J. I. (1996). Built to last: Successful habits of visionary companies. Long Range Planning, 29(2), 261–262. https://doi.org/10.1016/s0024-6301(96)90211-3

Commoner, B. (2020). The Closing Circle: Nature, Man, and Technology. Courier Dover Publications.

Cosio, L. D., Buruk, O. "Oz," Fernández Galeote, D., Bosman, I. D. V., & Hamari, J. (2023). Virtual and Augmented Reality for Environmental Sustainability: A Systematic Review. Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, 1–23. https://doi.org/10.1145/3544548.3581147

Dagblad010. (2019, April 24). Gemeente opent nieuwe locatie in Charlois. https://dagblad010.nl/algemeen/gemeente-opent-nieuwe-locatie-in-charlois

Dalila op TikTok. (2024). TikTok. Retrieved October 28, 2024, from https://www.tiktok.com/@insidedalilasmind/video/7409628763178192160?_t=8qtr8FKQ2C3&_r=1

De Groene Oase op Zuid – Een platform voor ontmoeting en samenwerking. (n.d.). Retrieved May 30, 2024, from https://www.degroeneoaseopzuid.nl/

Dorst, K. (2019). Design beyond Design. She Ji: The Journal of Design, Economics, and Innovation, 5(2), 117–127. https://doi.org/10.1016/j.sheji.2019.05.001

DuBose, J. (2020). The case for VR. Journal of Electronic Resources Librarianship, 32(2), 130–133. https://doi.org/10.1080/1941126X.2020.1739851

Dunleavy, M., & Dede, C. (2014). Augmented Reality Teaching and Learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of Research on Educational Communications and Technology (pp. 735–745). Springer. https://doi.org/10.1007/978-1-4614-3185-5_59

Duurzaamheid. (n.d.). MKB Rotterdam-Rijnmond. Retrieved November 12, 2024, from https://mkb-rotterdam.nl/themas/duurzaamheid/ Duurzaamheidsloket. (n.d.). Duurzaam 010. Retrieved November 12, 2024, from https://duurzaam010.nl/duurzaamheidsloket/

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st century business. Environmental Quality Management, 8(1), 37–51. https://doi.org/10.1002/tqem.3310080106

Erika R. Francis, Stephanie Bernard, Morgan L. Nowak, Sarah Daniel, and Johnathan A. Bernard. 2020. Operating Room Virtual Reality Immersion Improves Self-Efficacy Amongst Preclinical Physician Assistant Students. J Surg Educ 77, 4 (July 2020), 947–952.

Fauville, G., Queiroz, A. C. M., Hambrick, L., Brown, B. A., & Bailenson, J. N. (2021). Participatory research on using virtual reality to teach ocean acidification: A study in the marine education community. Environmental Education Research, 27(2), 254–278. https://doi.org/10.1080/13504622.2020.1803797

Fonarov, O. (2024). Council Post: The Role Of Immersive Technologies In Virtual Training: VR And Beyond. Forbes. Retrieved November 10, 2024, from https://www.forbes.com/councils/forbes-techcouncil/2024/05/31/the-role-of-immersive-technologies-in-virtual-training-vr-and-beyond/

Fraune, C., & Knodt, M. (2018). Sustainable energy transformations in an age of populism, post-truth politics, and local resistance. Energy Research & Social Science, 43, 1–7. https://doi.org/10.1016/j.erss.2018.05.029

Gadenne, D., Sharma, B., Kerr, D., & Smith, T. (2011). The influence of consumers' environmental beliefs and attitudes on energy saving behaviours. Energy Policy, 39(12), 7684–7694. https://doi.org/10.1016/j.enpol.2011.09.002

Geest, M. V. D. (2017, October 11). Innovatie in het medisch onderwijs: Van lesboek naar VR-bril. de Volkskrant. https://www.volkskrant.nl/wetenschap/innovatie-in-het-medisch-onderwijs-van-lesboek-naar-vr-bril~bab6eb09/

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Groot, A., Steehouder, P., Van de Beek, M., Heijne, W., & Bennes, G. (n.d.). Rapport Aanpak laaggeletterdheid binnen het sociaal domein. CINOP. Retrieved November 14, 2024, from https://cinop.nl/publicaties/rapport-aanpak-laaggeletterdheid-binnen-het-sociaal-domein/

Hart, B., & Risley, T. R. (2003). The early catastrophe. the 30 million word gap. The American Educator, 27(1), 4–9. https://eric.ed.gov/?id=EJ672461

Heilig, M. (1955). El Cine del Futuro (The Cinema of the Future), Espacios: Mexico City. Reprinted in Presence 1(3), 1992.
Hempel, M. (2014). Ecoliteracy: Knowledge Is Not Enough. In State of the World 2014: Governing for Sustainability (pp. 41–52). Island Press/Center for Resource Economics. https://doi.org/10.5822/978-1-61091-542-7_4

Hilmi, M. I., Lutfiansyach, D. Y., Hufad, A., Kamil, M., & Wahyudin, U. (2021). Eco-Literacy: Fostering Community Behavior Caring for the Environment. First Transnational Webinar on Adult and Continuing Education (TRACED 2020), Bandung, Indonesia. https://doi.org/10.2991/assehr.k.210508.022

Hofman, E (2024). Interview about Carnisse, Initiatives and Gouwe (Kl)ouwe

Holdren, J. P., & Ehrlich, P. R. (1974). Human Population and the Global Environment: Population growth, rising per capita material consumption, and disruptive technologies have made civilization a global ecological force. American Scientist, 62(3), 282–292.

References

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. Annual Review Of Ecology And Systematics, 4(1), 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245

Home — Gravity Sketch. (n.d.). Retrieved October 25, 2024, from https://gravitysketch.com/

Hoogenboom, J. (n.d.). Waarom stemmen Rotterdammers niet? Citisens. Retrieved November 14, 2024, from https://www.citisens.nl/cases/waarom-stemmen-rotterdammers-niet/

Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: Mapping different approaches. Sustainable Development, 13(1), 38–52. https://doi.org/10.1002/sd.244

How to Build a Circular Economy | Ellen MacArthur Foundation. (2013). Retrieved April 22, 2024, from https://www.ellenmacarthurfoundation.org/

Huang, J., Lucash, M. S., Scheller, R. M., & Klippel, A. (2019). Visualizing Ecological Data in Virtual Reality. 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), 1311–1312. https://doi.org/10.1109/VR.2019.8797771

IDEO Design Thinking. (n.d.). IDEO | Design Thinking. Retrieved November 14, 2024, from https://designthinking.ideo.com Informatie over Laaggeletterdheid in Nederland | Stichting Lezen en Schrijven. (2024, April 17).

Ingenbleek, P. T. M. (2015). Price strategies for sustainable food products. British Food Journal, 117(2), 915–928. https://doi.org/10.1108/BFJ-02-2014-0066

Ismail, A. The Sword Damocles. Available online: http://www.dsource.in/sites/default/files/course/virtual-reality-introduction/evolution-vr/sword-damocles-head-mounted-display/images/17.jpg (accessed on 14 September 2024).

Jasanoff, S. (2010). A New Climate for Society. Theory, Culture & Society, 27(2–3), 233–253. https://doi.org/10.1177/0263276409361497 Johnston, P., Everard, M., Santillo, D., & Robèrt, K.-H. (2007). Reclaiming the definition of sustainability. Environmental Science and Pollution Research International, 14(1), 60–66. https://doi.org/10.1065/espr2007.01.375

Katika, T., Karaseitanidis, I., Tsiakou, D., Makropoulos, C., & Amditis, A. (2022). Augmented Reality (AR) Supporting Citizen Engagement in Circular Economy. Circular Economy and Sustainability, 2(3), 1077–1104. https://doi.org/10.1007/s43615-021-00137-7

Katika, T., Karaseitanidis, I., Tsiakou, D., Makropoulos, C., & Amditis, A. (2022). Augmented Reality (AR) Supporting Citizen Engagement in Circular Economy. Circular Economy and Sustainability, 2(3), 1077–1104. https://doi.org/10.1007/s43615-021-00137-7

Keeble, B. R. (1988). The Brundtland report: 'Our common future.' Medicine and War, 4(1), 17–25. https://doi.org/10.1080/07488008808408783

Kramer, A & Snoep, A (2024) Interview about Immersive Technologies at the Municipality of Arnhem

Lai, A.-F., Chen, C.-H., & Lee, G.-Y. (2019). An augmented reality-based learning approach to enhancing students' science reading performances from the perspective of the cognitive load theory. British Journal of Educational Technology, 50(1), 232–247. https://doi.org/10.1111/bjet.12716

Lopez-Garido, G. (2023, July 10). Self-Efficacy: Bandura's Theory Of Motivation In Psychology. https://www.simplypsychology.org/self-efficacy.html

Maddux, J. E. (2013). Self-Efficacy, Adaptation, and Adjustment: Theory, Research, and Application. Springer Science & Business Media.

Marques Brownlee (Director). (2024, November 1). I Tried Real Augmented Reality Glasses! [Video recording]. https://www.youtube.com/watch?v=G0eKzU_fV00

Martins, B. R., Jorge, J. A., & Zorzal, E. R. (2023). Towards augmented reality for corporate training. Interactive Learning Environments, 31(4), 2305–2323. https://doi.org/10.1080/10494820.2021.1879872 Maya Review. (2022, October 17). PCMAG. https://www.pcmag.com/reviews/maya

McDonough, W., & Braungart, M. (2009). Cradle to Cradle: Remaking the Way We Make Things. Vintage Books.

Meta Quest MR, VR-headsets en Accessoires. (2024 Retrieved November 14, 2024, from https://www.meta.com/nl/quest/

Neumann, M. M., Keioskie, M. K., Patterson, D., & Neumann, D. L. (2022). Virtual, Augmented, and Mixed Reality: Benefits and Barriers for Early Childhood Education. Childhood Education, 98(4), 68–79. https://doi.org/10.1080/00094056.2022.2108298

Niantic. (n.d.). Niantic Labs. Retrieved October 25, 2024, from https://nianticlabs.com/

Okazaki, T., & Takaseki, R. (2017). Override ship maneuvering simulator using AR toolkit. Intelligent Automation & Soft Computing, 23(1), 167–174. https://doi.org/10.1080/10798587.2016.1142709

OPEN Rotterdam (Director). (2023, October 5). De wijk Carnisse: 'Veel criminaliteit en verpaupering maar ook gezellig en sociaal' | OPEN VRAAG [Video recording]. https://www.youtube.com/watch?v=zpWjSVVwFEw

Patton, M. Q. (2014). Qualitative Research & Evaluation Methods: Integrating Theory and Practice. SAGE Publications.

Pearce, D. W., & Turner, R. K. (1989). Economics of Natural Resources and the Environment. JHU Press.

Pena-Rios, A., Hagras, H., Owusu, G., & Gardner, M. (2018). Furthering Service 4.0: Harnessing Intelligent Immersive Environments and Systems. IEEE Systems, Man, and Cybernetics Magazine, 4(1), 20–31. IEEE Systems, Man, and Cybernetics Magazine. https://doi.org/10.1109/MSMC.2017.2769199

Pimentel, D., Amaya, R., Halan, S., Kalyanaraman, S., & Bailenson, J. (2019). Climate Change on Your Plate: A VR Seafood Buffet Experience. 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), 1120–1121. https://doi.org/10.1109/VR.2019.8798076

Programmaplan Rotterdam Circulair | Rotterdam Circulair. (n.d.). Retrieved November 14, 2024, from https://rotterdamcirculair.nl/actueel/programmaplan-rotterdam-circulair

Projecten—The Simulation Crew. (2023, July 21). https://thesimulationcrew.nl/projecten/

Przepiorka, W., & Diekmann, A. (2018). Heterogeneous groups overcome the diffusion of responsibility problem in social norm enforcement. PLOS ONE, 13(11), e0208129. https://doi.org/10.1371/journal.pone.0208129
Reference list Final

Renganayagalu, S. kumar, Mallam, S. C., & Nazir, S. (2021). Effectiveness of VR Head Mounted Displays in Professional Training: A Systematic Review. Technology, Knowledge and Learning, 26(4), 999–1041. https://doi.org/10.1007/s10758-020-09489-9
Robinett, W. (1994). Interactivity and individual viewpoint in shared virtual worlds: The big screen vs. networked personal displays. ACM SIGGRAPH Computer Graphics, 28(2), 127–130. https://doi.org/10.1145/178951.178969

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society, 14(2). https://www.jstor.org/stable/26268316

Rotterdam Circulair (2024). Instagram Feed. Retrieved November 14, 2024 from: https://www.instagram.com/rotterdamcirculair/

Rotterdam in Transformatie. (2024, October). Gemeente Rotterdam.

Rotterdam. (n.d.). Digitale Stad. Gemeente Rotterdam. Retrieved November 14, 2024, from https://www.rotterdam.nl/digitale-stad

'S Jongers, T. (2024). Armoede uitgelegd aan mensen met geld—Tim 'S Jongers—De Correspondent. Retrieved November 14, 2024, from https://decorrespondent.nl/cp/armoedeuitgelegdaanmensenmetgeld

Segrave, A. J. (2014). TIME TO CHANGE: The foreseeable future for water planning [[object Object]]. https://doi.org/10.4233/UUID:56DFD837-4121-411C-B36D-80BAAC2EFC81

References

SHC - Geschiedenis Charlois. (n.d.). Retrieved April 30, 2024, from https://historisch-charlois.nl/geschiedenis.html

Simonse, L. (2024). Design Roadmapping: Guidebook for Future Foresight Techniques. In TU Delft OPEN Textbooks. TU Delft OPEN Textbooks. https://doi.org/10.59490/tb.84

Situated Learning | Center for Innovative Teaching and Learning. (n.d.). Northern Illinois University. Retrieved October 21, 2024, from https://www.niu.edu/citl/resources/guides/instructional-guide/situated-learning.shtml

Sliep, H (2024) Interview about De Groene Oase, its past-, current- and future-state

Sociaal en Cultureel Planbureau. (2020). Sociaal domein op koers? Verwachtingen en resultaten van vijf jaar decentraal beleid (No. 2020–13). https://www.scp.nl/ publicaties/publicaties/2020/11/16/sociaal-domein-op koers

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Social Studies of Science, 19(3), 387–420. https://doi.org/10.1177/030631289019003001 Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285. https://doi.org/10.1016/0364-0213(88)90023-7

Syberfeldt, A., Danielsson, O., Holm, M., & Wang, L. (2016). Dynamic Operator Instructions Based on Augmented Reality and Rule-based Expert Systems. Procedia CIRP, 41, 346–351. https://doi.org/10.1016/j.procir.2015.12.113

Tranter, B. (2013). The Great Divide: Political Candidate and Voter Polarisation over Global Warming in Australia. Australian Journal of Politics & History, 59(3), 397–413. https://doi.org/10.1111/ajph.12023 Ullo, S. L., Piedimonte, P., Leccese, F., & De Francesco, E. (2019). A step toward the standardization of maintenance and training services in C4I military systems with Mixed Reality application. Measurement, 138, 149–156. https://doi.org/10.1016/j.measurement.2019.02.036 United Nations. (n.d.). Sustainability. United Nations; United Nations. Retrieved October 25, 2024, from https://www.un.org/en/academic-impact/sustainability

van der Goot, E. (2024, September 3). Burgers voelen zich niet gehoord: "Politici moeten niet alleen zenden." NU. https://www.nu.nl/politiek/6326319/burgers-voelen-zich-niet-gehoord-politici-moeten-niet-alleen-zenden.html

Van der Heijden, R. (2024) Interview about De Digitale Stad, and the role of AR in the municipality

Verheij, I & Steur, J (2024) interview about Communication Methods of Rotterdam Circulair

Visser, C. (2017, December 5). The motivation continuum: Self-determination theory in one picture. https://www.progressfocused.com/2017/12/the-motivation-continuum-self.html

Vocke, W. (2024, March 30). Charlois spreken we uit als Sjaarloos: Hier komt die naam vandaan. indebuurt Rotterdam. https://indebuurt.nl/rotterdam/genieten-van/mysteries/hoe-komt-charlois-aan-haar-naam~50557/

Vogelzang. (2022, July 13). VRelax—De noodzaak van VR in de zorg / Stefan Vogelzang. VRelax. https://vrelax.com/2022/07/13/hallo-wereld/

Weinbaum, S. G. (1935). Pygmalion's spectacles. Wonder Stories, (6). https://www.gutenberg.org/files/22893/ 22893-h/22893-h.htm Wijkprofiel Rotterdam. (2024 Wijkprofiel Rotterdam. Retrieved April 25, 2024, from https://wijkprofiel.rotterdam.nl/nl/2024/rotterdam Wix, L., Bayles, D., & Orland, T. (1998). Art and Fear: Observations on the Perils (and Rewards) of Artmaking. Studies in Art Education, 39(3), 281. https://doi.org/10.2307/1320371

Xu, Z., Liang, Y., Campbell, A. G., & Dev, S. (2022). An Explore of Virtual Reality for Awareness of the Climate Change Crisis: A Simulation of Sea Level Rise. 2022 8th International Conference of the Immersive Learning Research Network (iLRN), 1–5. https://doi.org/10.23919/iLRN55037.2022.9815983 Yoon, S., Anderson, E., Lin, J., & Elinich, K. (2017). How Augmented Reality Enables Conceptual Understanding of Challenging Science Content. Journal of Educational Technology & Society, 20(1), 156–168.

Appendices

In this chapter, all the appendices with extra information can be found. Below, an overview of all appendices is listed.

In this chapter:

Appendix A: *Initial Project Brief*

Personal Project Brief – IDE Master Graduation Project

Name student Sjoeke Suilen

Student number 4,859,715

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Improving Circular Economy communication between Rotterdam and the inhabitants of Carnisse by using Augmented Reality

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Climate change and Sustainability are perhaps the most formidable issue of our time. What makes these challenges o-so interesting, is the fact that their impact spans socio-economic and environmental domains, making them particularly challenging. Despite the growing emphasis on sustainability and the Circular Economy in Rotterdam (i.e. the ambition to be Circular in 2050), many individuals, particularly those from lower-income households, encounter significant barriers to adopting sustainable practices. These barriers manifest in various forms:

-The premium prices of sustainable products, which often incorporate additional social and ecological costs (Ingenbleek, 2015).
-Ambiguity surrounding sustainability and the Circular Economy, leading to diverse perceptions among stakeholders and conflicting research findings (Bulten et al., 2021; Segrave, 2014).
- Diffusion of responsibility among multiple stakeholders, increasing the challenge of collective action (Przepiorka, 2018).
- Low levels of trust in governmental entities to deliver on (sustainability) commitments (Gadenne et al., 2011) resulting in the feeling of not being heard (Citisens, 2022).
- Declining ecological literacy in urbanized societies, diminishing connections with nature and wildlife (Hempel, 2014), that as a result lead to decline in sustainable behaviour (Hilmi et al., 2021).
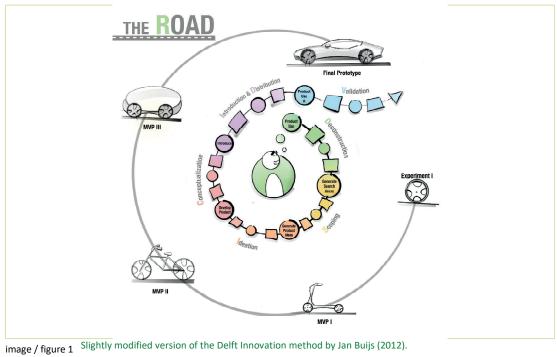
These barriers make sustainability and Circular Economy discussions overwhelming and polarizing, hindering efforts to promote sustainable behaviors (Fraune & Knodt, 2018; Tranter, 2013). However, Augmented Reality (AR) might pose an opportunity to communicate Circular Economy principles in a more engaging, comprehensible and memorable way. as papers suggest that AR has the power to help with the transfer of knowledge, specifically users with lower levels of prior knowledge on a specific topic tend to benefit most from this immersive technology (Katika et al., 2022).

➜ *space available for images / figures on next page*

image / figure 1   Slightly modified version of the Delft Innovation method by Jan Buijs (2012).

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

The municipality of Rotterdam is having multiple initiatives to share and spread knowledge about the Circular Economy with its citizens to improve the Circular Economy Literacy and influence behaviour. However when speaking to inhabitants, it is apparent that these initiatives do not stick long-term nor fit the preferences of the inhabitants.

In Carnisse, 34% of the inhabitants struggle with lower levels of literacy (CINOP et al, 2016). Next to that, the neighborhood is the lowest-income neighborhood of Rotterdam (CBS, 2023), meaning the usual suspects of sustainable behaviour (i.e. buying sustainable products & installing solar panels) are out of the equation.

I want to provide the inhabitants of Carnisse with a physical "probe" with AR functionality that helps communicating circular economy principles in a comprehensible, engaging and memorable way. Next to that, a system that facilitates closer connection with the municipality should be achieved to allow the inhabitants to make that what they learned actionable.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence)
As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

I want to answer the following research question: "Can AR be used to make Circular Economy Principles more engaging, comprehensible and memorable, to the lower-income households of Carnisse (Rotterdam-Zuid)?"

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

This thesis adapts the Delft Innovation Method (Buijs, 2012) (Figure 1) to guide the research process:

1. Product Use I: Analyze current communication methods through desk research, stakeholder interviews, and small experiments.
2. Generating Search Areas: Translate identified needs into search areas for directed ideation, testing ideas with a minimum viable product (MVP).
3. Generating Product Ideas: Develop various ideas in a sensitizing package, allowing stakeholders to autonomously test them.
4. Product Development: Further develop and test the sensitizing package based on insights from previous phases.
5. Market Introduction & Distribution: Test the refined communication concept with a larger sample size.
6. Product Use II: Assess and validate the concept's impact on Circular Economy Literacy, in the domains of communication and memorization.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	26 Mar 2024
Mid-term evaluation	4 Jun 2024
Green light meeting	10 Sep 2024
Graduation ceremony	22 Oct 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	30
Number of project days per week	5,0

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

Throughout my studies in Delft, I learned that often people use the same words when communicating, but then end up meaning completely different things. As a result, I want to employ the visualization tactics and strategies I aim to take abstract terms such as Sustainability and the Circular Economy and turn them into tangible, understandable narratives for diverse audiences. I would love to take this opportunity to develop these skills further, and achieve a positive outcome in the realm of municipalities and sustainability.

This project will be a stepping stone for my ambition to become a Social Designer. I am motivated to pioneer innovative solutions that resonate with both experts and laymen, with the aim of achieving a more sustainable and interconnected community.

So in short I want to:
· Improve my knowledge and skills in visualization, communication and Sustainability
· Get valuable experience within the realm of Social Design and Municipalities
· Use new technologies to make otherwise "seemingly static" concepts come to life

Appendix B: *Blank Consent Form and Questionnaire for Prototype 1: AR Website Translation*

Blank Consent Form

Evaluatie van Website bij het Communiceren van Principes van de Circulaire Economie

Hoofdonderzoeker: Sjoeke Suilen, Technische Universiteit Delft
Contactgegevens:

Doel van het Onderzoek:
U wordt uitgenodigd om deel te nemen aan een onderzoek uitgevoerd door Sjoeke Suilen. Het doel van deze studie is om de effectiviteit van Augmented Reality (AR) te vergelijken met traditionele webgebaseerde communicatiemethodes bij het communiceren van principes van de Circulaire Economie (CE) aan de inwoners van Carnisse.

Procedures:
Als u akkoord gaat met deelname, wordt u gevraagd om:

Voor de test:
-        Een korte vragenlijst in te vullen met uw basis demografische informatie (naam, leeftijd, telefoonnummer).
-        Dit toestemmingsformulier te lezen en te ondertekenen.
-        Ofwel een traditionele webgebaseerde communicatiemethode of een Augmented Reality ervaring over CE-principes te volgen.

Activiteiten na de Test:
-        Een vragenlijst in te vullen die uw betrokkenheid, begrip en memorisatie van de inhoud beoordeelt.
-        Kort de ervaring te bespreken met de onderzoeker.

Follow-up:
-        Ongeveer veertien dagen na de test ontvangt u een telefoontje om nog wat vragen over de test te beantwoorden.

Uw deelname aan deze studie is geheel vrijwillig. U kunt op elk moment zonder gevolgen stoppen met deelnemen. Als u besluit niet deel te nemen of uw deelname wilt beëindigen, zijn hieraan geen negatieve gevolgen verbonden.

Vertrouwelijkheid:
Alle informatie die in deze studie wordt verzameld, blijft vertrouwelijk. Gegevens worden geanonimiseerd en veilig opgeslagen. Alleen het onderzoeksteam heeft toegang tot de gegevens. Uw identiteit wordt niet bekendgemaakt in publicaties of presentaties die voortvloeien uit deze studie.

Contactgegevens:
Als u vragen of zorgen heeft over deze studie, neem dan contact op met:
Sjoeke Suilen,

Toestemming:
Door hieronder te tekenen, erkent u dat u de bovenstaande informatie hebt gelezen en begrepen. U stemt ermee in deel te nemen aan deze studie en begrijpt dat uw deelname vrijwillig is.

Naam Deelnemer:

Handtekening Deelnemer:

Datum:

Dank u voor uw deelname!

Deelname #___

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

    _____

2. Wat is uw leeftijd?

    _____

3. Wat is uw telefoonnummer? (06-, of huisnummer)

    _____

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

◯ Ik weet weinig of niks over duurzaamheid

◯ Ik weet de basis van duurzaamheid

◯ Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid

◯ Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

_____

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	◯	◯	◯	◯	◯	◯	◯	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	◯	◯	◯	◯	◯	◯	◯	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	◯	◯	◯	◯	◯	◯	◯	Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt?   Gebruik het tekstvlak beneden om het antwoord op te schrijven.

_____

_____

_____

_____

_____

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

_____

_____

_____

_____

_____

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Appendix C: *Research Protocol for Prototype 1*

Protocol for Group A:

Number:	Activity Description:	Instruction:	Time:
1.	Welcoming the participant	Make participants feel at ease by asking how they are doing etc. Explain the participant the reason of this research that they are participating in.	2 min.
2.	Informed consent form	Ask the participant to read and sign the informed consent form. Tell the user that he/she has the possibility to stop the research at will.	5 min.
3.	Start of the test	Participant is tasked to open questionnaire, and answer the following questions: - What is your name? - What is your age? - What is your phone number? - What is your prior knowledge on CE principles?	2 min.
4.	Engaging with the webpage	Participant is now given the laptop with the webpage and is asked to read through the first five paragraphs. Explain to participant that they can ask questions at any time. At this point, the researcher secretly times the participant. When the participant notifies the researcher that they are finished, the researcher stops the timer.	5 min.
5.	Continuation of Questionnaire	Participant will be tasked to continue filling in the questionnaire. The questions are categorized in the two themes; Engagement and Comprehension. **Engagement:** • How long do you think the test took? (Subjective Perception of Time test (SPT)) • From a scale of 1 – 7, how engaged did you feel with the content? • From a scale of 1 – 7, how much control did you feel you had when interacting with the content? • From a scale of 1 – 7, to what level did you trust the content you interacted with to be the truth? **Comprehension:** • Can you recite verbally what you experienced during the test? • Can you explain to me what a circular economy is?	5 min.

Number:	Activity Description:	Instruction:	Time:
6.	Reflecting on the answers	The participant and the user will now engage in a reflecting conversation on what the participant has experienced. Ask why they answered specific questions the way they did. This piece of the conversation is recorded for future reference and is used to gather insights that can improve the next prototype. This can be considered an informal interview.	5 min.
7.	Last questions	At last, the participant will have the opportunity to ask final questions, and can give their opinions.	2 min.
8.	Closing	Thank the participant for his/her time and valuable feedback.	2 min.
9.	+-14 days after the test – Memorisation	Participant is called on the given phone number, as explained in the introduction of the protocol. Some final questions are asked regarding memorisation: "Can you recite verbally what you experienced in the test a week ago?" Once the participant gave answer, ask follow-up questions: "Apart from what you already mentioned, is there anything specific that struck you?" "Can you explain a Circular Economy to me?" There is also room for further questions asking if the participant understood what they saw.	10 min.

Protocol for Group B:

Number:	Activity Description:	Instruction:	Time:
1.	Welcoming the participant	Make participants feel at ease by asking how they are doing etc. Explain the participant the reason of this research that they are participating in.	2 min.
2.	Informed consent form	Ask the participant to read and sign the informed consent form. Tell the user that he/she has the possibility to stop the research at will.	5 min.
3.	Start of the test	Participant is tasked to open questionnaire, and answer the following questions: - What is your name? - What is your age? - What is your phone number? - What is your prior knowledge on CE principles?	2 min.
4.	Engaging with the webpage	Participant is now given the iPad with the AR experience and is asked to walk through it. Explain to participant that they can ask questions at any time. At this point, the researcher secretly times the participant. When the participant notifies the researcher that they are finished, the researcher stops the timer.	5 min.
5.	Continuation of Questionnaire	Participant will be tasked to continue filling in the questionnaire. The questions are categorized in the two themes; Engagement and Comprehension. **Engagement:** • How long do you think the test took? (Subjective Perception of Time test (SPT)) • From a scale of 1 – 7, how engaged did you feel with the content? • From a scale of 1 – 7, how much control did you feel you had when interacting with the content? • From a scale of 1 – 7, to what level did you trust the content you interacted with to be the truth? **Comprehension:** • Can you recite verbally what you experienced during the test? • Can you explain to me what a circular economy is?	5 min.

Number:	Activity Description:	Instruction:	Time:
6.	Reflecting on the answers	The participant and the user will now engage in a reflecting conversation on what the participant has experienced. Ask why they answered specific questions the way they did. This piece of the conversation is recorded for future reference and is used to gather insights that can improve the next prototype. This can be considered an informal interview.	5 min.
7.	Last questions	At last, the participant will have the opportunity to ask final questions, and can give their opinions.	2 min.
8.	Closing	Thank the participant for his/her time and valuable feedback.	2 min.
9.	+-14 days after the test – Memorisation	Participant is called on the given phone number, as explained in the introduction of the protocol. Some final questions are asked regarding memorisation: "Can you recite verbally what you experienced in the test a week ago?" Once the participant gave answer, ask follow-up questions: "Apart from what you already mentioned, is there anything specific that struck you?" "Can you explain a Circular Economy to me?" There is also room for further questions asking if the participant understood what they saw.	10 min.

Appendix D: *Empty Consent Form experiment 2*

Evaluatie van Digitale Duurzaamheidstour

Hoofdonderzoeker: Sjoeke Suilen, Technische Universiteit Delft
Contactgegevens:

Doel van het Onderzoek:
U wordt uitgenodigd om deel te nemen aan een onderzoek uitgevoerd door Sjoeke Suilen. Het doel van deze studie is om de effectiviteit van Augmented Reality (AR) te toetsen bij het communiceren van principes van de Circulaire Economie (CE) aan de inwoners van Rotterdam Carnisse en Leidschendam Prinsenhof.

Procedures:
Als u akkoord gaat met deelname, wordt u gevraagd om:

Voor de test:
-          Een korte vragenlijst in te vullen met uw basis demografische informatie (naam, leeftijd, telefoonnummer).
-          Dit toestemmingsformulier te lezen en te ondertekenen.
-          Een Augmented Reality ervaring over duurzaamheid te volgen

Activiteiten na de Test:
-          Een vragenlijst in die reflecteert over de ervaring
-          Kort de ervaring te bespreken met de onderzoeker.

Uw deelname aan deze studie is geheel vrijwillig. U kunt op elk moment zonder gevolgen stoppen met deelnemen. Als u besluit niet deel te nemen of uw deelname wilt beëindigen, zijn hieraan geen negatieve gevolgen verbonden.

Vertrouwelijkheid:

Alle informatie die in deze studie wordt verzameld, blijft vertrouwelijk. Gegevens worden geanonimiseerd en veilig opgeslagen. Alleen het onderzoeksteam heeft toegang tot de gegevens. Uw identiteit wordt niet bekendgemaakt in publicaties of presentaties die voortvloeien uit deze studie.

Contactgegevens:
Als u vragen of zorgen heeft over deze studie, neem dan contact op met:
Sjoeke Suilen

Toestemming:
Door hieronder te tekenen, erkent u dat u de bovenstaande informatie hebt gelezen en begrepen. U stemt ermee in deel te nemen aan deze studie en begrijpt dat uw deelname vrijwillig is.

Naam Deelnemer:

Handtekening Deelnemer:

Datum:

Dank u voor uw deelname!

Appendix E: *Pilot Test Prototype 1*

Pilot test Prototype 1

Before testing with real inhabitants of Carnisse, a pilot test will be conducted with IDE master students. To save time, the question regarding the theme memorisation will be asked immediately after the test, as the results are not important for this pilot. Next to that, the AR experiment was not conducted in Carnisse.

The goals of the pilot test were to:
• Check the timing of the test
• Test whether it is awkward for the participant to be followed by the researcher during the AR experiment

• Test whether it is possible for the participant to think aloud during the AR experiment
• Test if everything works smoothly and is easy to follow.

After the pilot test, the feedback gathered will be implemented in an improved and iterated upon test plan.

The pilot test was conducted with two IDE Design for Interaction students, due to their skill and knack for interactions. The provided feedback can be summarized in the following points:

A lot is happening on the screen, try to give input to the user in a piecewise manner and synchronize the audio with the visual effects. This will help guide the user, and will let them know where to go at what time. This aligns with the continuity principle in multimedia theory.
Augmented Reality is fairly novel to many people, consider making a brief "tutorial" or something to let the user familiarise themselves with the mechanics of the interaction.
Consider to add more interactions in the form of buttons, to make the user feel like they are in charge more.
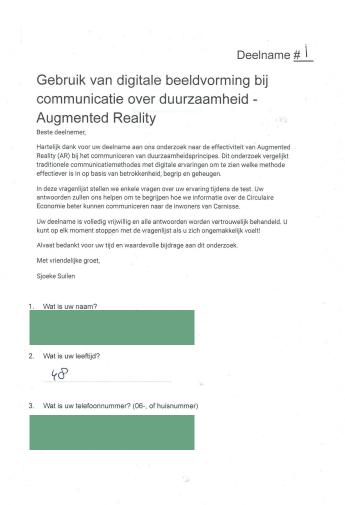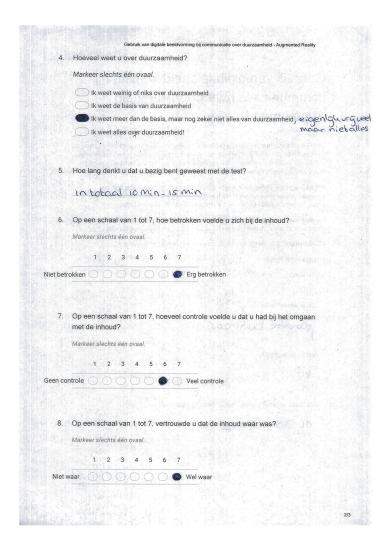
With the feedback gathered from these students, the prototype was upgraded and tested another time to iron out any last wrinkles.

The figures on this page show the updated prototype in use. As a result of the gathered feedback, a tutorial island, a Path that connects the islands and more buttons have been added. An overview of these changes can be seen in the next page.

Appendix F: *A/B Test Questionnaire Results*

AR Group B Results:

Deelname # 1

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

48

3. Wat is uw telefoonnummer? (06-, of huisnummer)

1/3

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- ( ) Ik weet weinig of niks over duurzaamheid
- ( ) Ik weet de basis van duurzaamheid
- (●) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid, *eigenlijk vrij veel maar niet alles*
- ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

in totaal 10 min - 15 min

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	○	○	○	○	○	○	●	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	○	○	○	○	●	○		Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	○	○	○	○	○	●		Wel waar

2/3

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een reis door Rotterdam, met name het veranderen van het waterpeil trof me.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Producten zoveel mogelijk hergebruiken, duurzame materialen gebruiken ipv materialen die bv na 1x gebruiken weggegooid worden. Gebruik maken van diensten die hier zoveel mogelijk gebruik van maken.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

43 jaar

3. Wat is uw telefoonnummer? (06-, of huisnummer)

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- Ik weet weinig of niks over duurzaamheid
- Ik weet de basis van duurzaamheid
- Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

7 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	◯	◯	◯	◯	⬤	◯	◯	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	◯	◯	◯	◯	⬤	◯	◯	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	◯	◯	◯	◯	⬤	◯	◯	Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Rondleiding o, waarbij meerdere uitlegmomenten waren over duurzaamheid.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Reduce * Re-use * Recycle ?
Het verminderen van natuurlijke bronnen en reeds gebruikte hergebruiken om zo de natuur te ontlasten.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Deelname # 3

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

P - 15-20 mi

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

2. Wat is uw leeftijd?

32

3. Wat is uw telefoonnummer? (06-, of huisnummer)

---

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- ( ) Ik weet weinig of niks over duurzaamheid
- ( ) Ik weet de basis van duurzaamheid
- (✓) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

ong. 5 min

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	( )	( )	(✓)	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	(✓)	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	( )	( )	( )	(✓)	( )	( )	( )	Wel waar

185

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt?   Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een interactieve, virtual-reality informatieve presentatie over klimaat verandering.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Circulaire economie verwijst naar de een economie waarin er hergebruikt en gerecycled wordt.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1.

2. Wat is uw leeftijd?

7 8-

3. Wat is uw telefoonnummer? (06-, of huisnummer)

4. Hoeveel weet u over duurzaamheid?

   Markeer slechts één ovaal.

   ( ) Ik weet weinig of niks over duurzaamheid

   ( ) Ik weet de basis van duurzaamheid

   (X) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid

   ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

   15 MIN

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	( )	( )	( )	(X)	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	( )	( )	( )	(X)	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	( )	( )	( )	( )	( )	( )	(X)	Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

   IK VOND HET MOOI OM MEE TE DOEN
   IK HOOP DAT HET WERKT DAT HET
   IN TE MINSTE NIETS BETER WORD

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

    IK VIND HET HEEL GOED DAT JE ER
    MEE BEZICH BEN
    IK VIND HET HEEL GOED.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

    40

3. Wat is uw telefoonnummer? (06-, of huisnummer)

---

4. Hoeveel weet u over duurzaamheid?

    Markeer slechts één ovaal.

    ( ) Ik weet weinig of niks over duurzaamheid
    ( ) Ik weet de basis van duurzaamheid
    (X) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
    ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

    ± 15 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

    Markeer slechts één ovaal.

    1   2   3   4   5   6   7

    Niet betrokken ( ) ( ) ( ) ( ) ( ) (X) Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

    Markeer slechts één ovaal.

    1   2   3   4   5   6   7

    Geen controle ( ) ( ) ( ) ( ) ( ) (X) Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

    Markeer slechts één ovaal.

    1   2   3   4   5   6   7

    Niet waar ( ) ( ) ( ) ( ) ( ) (X) Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een versmelting van argumented reality en de werkelijke/tastbare omgeving waar ik mij op dat moment bevad.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een utopie die we na moeten streven en waar iedereen een bijdrage aan moet (kunnen) leveren. We moeten niet alleen produceren en consumeren maar ook (vooral) nadenken voor het produceren, dan herstellen en hergebruiken.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

3/3

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

    25

3. Wat is uw telefoonnummer? (06-, of huisnummer)

participant filled in survey online, manually transcribed by Sjoeke

1/3

189

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- ( ) Ik weet weinig of niks over duurzaamheid
- ( ) Ik weet de basis van duurzaamheid
- (X) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

5 - 10 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	(X)	( )	( )	( )	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	(X)	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	( )	( )	( )	( )	( )	( )	(X)	Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een omgeving die mij uitleg gaf over Duurzaamheid en hoe ik Daarmee om kon gaan.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Dat is als Ipv alles Aan het einde vam hun leven duur wordt weggegooid we zorga dat die dinge terug koma in het Systeem.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Deelname # 7

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

   24

3. Wat is uw telefoonnummer? (06-, of huisnummer)

▽
0
participant
Filled in survey
online, manually
transcribed
By Sjocke

4. Hoeveel weet u over duurzaamheid?

   Markeer slechts één ovaal.

   ( ) Ik weet weinig of niks over duurzaamheid
   ( ) Ik weet de basis van duurzaamheid
   (X) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
   ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

   15 - 20 mins

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	( )	(X)	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	( )	( )	( )	(X)	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet waar	( )	( )	( )	( )	( )	( )	(X)	Wel waar

191

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

ik kreeg een virtuele wereld boven op
de echte wereld, en n die wereld
loop ik een pad of naar verschillende
punten waar ik informatie kreeg over
Recyclen en circulair zijn

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Circulaire economie is dat alle grondstoffen
in een cirkel van "make" →
"gebruike" → "grondstoffen" gaan om
opnieuw gebruikt te worden.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Deelname # P

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Augmented Reality

28 min

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

24

3. Wat is uw telefoonnummer? (06-, of huisnummer)

192

4. Hoeveel weet u over duurzaamheid?

   Markeer slechts één ovaal.

   ◯ Ik weet weinig of niks over duurzaamheid

   ◯ Ik weet de basis van duurzaamheid

   ⬤ Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid

   ◯ Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

   30 min.

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

   Markeer slechts één ovaal.

   1 2 3 4 5 6 7

   Niet betrokken ◯ ◯ ◯ ◯ ◯ ⬤ ◯ Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

   Markeer slechts één ovaal.

   1 2 3 4 5 6 7

   Geen controle ◯ ◯ ⬤ ◯ ◯ ◯ ◯ Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

   Markeer slechts één ovaal.

   1 2 3 4 5 6 7

   Niet waar ◯ ◯ ◯ ◯ ◯ ◯ ⬤ Wel waar

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

   Na korte intro kreeg ik informatie in audio en animaties over hoe Rotterdam kan (en moet) verduurzamen. Dit werkte door over virtuele paden te lopen en op knoppen te drukken. In de informatie werd o.a. benadrukt wat ik als inwoner kan doen, zoals recyclen.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

    In een Circulaire economie is het ultieme doel om geen afval te hebben, omdat alles na veelvuldig hergebruik en onderhoud wordt gerecycled. Hierdoor wordt er zo min mogelijk nieuw materiaal gebruikt, wat goed is voor het milieu.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Control Group A Results:

£ 16

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

haven
Sne
website
ure b page

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

2. Wat is uw leeftijd?

39

(mmer)

1/3

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- Ik weet weinig of niks over duurzaamheid
- ✓ Ik weet de basis van duurzaamheid
- Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

10 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	○	○	○	○	○	⊗	○	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	○	○	○	⊗	○	○	○	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	○	○	○	○	○	⊗	○	Ik vertrouwde de inhoud

2/3

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Ik kom uit Turkise . Ik probeerde die inhoud begrijpen. dat vond ik belangrijke voor onze milieu.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

het is over duurzaam energie . zoal je weet dat de kilimaat verandert. We moeten tegen ~~diet dit~~ doen.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

3/3

Deelname # 2   ± 10

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

(handwritten: naar sa website.)

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

37

3. Wat is uw telefoonnummer? (06-, of huisnummer)

1/3

195

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- ( ) Ik weet weinig of niks over duurzaamheid
- (✓) Ik weet de basis van duurzaamheid
- ( ) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

10 minuten.

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	( )	( )	(X)	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	(X)	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	( )	( )	( )	( )	( )	( )	(X)	Ik vertrouwde de inhoud

---

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Ik kom uit Twitje. Ik begreep het niet helemaal. Ik heb mijn test gedaan.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Ik begrijp het dat Circulaire Economie belangrijk is voor het milieu en dierenleven, mensenleven, schone lucht. Dit.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

[handwritten:] ± 5 min,

[handwritten:] S Aw website before wh door Knouwkns expairucys gud

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

   [handwritten:] 18

3. Wat is uw telefoonnummer? (06-, of huisnummer)

4. Hoeveel weet u over duurzaamheid?

   Markeer slechts één ovaal.

   ( ) Ik weet weinig of niks over duurzaamheid
   (X) Ik weet de basis van duurzaamheid
   ( ) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
   ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

   [handwritten:] 5 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	( )	(X)	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	(X)	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	( )	( )	( )	( )	( )	(X)	( )	Ik vertrouwde de inhoud

197

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt?   Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Het heeft laten zien dat er initiatief genomen wordt wat betreft het verduurzame van Rotterdam

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Hoe ik het begrijp is dat een economie gebaseerd op vraag en aanbod, des te meer vraag des te meer aanbod. Meestal geld het tegengestelde niet

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Deelname # 4

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

At 6 - 10 min
For total

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

33

3. Wat is uw telefoonnummer? (06-, of huisnummer)

Designs workers at Almene Strandbb, He graduated in IDc Eindhoven 2018

198

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

( ) Ik weet weinig of niks over duurzaamheid

( ) Ik weet de basis van duurzaamheid

(X) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid

( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

1 / 1,5 min (?)

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	X	( )	( )	( )	( )	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	X	( )	( )	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	( )	( )	( )	( )	( )	X	( )	Ik vertrouwde de inhoud

2/3

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Het voelt als of ik in een thema word gegooid zonder introductie. Ik weet wat circulair betekend maar een specifieke contact info zou fijn zijn. Ook vind ik de teksten op de website niet lekker lezen en het is niet duidelijk ingedeeld (plaatjes) maar lijkt als of alles bij elkaar hoort in een lineaire verhaal.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Een circulaire economie is een uitwisseling van waarde waar de begin en het eind van het proces gesloten zijn tot een cirkel en waar tijdens het proces geen waarde ontstaat.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

3/3

199

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

± 3 m

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

39

3. Wat is uw telefoonnummer? (06-, of huisnummer)

notes:
Cyber security
wants As taalcoach
Simpele taal is key

---

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

- ( ) Ik weet weinig of niks over duurzaamheid
- (X) Ik weet de basis van duurzaamheid
- ( ) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
- ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

2 min of 3 min

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken X	( )	( )	( )	( )	( )	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle X	( )	( )	( )	( )	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	( )	( )	( )	(X)	( )	( )	( )	Ik vertrouwde de inhoud

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

meelyen broeikast effecten

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

[x] note : Lostige vraag, geen antwoord.

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

---

4 min 40

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

55

3. Wat is uw telefoonnummer? (06-, of huisnummer)

201

4. Hoeveel weet u over duurzaamheid?

Markeer slechts één ovaal.

◯ Ik weet weinig of niks over duurzaamheid

◯ Ik weet de basis van duurzaamheid

⊗ Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid

◯ Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

_____

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	◯	◯	◯	◯	◯	⊗	◯	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	◯	◯	◯	◯	◯	⊗	◯	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	◯	◯	◯	◯	◯	⊗	◯	Ik vertrouwde de inhoud

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Belang van duurzaamheid, je staat normalite niet in dagelijks leven bij stil, maar alles wat we doen (handelingen) hebben direct betrekking op zaken om ons heen

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Verantwoord omgaan met alles om ons heen

Bedankt!

Hartelijk dank vioor het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

Deelname # _7_

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

15 min. 46 sec.

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

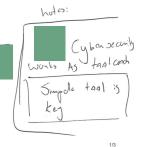Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

   26 jaar

3. Wat is uw telefoonnummer? (06-, of huisnummer)

---

4. Hoeveel weet u over duurzaamheid?

   Markeer slechts één ovaal.

   - ( ) Ik weet weinig of niks over duurzaamheid
   - (X) Ik weet de basis van duurzaamheid
   - ( ) Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
   - ( ) Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

   10 min, in totaal 15 min.

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	( )	( )	( )	(X)	( )	( )	( )	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	( )	( )	( )	(X)	( )	( )	( )	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

   Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	( )	( )	( )	(X)	( )	( )	( )	Ik vertrouwde de inhoud

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Niet veel eigenlijk. Ik probeer zelf altijd wel een beetje extra op te letten om mijn voetdruk te verminderen. Of de marsa productie in de toekomst zal afnemen of verbeteren? Ik ben daarover te weinig geïnformeerd om daar dus wel of geen vertrouwen in te ervaren.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

Zoals ik het heb begrepen? Lijkt het mij te gaan om de bewustwording en mogelijkheden die er zijn om op een betere manier om te gaan met het mileu..

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Deelname # 8

Gebruik van digitale beeldvorming bij communicatie over duurzaamheid - Website

+ - 10 min

Beste deelnemer,

Hartelijk dank voor uw deelname aan ons onderzoek naar de effectiviteit van Augmented Reality (AR) bij het communiceren van duurzaamheidsprincipes. Dit onderzoek vergelijkt traditionele communicatiemethodes met digitale ervaringen om te zien welke methode effectiever is in op basis van betrokkenheid, begrip en geheugen.

In deze vragenlijst stellen we enkele vragen over uw ervaring tijdens de test. Uw antwoorden zullen ons helpen om te begrijpen hoe we informatie over de Circulaire Economie beter kunnen communiceren naar de inwoners van Carnisse.

Uw deelname is volledig vrijwillig en alle antwoorden worden vertrouwelijk behandeld. U kunt op elk moment stoppen met de vragenlijst als u zich ongemakkelijk voelt!

Alvast bedankt voor uw tijd en waardevolle bijdrage aan dit onderzoek.

Met vriendelijke groet,

Sjoeke Suilen

1. Wat is uw naam?

2. Wat is uw leeftijd?

24

3. Wat is uw telefoonnummer? (06-, of huisnummer)

204

4. Hoeveel weet u over duurzaamheid?

    Markeer slechts één ovaal.

    ◯ Ik weet weinig of niks over duurzaamheid
    ◯ Ik weet de basis van duurzaamheid
    ⊗ Ik weet meer dan de basis, maar nog zeker niet alles van duurzaamheid
    ◯ Ik weet alles over duurzaamheid!

5. Hoe lang denkt u dat u bezig bent geweest met de test?

    7 minuten

6. Op een schaal van 1 tot 7, hoe betrokken voelde u zich bij de inhoud?

    Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Niet betrokken	◯	◯	◯	◯	◯	⊗	◯	Erg betrokken

7. Op een schaal van 1 tot 7, hoeveel controle voelde u dat u had bij het omgaan met de inhoud?

    Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Geen controle	◯	⊗	◯	◯	◯	◯	◯	Veel controle

8. Op een schaal van 1 tot 7, vertrouwde u dat de inhoud waar was?

    Markeer slechts één ovaal.

	1	2	3	4	5	6	7	
Ik vertrouwde de inhoud niet	◯	◯	◯	◯	◯	⊗	◯	Ik vertrouwde de inhoud

9. Kunt u in woorden uitdrukken wat u tijdens de test heeft meegemaakt? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

    Ik heb op een website van gemeente Rotterdam gelezen dat we meer aan circulaire economie moeten doen.

10. Kunt u in woorden uitleggen wat een Circulaire Economie is? Gebruik het tekstvlak beneden om het antwoord op te schrijven.

    In een circulaire economie worden gebruiksvoorwerpen en materialen hergebruikt, ~~zorg~~ gerecycled en verminderd

Bedankt!

Hartelijk dank voior het invullen van deze enquête. Over een week zal ik nog kort contact opnemen voor een paar laatste vragen, dit duurt ongeveer 5 minuutjes!

Groetjes en nog een fijne dag,

Sjoeke

Google Formulieren

205

Retention & Memorisation Test Results

Control Group A: AR Group. *no show*

Checks	Participant #							
	~~X 6~~	~~X 7~~	8	4	5	~~Ø~~ 1	7 2	~~Ø~~ 3
1. Reuse-Reduce & Recycle	√	√	√		–	√	√	√
2. The climate is changing	√	√	–		–	√	√	√
3. Waste, we can do something with that	√	√	√		–	√	√	√
4. Demand is challenging supply	–	–	–		–	–	√	–
5. Daunting task, but we can tackle it piecewise		√	–		–	–	–	–
Points total	4	3	2		Ø A	3	4	3	= 2,7

Table XX: Control Group A results of Retention & Memorization test

AR Group B: *website*

Checks	Participant #							
	1	2	3	4	5	6	7	8
1. Reuse-Reduce & Recycle	√	√		√ gevraagt	√			√
2. The climate is changing					√			
3. Waste, we can do something with that	√	√		√				
4. Demand is challenging supply								
5. Daunting task, but we can tackle it piecewise								
Points total	2	2		2	2		0	1

Table XX: AR Group B results of Retention & Memorization test

Notes AR Retention & Memorization Call

Ⓐ CE is als dinge in economie niet wegge-gooid worden maar op een manier hergebruikt

P6
AR:
C: ik kwam bij een platvorm en ging het over CE. En er was iets met tijd.
Moeten we het zij alle dinge doen, was anders krijgen we overstroming in Rotterdam. Reduce Reuse Recycle Repair, ik zag dat blikje

P7 P8:
① Er was een VR-experience doen op iPad en kan je door zien wat er gebeurde. Het ging over CE in Rotterdam. Het legde alles uit. Water bij erasmusbrug ging omhoog. plastic werd geblet

② Bij CE willen we Repareren, Recyclen, grondstof wordt hergebruikt

P8: ik zag een parkomgeving op iPad en in die Virtuele Wereld werden me onderwerpen verteld over Duurzaamheid en CE, Druk op knop leer info. Je liep een traject doen en kreeg Recyclen en waar grappige Animaties

P1 P4: ik liep naar verschillende plekken waar verschillende informatie gedeeld werd. Reuse Reuse water peil zag er mooi uit. Schrok me 2.0.2

p0. Animatie Hydraulic press bled bij
En ik zie het wel voor me in
buurt ontwikkeling

2. CE is een economie waarin we
zo min mogelijk / geen slot dan niuw hane
We hebben een materiaal kring loop.
Kopain, 2nd hand. Recych.

+P1 ② zoveel mogelijk hergebruiken ipv
nieuw kopen, Recych e.d.

— Afval scheiden, ik weet nog over
— Stijgend waterpeil wat me erg raakte
— .

Call
back
At ±
17:00

p2 — Virtuele Rondleiding met VR Bril gig over
— Recycle en hergebruik, beter voor milieu
— en dit meer te doen. op knoppen drukk
— dan gebeurde er dingen stukje boven.
— Als ik het goed begrepen, meer recych a
Hergebruiken Zo min mogelijk bezig met weggooik
a meerhergebruiken. Wat we hebben nid zoveel meer.

p3 — ik herinner me een filmpje doel gig over waterverbruik.
— ik herinner veel waterverbruik, maar
— dat komt misschien ook door noodhuis
— En water paden paden en op knopjes drukk—
— Ernstusbezig overstroming Animatie.

p4
___
___
___

P3. CE in mijn woorden is
Recycle, hergebruik, upcycle.
materiaal voor nieuwe doeleinden
gebruiken.

Brandstoffen wordt hergebruikt - zodat
Alles in de cirkel zit.
3 R's   Reuse Reduce Recycle + Repair

● Je doet er niks mee, dus

"Data Dumpen"?

※ na de test ben ik gelijk doorgegaan
met mijn team, en heb ik het er ook
met niemand over gehad, dus inhoudelijk?
is het niet blijven hangen - beelden wel
en ook overstroming.

※ Sjoerd vertelt idee ※
Dat zie ik wel werken, omdat
je dan aldiet met prijzen aan de
slag gaat.

P5 projectie van Animatie Anvaalseplein.

Voornamelijk groene piek en verhaal over
Duurzaamheid wilt, gevolgd.

CC is een uto pie

NPO staal door tata

Notes Website Retention & Memorization Call

P1: i read Duurzaamheid en CE
Recycling, i.e. instead of weggooie
you can Repair stuff that was
what I heard about.

P2: ik heb niet als mijn man gelezen
over Duurzaamheid en millieu.
Dat Reparanem beter is.

P3: niet.

P4 no show Z. O. Z.

---

o Het ging over circulariteit.
niet echt goede uitleg kan ik me
herinner.
was pagina met specifieke activiteiten.
kan me wel iets herinner dat burgers
iets kunnen melden als
door
geen plantjes. oaksnel te schalen zodat
aandacht bij te houden

o en CE is de economie waar alles wat
van waarde weer in het systeem gegaan kan.
kans circkel is rond. nadat het misschien
al gemaakt wordt.
kan jo recyclen, inkomen, het hele
proces is geen dead end, geen
waste. echt circulair dat is het
echt toughe. of op een andere
manier kan ook. Bijv vrijwesbedrijf
sociaal, vrijwilligers Af. stuurt.
het niet over producten. geen energie loopt
door

209

P5 Dus Recyclen, kledig gerecycled en gerepareerd
Broeikaseffect.

ik weet ook niet wat een
Circulaire Economie is

P6: nvt.

P7: 2.0.2.

P8: (1) ik moest een website ken van gen... ve
rott van Duitsland [Recyclen, Hergebruik]
en minder (zovel producten als materiale)
En werd veel verhaald wat niets
samenhangd was.

(2) CE is een economie waarin producten
zovel mogelijk word gerecycled
en hergebruik.

P7

Duurzaamheid. Van de gemeent wil
lätm landen, berust wandin g

Hoe de gemeente

Nee niets specifieks
2023 programma tot 2023

Manier waarop we musa op Duurzaamhod.
wilh stelle, doan tenders,
wat doe je om duurzam te leven

Onduidelijk waar de ticket han gig

Appendix G: *A/B Test Tables of Results*

Introductory Questions

The introductory questions, which can be found below, were used to gather information that was necessary to execute the memorisation retention test. The last question: "How much do you know about sustainability?" however, had other significance. This question helped differentiate between participants based on prior knowledge.

For convenience sake, the questions are shared below:
- What is your name?
- What is your age?
- What is your phone number?
- How much do you know about sustainability?

The answers to the question: "How much do you know about sustainability?" can be found in Tables 1 & 2 below:

Control Group A		Participant #							
		1	2	3	4	5	6	7	8
Question:	"How much do you know about sustainability?"	Basic Level	Basic Level	Basic Level	More than basic Level	Basic Level	More than basic Level	Basic Level	More than basic Level

Table 1: Levels of Sustainability knowledge prior to test, Control Group A

AR Group B		Participant #							
		1	2	3	4	5	6	7	8
Question:	"How much do you know about sustainability?"	More than basic Level	Basic Level	More than basic Level	More than basic Level	More than basic Level	More than basic Level	More than basic Level	More than basic Level

Table 2: Levels of Sustainability knowledge prior to test, AR Group B

The first set of questions from both questionnaires for Control Group A and AR Group B were used to find identify engagement levels and patterns. For convenience, the questions are listed below:

- How long do you think the test took? (Subjective Perception of Time test (SPT-test))
- From a scale of 1 – 7, how engaged did you feel with the content?
- From a scale of 1 – 7, how much control did you feel you had when interacting with the content?

- From a scale of 1 – 7, to what level did you trust the content you interacted with to be the truth?

The answers to the engagement test from Control Group A can be found in Tables 3 & 4. The answers of AR Group B can be found in Tables 5 & 6.

Control Group A	Participant #								Averages
	1	2	3	4	5	6	7	8	
Estimated Time (Mins.)	10	10	5	1.5	2.5	10	15	7	7,94 m = 476s
Real Time (Mins. + s.	8m54s = 534s	9m32s =572s	3m28s =208s	1m52 = 112s	1m47 =107s	4m54s =294s	9m48s =588s	10m12s =612s	6,3 m = 378s

Table 3: SPT Test Control Group A

Control Group A:		Participant #								Averages
		1	2	3	4	5	6	7	8	
Question #	2	6	6	5	1	1	6	4	6	4,4
	3	4	4	4	2	1	6	4	1	3,25
	4	6	7	6	7	4	6	4	6	5,75

Table 4: Engagement results Control Group A

AR Group B	Participant #								Averages
	1	2	3	4	5	6	7	8	
Estimated Time (Mins.)	12.5	7	5	15	15	7.5	17.5	30	13,68m =821s.
Real Time (Mins. + s.)	14m52s = 892s	15m07s =907s	15m58s =958s	15m12s =912s	15m04s =904s	14m55s = 895s	15m09s =909s	28m16s =1696	16,8m= 1009s.

Table 5: Engagement results AR Group B

AR Group B:		Participant #								Averages
		1	2	3	4	5	6	7	8	
Question #	2	7	5	6	7	7	3	5	6	5,8
	3	6	5	5	7	7	4	7	3	5,5
	4	7	6	5	7	7	7	7	7	6,6

Table 6: Engagement results AR Group B

Comprehension Results

The principle of comprehension was tested via the following two questions:

- Can you recite verbally what you experienced during the test?
- Can you explain to me what a circular economy is?

The participants' answers were compared with predefined keywords representing key principles discussed during the test. Tables 7 and 8 present the selected keywords and participants' scores. Participants were awarded a point for each correct response, including instances where synonyms or alternative phrasing conveyed the same meaning.

Checks	Participant # 1	2	3	4	5	6	7	8	
1. Reuse-Reduce & Recycle	-	-	-	-	X	-	-	X	
2. The climate is changing	-	-	-	-	X	X	X	-	
3. Waste, we can do something with that	X	X	-	-	-	-	-	-	Total
4. Demand is challenging supply	-	-	-	-	-	-	X	-	8
5. Daunting task, but we can tackle it piecewise	-	-	-	-	-	-	-	-	Mean
Points total	1	1	0	0	2	1	2	1	1

Table 7: Control Group A results of Comprehension

Checks	Participant # 1	2	3	4	5	6	7	8	
1. Reuse-Reduce & Recycle	X	X	X	-	X	X	X	X	Total
2. The climate is changing	X	-	-	-	-	-	-	X	
3. Waste, we can do something with that	X	X	X	-	X	X	x	X	18
4. Demand is challenging supply	-	X	-	-	X	-	-	-	Mean
5. Daunting task, but we can tackle it piecewise	-	-	-	-	-	-	-	-	
Points total	3	3	2	0	3	2	2	3	2,25

Table 8: AR Group B results of Comprehension

Retention & Memorisation Results

The retention and memorisation test was conducted approximately 14 days after participants were exposed to either the website or AR experience. Unfortunately, fewer participants completed this phase, as some were uncomfortable sharing their phone numbers, and others did not answer when called. These participants, highlighted in orange, are excluded from the total and mean calculations.

In total, 13 participants were contacted from both Control Group A and AR Group B. The retention and memorisation test mirrored the comprehension test but was administered later via phone. The identical results are presented in Tables 9 and 10 below.

Checks	1	2	3	4	5	6	7	8	
Participant #									
1. Reuse-Reduce & Recycle	x	x	-	x	x	-	-	x	Total
2. The climate is changing	-	-	-	-	x	-	-	-	
3. Waste, we can do something with that	x	x	-	x	-	-	-	-	9
4. Demand is challenging supply	-	-	-	-	-	-	-	-	Mean
5. Daunting task, but we can tackle it piecewise	-	-	-	-	x	-	-	-	
Points total	2	2		2	2	-	0	1	1,5

Table 9: Control Group A results of Retention & Memorisation test

Checks	1	2	3	4	5	6	7	8	
Participant #									
1. Reuse-Reduce & Recycle	x	x	x		-	x	x	x	Total
2. The climate is changing	x	x	x		-	x	x	-	
3. Waste, we can do something with that	x	x	x		-	x	x	x	19
4. Demand is challenging supply	-	x	-		-	-	-	-	Mean
5. Daunting task, but we can tackle it piecewise	-	-	-		-	x	-	-	
Points total	3	4	3		0	4	3	2	2,7

Table 10: AR Group B results of Retention & Memorisation test
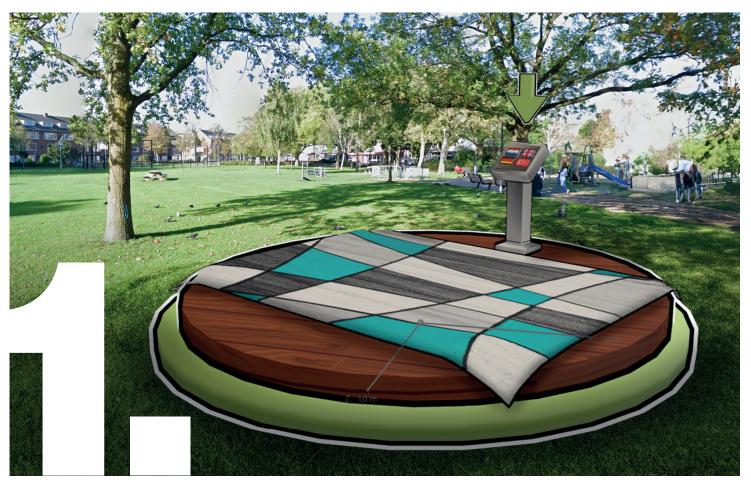
Appendix H: *Detailed Overview of the Digital Sustainability Tour*

1. Language Selector

This is the Dutch version of the script that will be used in the new iteration of the AR concept. The script is subdivided in different sections that will be recorded separately and synchronized to the AR environment. This text has been cleared with a language coach and the website "Is het B1".

Actions:
- Control panel appears in which Language can be selected
- Select the selected language and move on to Tutorial Island

2. Tutorial Island

Leuk dat je meedoet met deze digitale Duurzaamheidstour. Tijdens de tour zul je soms op knoppen moeten klikken. Klik op de
rode knop om kennis te maken met de interacties.

2.1 Groene knop gevonden
Goedzo! Zoek nu de groene knop, je kunt ronddraaien met het apparat om rond te kijken.

2.2 Tutorial klaar
Perfect! Je weet nu alles wat je nodig hebt om deze tour te voltooien. Volg de houten plateaus en klik op de knoppen om te ervaren
wat duurzaamheid en de circulaire economie betekent voor Rotterdam.

3. Circulaire Economie

In 2030 wordt 'circulair' de norm in Rotterdam. Maar wat betekent dat eigenlijk?

3.1 Linear naar Circulair
Momenteel halen we materialen uit de aarde om producten te maken. Deze gebruiken we dan en gooien we als we klaar zijn weg.
Wat als we, in plaats van weg te gooien, producten en materialen hergebruiken?
Dan veranderen we ons materialensysteem in een
cirkel, waarin we zuiniger omgaan met producten. Hierdoor hebben we uiteindelijk ook minder afval!

4. Waarom is dit nodig?

Je vraagt je misschien af: "Waarom is dit nodig?" Er is maar een bepaalde hoeveelheid materiaal op onze Aarde. Als dit op is, is het op. We komen langzaam dichterbij deze grens. Hierdoor worden producten alsmaar duurder. Het is belangrijk om de grenzen van de Aarde te respecteren, zodat ook generaties na ons nog van de aarde kunenn genieten.

4.1 Stad naast de Maas
Als we inzoomen naar Rotterdam zien we ook waarom het belangrijk is. Het is namelijk zo dat Rotterdam naast de Maas ligt. Als het te veel regent, hier of ergens anders langs de Maas, kan deze obverstromen. Dit zorgt voor problemen.

4.2 Versteende Stad
Door de hoeveelheid steen in de stad kan het water moeilijk weg. Ook zorgt het steen ervor dat de stad heel heet wordt in de zomer, omdat warmte blijft hangen. Dit noemen we hittestress.

4.3 Wat te doen
Dit kunnen we oplossen: Door meer groen in de stad kan het water beter naar de grond, zonder dat het naar het riool hoeft. Ook zorgt dit ervoor dat de stad in de zomer afkoelt. Uit onderzoek blijkt dat het op een hete zomerdag zo'n 10 graden verschil kan maken! Als extra komt er nog bij dat meer groen ook nog eens goed is voor veel verschillende insecten, dieren en planten.

4.4 Kies wat je wilt weten
Als je meer wilt weten over een van deze onderwerpen, nodig ik je uit om op het desbetreffende pad te lopen! Voor biodiversiteit loop je naar links, voor hittestress neem je het middelste pad, en het rechtse pad gaat over wateroverlast! Als je klaar bent kan je terug lopen naar dit level, en op de groene knop klikken voor een afsluiter!

5. Biodiversiteit

Biodiversiteit betekent de variatie aan planten, dieren in een gebied. Hoe meer soorten er zijn, hoe sterker en gezonder de natuur is. Dit is belangrijk omdat het zorgt voor een stabiel ecosysteem: bomen en planten zuiveren de lucht, dieren bestuiven bloemen en houden ongedierte in toom. Biodiversiteit is de variatie aan planten en dieren. Hoe meer soorten, hoe sterker het ecosysteem, met schone lucht en een gezondere natuur als gevolg.
Klik op de groene knop om te zien hoe een biodiverser Rotterdam eruit kan zien!

5.1 Wat kan je doen om bij te dragen aan meer biodiversiteit?
De gemeente kan je helpen met het aanleggen van geveltuinen of stukjes groen. Er zijn subsidies beschikbaar, maar de gemeente moet hiervan weten. Dus meld je plannen!

6. Hittestress

In de zomer kunnen steden heet worden door steen en asfalt, wat hittestress veroorzaakt. Dit kan gezondheidsproblemen geven, vooral voor ouderen, kinderen en huisdieren. Meer groen, zoals bomen en parken, helpt door schaduw en verdamping, wat de temperatuur tot 10 graden kan verlagen.
Klik op de knop om een plek aan te leggen die iets doet aan hittestress!

6.1 Wil je wat doen aan hittestress?
Wil je helpen de stad te verkoelen? De gemeente biedt subsidies voor het aanleggen van groene ruimtes, zoals geveltuinen of parkjes. Vergeet niet om dit aan te geven bij de gemeente!

7. Wateroverlast

Rotterdam ligt naast de Maas en kan risico lopen op overstromingen als het te veel regent. Omdat de stad veel bebouwd is, kan het water niet goed weg. Dit vergroot de kans op wateroverlast. We kunnen natuurlijk Dijken bouwen, maar dit is erg duur en is een tijdelijke oplossing.

Het zou beter zijn om de stad zo in te richten, dat hij beter met water overweg kan. Gelukkig is dit mogelijk!

Bijvoorbeeld meer parken en minder bestrating helpen al enorm om het water beter te laten wegstromen. Planten en bomen kunnen water opnemen, wat de druk op het riool vermindert en overstromingen helpt voorkomen. Zo maken we de stad beter bestand tegen hevige regenbuien. Daarnaast is di took beter voor de hittestress en biodiversiteit!

7.1 Wat kun je doen tegen wateroverlast?

Ook de gemeente werkt hieraan mee! Er zijn subsidies voor het vergroenen van je buurt, zoals voor de aanleg van geveltuinen en groene daken. Informeer de gemeente als je hieraan wilt bijdragen.
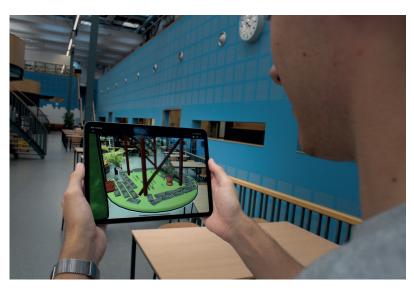
8. Afsluiting

Bedankt voor het meedoen met deze digitale duurzaamheidstour. Je kan nu een formulier, dit invullen, en inleveren in de stem doos. We hopen je geïnspireerd en geïnformeerd te hebben over duurzaamheid. Als je meer vragen hebt, nodigen we je uit om langs te komen op het gemeentekantoor, en we willen je vragen om na te denken over duurzaamheid!

Appendix I: *Pilot Test Prototype 2*

Prototype 2: The Digital Susuinability Tour has been tested at IDE with a number of students, IPD, SPD and DFI for their unique view on the model. Images are shared below:

Appendix J: *Test Protocol Prototype 2: The Digital Sustainability Tour*

Prototype 2: The Digital Susuinability Tour has been tested at the Zuidplein Library as well as the Fluitpolderplein Library with the following protocol.

Number:	Activity Description:	Instruction:	Time:
1.	Welcoming the participant	Make participants feel at ease by asking how they are doing etc. Explain the participant the reason of this research that they are participating in.	2 min.
2.	Informed consent form	Ask the participant to read and sign the informed consent form. Tell the user that he/she has the possibility to stop the research at will. A blank consent form can be found in Appendix B.	5 min.
	Start of the test	Participant is given the iPad and the Digital Sustainability Tour starts	1 min.
	Engaging with the Digital Sustainability Tour	Participant is now following the Digital Sustainability Tour and the researcher follows them to assist with any questions or help that is required by the participant	10 min.
	End of test – Open ended, semi-structured interview based on the "Reflectionnaire"	Participant will be tasked to participate in a short semi-structured interview, in which the following questions will be asked: 1. Did you have previous experiences with AR? 2. What did you think of this experience? 3. Could you follow everything? Was the experience easy to grasp? 4. Would you have wanted to learn something in this way in the past? If yes 5. Do you think this concept has a place in the future of education and communication? 6. Did you learn something in this test that you think is interesting? 7. Do you have any other questions?	10 min.
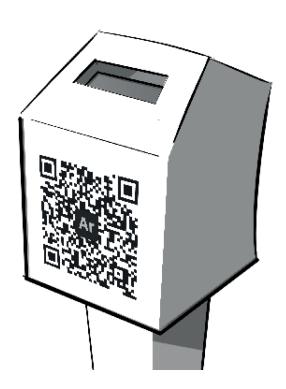
Test protocol / list of activities for Prototype 2: Digital Sustainability Tour

Appendix K: *Reflectionnaire*

To accommodate different users, a reflectionnaire is used to guide the interview. Participants have the ability to either answer the questions on paper or verbally. But the same questions will be asked.

The name reflectionnaire comes from the first three questions, which reflect on the things that were shown to the participants throughout the experience. The other questions are used to make sure all important aspects are discussed.
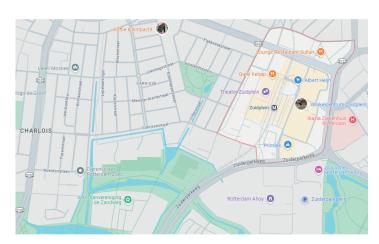
Digitale Beeldvorming en Duurzaamheid

Enquête over Digitale Beeldvorming

Bedankt voor het meedoen met dit onderzoek over hoe goed digitale beeldvorming werkt. Om antwoord te geven mag je schrijven of tekenen in de rechthoeken!

1. Waar zou je in de wijk meer natuur willen zien en waarom? Geef dit aan met een boom op de kaart.
2. Waar zou je in de zomer graag willen zitten in de wijk, waar dat nu niet kan? Geef dit aan met een stoel op de kaart.

3. Hoe zou jij je voorbereiden op een overstroming?

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! ○ ○ ○ ○ ○ ○ ○ Niet leuk
       1 2 3 4 5 6 7

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes), en over welk onderwerp?

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

8. Is er iets dat je verder had willen weten?

9. Vul hier je naam en telefoonnummer in als je mee wilt doen met een kort telefonisch vervolgonderzoek wat maximaal 5 minuten duurt!

Appendix L: *Filled in Reflectionnaires*
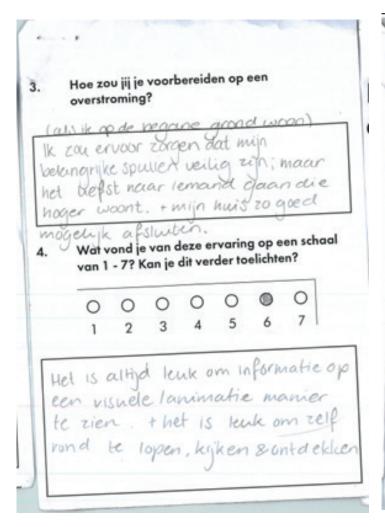
To accommodate different users, a reflectionnaire is used to guide the interview. Participants have the ability to either answer the questions on paper or verbally. But the same questions will be asked.
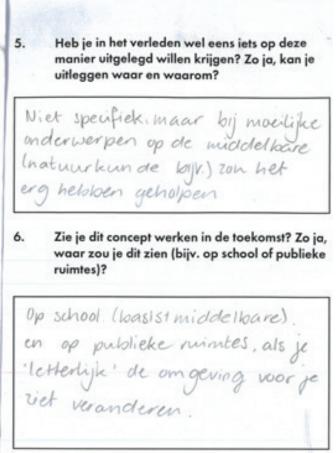
The name reflectionnaire comes from the first three questions, which reflect on the things that were shown to the participants throughout the experience. The other questions are used to make sure all important aspects are discussed.
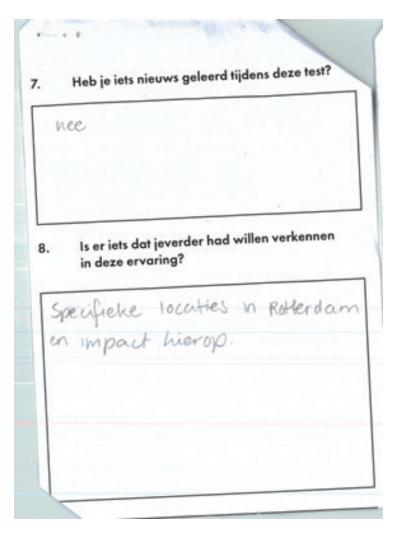
However, due to the immersive nature of the experiment, the reflectionnaires were mostly used to start the interview. In most cases the reflectionnaire was used as a way for me to structure notes from the conversations.

PS. apologies for the Coffee marks and chaos, testing was stressfull. :)

Participant 1

3. Hoe zou jij je voorbereiden op een overstroming?

(als ik op de begane grond woon)
Ik zou ervoor zorgen dat mijn belangrijke spullen veilig zijn; maar het liefst naar iemand gaan die hoger woont. + mijn huis zo goed mogelijk afsluiten.

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Kan je dit verder toelichten?

O 1 O 2 O 3 O 4 O 5 ● 6 O 7

Het is altijd leuk om informatie op een visuele/animatie manier te zien. + het is leuk om zelf rond te lopen, kijken & ontdekken

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

Niet specifiek. maar bij moeilijke onderwerpen op de middelbare (natuurkunde bijv.) zou het erg hebben geholpen

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes)?

Op school (basis/ middelbare). en op publieke ruimtes, als je 'letterlijk' de omgeving voor je ziet veranderen.

7. Heb je iets nieuws geleerd tijdens deze test?

nee

8. Is er iets dat je verder had willen verkennen in deze ervaring?

Specifieke locaties in Rotterdam en impact hierop.

Notes:
Participant 1 liked the concept of AR and mentioned it is always fun to get information in a visual way. Next to that, the participant noted that it is nice to walk around and explore the information at your own pace.

Next to that, the participant noted that AR could work with difficult to grasp concepts at high school (like physics), and noted it would have been useful in her own career.

Apart from her own experience, she sees the concept working at lower-middle-high schools and in public spaces as you can truly see everything that changes in front of you, which immerses. Participant 1 did not learn anything new, but noted that the experience would have been cool to have at specific locations within Rotterdam, for example at the real Erasmusbridge, and then seeing the Maas flood in real time.

Participant 2

3. Hoe zou jij je voorbereiden op een overstroming?

> Water inslaan (drink water) +eten.
> Bootje kopen, verhuizen naar hoger gelegen gebied

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Kan je dit verder toelichten? Waarom?

O 1   O 2   O 3   O 4   O 5   ⊗ 6   O 7

> de interactie zorgde dat ik nieuws-gierig bleef naar het volgende verhaal.

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

> Nee nog nooit

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes)?

> School, musea, winkels/Showroom, overal waar je informatie wil overbrengen

7. Heb je iets nieuws geleerd tijdens deze test?

dat er een subsidie loket is
dat je subsidie kan krijgen voor allerlei
dingen zoals gevel tuinen

8. Is er iets dat je verder had willen verkennen in deze ervaring?

miss nog ~~more~~ meer specifiek ~~hoe~~ wat
een overstroming zou veroorzaken
in rotterdam en met mijn huis/
wijk

Notes:
Participant 2 liked the AR concept and noted that the interaction ensured that he stayed curious to what whas to come, and was excited to see the story unfold.
The participant also noted that he had never used AR before. Yet he sees the potential in for example museums, schools, stores and showrooms, and mentions that its useful at all locations where information is shared.

Next to that, Participant 2 noted that he did not know there were any subsidies for enhancing your neighbourhood or house on the discussed themes, like façade gardens. By linking the websites, the participant also was able to immediately learn more about how he can get access to these subsidies.

Lastly, participant 2 would have liked to see specifically what the cause of a flood in Rotterdam would be, and would have liked to see what effects a flood has on his house/neighbourhood.

Participant 3

3. Hoe zou jij je voorbereiden op een overstroming?

Voedselvooreed aan leggen
Zandzakken voor de deuren leggen

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! ⊗ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 | Niet leuk

Het was heel cool dat het gewoon zo op een random ruimte kan

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

Nee, ik wist eigelijk niet dat dit ook gebruikt kan worden om dinge te leren

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes), en over welk onderwerp?

op School bij maatschappijleer en geschiedenis.
op monumenten zodat je meer over te weten kan komen

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

Nee eigelijk niet, no nieuws geleerd maar ik vond het wel interessant over die hitte bestrijding

8. Is er iets dat je verder had willen weten?

waar in Rotterdam die duurzaam heids dinges worden toegepast (voorbeelden geven)

Notes:
Participant 3 thought the concept was "cool" because it can be used at every location. Prior to the test he did not imagine that AR could be used in a learning-context.

After learning more about AR, the participant shared multiple ideas about how AR could be used in schools, during history classes or on monuments so you can learn more about the background of the object. Another use case would be during social study classes in high school.
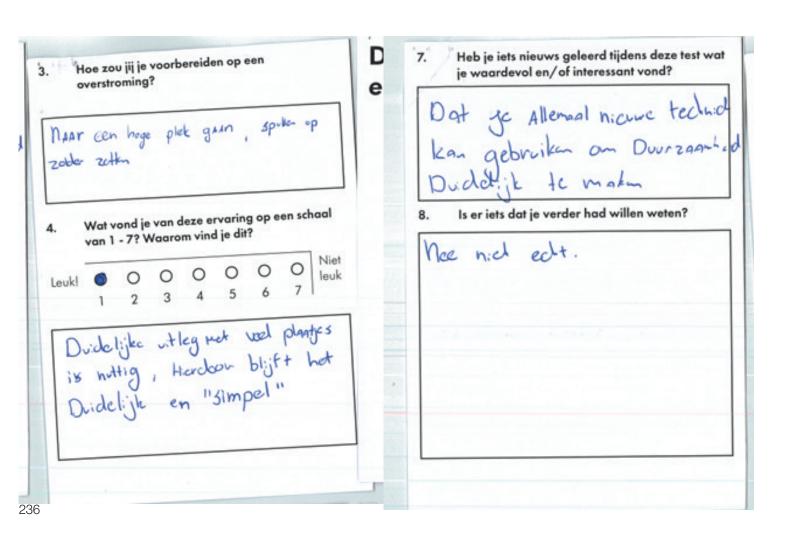
Participant 3 also noted that heat stress was an interesting subject, and would have liked to see specific strategies or examples of things Rotterdam has done to combat heat-stress, floods and increase biodiversity. So more applied examples.

Observations:
Enthusiastic about the concept of AR, and understands the message. At first the participant was hesitant to join research, but then I showed him the concept and he was eager to try!

Feedback:

- Adding more interactions is a good idea and would be fun.
- AR fatigue was noticeable (so perhaps do it with a phone instead of a tablet.
- Idea to show AR on monuments and in classes with Social Studies and history
- I would like to see where Sustainability things were applied.

Participant 4

3. Hoe zou jij je voorbereiden op een overstroming?

Naar een hoge plek gaan, spullen op zolder zetten

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! ● ○ ○ ○ ○ ○ ○ Niet leuk
　　　1　2　3　4　5　6　7

Duidelijke uitleg met veel plaatjes is nuttig, Hierdoor blijft het Duidelijk en "simpel"

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

Dat je Allemaal nieuwe technick kan gebruiken om Duurzaamhd Duidelijk te maken

8. Is er iets dat je verder had willen weten?

Nee niet echt.

Notes:
Participant 4 noted that having more visualisations and animations enhanced interaction. Next to that, the participant noted that he is spending a lot of time on the topic.
The participant sees an opportunity in geography lessons, where books can be enhanced with AR, and mountains can appear on books. Next to that, the participant would like to see the concept in libraries or schools.

Participant 4 never realised that visualisations can be so powerful, and can really immerse users, and noted a special interest in how one can produce a concept like this.
Observations:

Liked the concept and wanted to see more AR, thought AR was a good idea to use in library and schools.

Feedback:
- Some pieces had too much information, it would be nice to keep the information load at a minimum.
- I really liked the environment, and appreciated the Augmented reality as opposed to using Virtual Reality which uses glasses. This makes the environment more open and makes it easier to still engage with people.

Participant 5

Hallo Sjoeke,

Allereerst, ik voelde me vereerd de test te mogen doen. Leuk zo'n modern apparaat met virtuele rode en blauwe (of waren het groene?) knoppen om keuzes te maken.
In het begin een beetje spannend voor mij, vandaar dat ik de kleur niet meer weet, maar het kwam goed.

Nu een paar antwoorden:
1. Eerste opwelling, opblaasbare rubberboot op de zolder. Maar dat is natuurlijk heel egoïstisch en slaat eigenlijk nergens op. Hier komt het aan op het grote belang van het beheer van waterwerken. Niet alleen maar met zijn allen.

2. Ervaring 1. Het hoogste punt dus. Heeel leukkkk!
(Omgekeerde puntentelling?)

3. Zo'n duidelijke uitleg is heel nuttig. Intelligent gedaan. Er komt veel aan bod maar het blijft overzichtelijk.

4. Ik zie dit concept zeker werken.
Duidelijk, overzichtelijk en veel terzake doende informatie.
Scholen sowieso, de jeugd is de toekomst!
Openbare ruimten ook. Alles helpt.
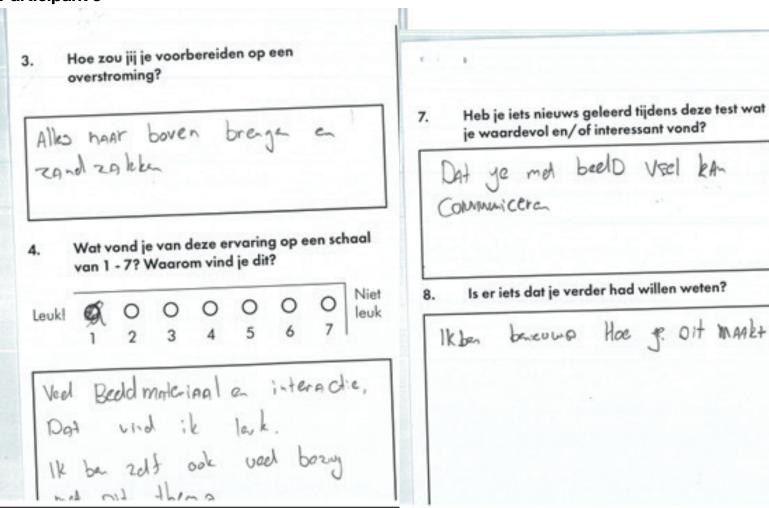
5. Iets nieuws geleerd? Natuurlijk, altijd, al was het alleen al de omgang met moderne apparaten. Maar de informatie die je kon krijgen na het doorklikken vond ik heel fijn, duidelijk en overzichtelijk. Daar heb je wat aan! Ik heb alleen niet alles onthouden.

6. Geen vragen meer.
Wel wil ik nog zeggen dat ik het fijn vind dat er een jonge generatie bezig is met iets dat ik altijd al belangrijk vond, maar waar ik me erg alleen in voelde.
Fantastisch!!!!!

Met hartelijke groet, succes ermee,
Corrie

Participant 6

3. Hoe zou jij je voorbereiden op een overstroming?

Alles naar boven brenga en zand zakken

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! ⊗ ○ ○ ○ ○ ○ ○ Niet leuk
1   2   3   4   5   6   7

Veel Beeld materiaal en interactie, Dat vind ik leuk. Ik ben zelf ook veel bezig met dit thema

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

Dat je met beeld veel kan Communiceren

8. Is er iets dat je verder had willen weten?

Ik ben beuuwe Hoe g. oit maakt

Notes:
Participant 6 liked the concept as well, and stressed that explanations with a bunch of imagery and analogies work well. This maintains clarity and simplicity.

Next to that, the participant noted that the tour could be beneficial in schools as well as public locations, and even invited me to participate in the Sustainability week that will be organised half December in the Fluitpolder library.

Participant 7

3. Hoe zou jij je voorbereiden op een overstroming?

lijstje met Spollen Make die ik ood in kan pakken, en noar Familie gaan

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Kan je dit verder toelichten?

① 〇 〇 〇 〇 〇 〇
1 2 3 4 5 6 7

Het zeagde avoon dat ik mean nadacht oven gevolgen van du Klimaat

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

Misschien bij gemeentehuzen zodat mensen als ze wachten iets kunnen leren.

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes)?

Misschien bij toekomst plannen in de bovw, zodat ik kan zien hoe de straat eruit gaat zien.

242

7. Heb je iets nieuws geleerd tijdens deze test?

Dat we zelf veel invloed kunnen hebben op de straat

8. Is er iets dat jeverder had willen verkennen in deze ervaring?

Heeft gemente had schaden ook potjes geld hcervoor?

Notes:
Participant 7 was enthusiastic about the visualisations and gamification of the topic. The element of choice was also appreciated. She also mentioned that having information in this way is much more interactive than a website, and sees it working in situations where cause and effect is difficult to explain. Using AR could visualise the causes and effects in an interactive way.

She also mentioned that it would be fun to have these interactions at recycling centers, so you can visually explain how their waste becomes something new. Next to that, participant 7 was wowed by the fact that Rotterdam already has quite a lot of possibilities to start initiatives, and was curious to learn more about Leidschendam and committed to googling more about it.

Participant 8

3. Hoe zou jij je voorbereiden op een overstroming?

begin bij ellbo, noodpakket en water. Ook belangrijke documenten veiligstelk

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! O ● O O O O O Niet leuk
　　　1　2　3　4　5　6　7

Het vedde interactief en is echt Anders Dan een website ken

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

Vooral Handig md onderwerpen waar oorzaak + gevolg lastig te zien is.

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes), en over welk onderwerp?

Misschien leuk bij milieustraten waar mensen willen leren over hun omgeving

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

> Dat er al best veel is waar De Rottedamse gemente mee helpt, nu leidschadam nog.

8. Is er iets dat je verder had willen weten?

> Hoe dit verhaal op Leidschadam wakt.

Notes:
Participant 8 noted that the experience made him think more about the effects humans have on the climate and vice versa. He was also thinking about floods, especially since the Catastrophe in Valencia just happened.

Places of interest for this technology would be town halls, so that people in the waiting room can engage in a meaningful activity while waiting. He also mentioned that AR could be interesting to see what the city of the future could look like. "Does Leidschendam also have money for initiatives?"

Participant 9

3. Hoe zou jij je voorbereiden op een overstroming?

Medicijnen voor partner en mij
inslaan

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! O O⦿O O O O O Niet leuk
   1 2 3 4 5 6 7

Leuk om alles digitaal te volg
zou nóg leuker zijn met
Meer interactie

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

ik leer beter als ik dingen
kan zien

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes), en over welk onderwerp?

in De bieb !

7. **Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?**

Dat je best simpel en verschil ka maka.

8. **Is er iets dat je verder had willen weten?**

Welke hulp ik kan bellen bij over stromingen.

Notes:
Participant 9 appreciated the style of the visuals, saying they felt playful and work well if you want to give an atmospheric impression. She mentioned that this way of engaging with content is exciting and she felt like she was exploring.
This tech could work for Asylum Seeking Centers, Town Halls, Community buildings and places for integration.
She also mentioned that this way of learning can be suitable for the "TikTok generation".

After the test, she was wondering what she has to do to get a façade garden in a Flat in Leidschendam.

Participant 10

3. Hoe zou jij je voorbereiden op een overstroming?

> Met de buurt en buren besproken hoe we elkaar kunnen helpen, want ik heb een bootje.

4. Wat vond je van deze ervaring op een schaal van 1 - 7? Waarom vind je dit?

Leuk! ● ○ ○ ○ ○ ○ ○ | Niet leuk
    1 2 3 4 5 6 7

> Door de stijl voelde het speels en fun.

5. Heb je in het verleden wel eens iets op deze manier uitgelegd willen krijgen? Zo ja, kan je uitleggen waar en waarom?

> Dit is een hele andere manier van leren die goed blijft hangen, dus op school

6. Zie je dit concept werken in de toekomst? Zo ja, waar zou je dit zien (bijv. op school of publieke ruimtes), en over welk onderwerp?

> Voor gemeenschapscentra of AZC's, voor inburgering

7. Heb je iets nieuws geleerd tijdens deze test wat je waardevol en/of interessant vond?

Dat leren ook leuk kan zijn zo ipv. tiktok en sociale media

8. Is er iets dat je verder had willen weten?

Hoe ik in Leidschendam een geveltuin aan vraag in een flat.

Notes:
Participant 10 mentioned that the experience would be even more fun if there were more interactions. He also mentioned that the experience fit with his learning style, as he prefers visualisations instead of plain text. He also mentioned that he watches a lot of youtube videos to learn. In the library this concept could work he said.

He found it interesting to see how, with simple interventions, he can make a difference. He used to think sustainability is too difficult. Yet he wanted to learn how these things applied to Leidschendam.