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The Strategic Broadening of Organisational Expertise through Experiential Learning

A UX for XR Case Study

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The Strategic Broadening of Organisational Expertise through Experiential Learning: A UX for XR Case Study

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Foreword

Before you lies the MSc Thesis "The Strategic Broadening of Organisational Expertise through Experiential Learning: A UX for XR Case Study", written to finalise my studies Industrial Design Engineering at the University of Twente. For a long time throughout my studies, I did not know what kind of Industrial Design Engineer I wanted to be. However, throughout my studies it slowly started to become clear that I had an interest more so in digital design and interactions, than in the design of physical products (packaging design being the notable exception). My interest in psychology and especially the way in which an understanding of it in design can positively influence people's behaviour and ability to learn started to grow too. I believe it was during a conversation with Eric Lutters that I realised that my interests come together in one specific world: the world of the interactive scientific museum. Full of excitement I contacted a variety of such museums for a potential assignment and was welcomed at Rijksmuseum Boerhaave in Leiden. At the same time, I was in contact with Soda studio, experts in user experience (UX) design. They expressed interest into learning more about the design for spatial computing technologies, as opposed to their current work in web and app. As such, a unique opportunity for my thesis started to surface. Where Soda studio offered me a chance to analyse their design process in a new light, aptly suiting the process-oriented focus of my master track, Rijksmuseum Boerhaave offered me a project to explore this way of working in. Over time, it became clear that what Soda studio really needed in their development process was a way to use the findings from such projects as a foundation to expand their expertise to new fields. As such, my research efforts expanded towards organisational learning and this thesis was born.

I would like to thank all those who supported me and guided me during the completion of this thesis. First, my supervisors: Roy, Leslie, Ilse and Desirée. Thank you for providing me with invaluable feedback from your unique perspectives and for always providing me with a listening ear. My gratitude also goes out to my family and friends. To my parents and brother, thank you for always looking out for me and my mental health. Your love and support mean the world. To my friends, thank you for being there for me during the challenges this year posed. I am so grateful to have had your support even though I moved to another city. A special shout-out goes to Janneke for being my rubber duck throughout this thesis process (and for making me face my imposter syndrome). To my colleagues at Soda studio, thank you for making my workdays fun with Mario Kart, teaching me how to properly make coffee and lending me your UX expertise. I want to thank Rosa and Chinouk specifically for lending me a helping hand where you could. Lastly and most importantly, I would like to thank Marijn for being at my side through it all, for believing in me more than I believe in myself and for being my shoulder to cry on. I don't know what I would have done without you.

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Abstract

The fast-paced and ever quickly changing landscape of technological innovation requires organisations to adapt and learn in order to remain competitive. This thesis explores the way in which project-based companies in such dynamic landscapes can be supported in this process. Experiential learning is put forward as a foundation with which to strategically broaden organisational expertise. Both a theoretical and practical approach is adopted to gain insight into the way in which experiential learning can be used in this capacity.

On a theoretical level, this thesis aims to create a basic understanding on how to view the concepts of knowledge, expertise and learning on both an individual and organisational level. The subjectivity and context-dependency of knowledge is highlighted, as well as the need for strategic competency development as a basis for expertise. The group is identified as the key stepping stone to translate individual knowledge to organisational knowledge through rich means of communication and dialogue.

From a practical point of view, the value of experiential learning in organisational settings is explored in a case study is for the user experience (UX) design agency Soda studio. Currently offering UX services for web and app, they are interested in broadening their expertise to design for immersive spatial technology, known as extended reality (XR). However, a lack of theoretical support in this field makes it difficult for the organisation to adequately envision and prepare for the future. To gain the experiential knowledge required to start navigating this field, a UX for XR project is completed at Rijksmuseum Boerhaave in Leiden, focusing on the design of a new exhibit for one of their key artefacts: the first artificial kidney. Reflecting on this project, the strategic opportunities, and operational implications of expanding expertise to UX for XR for Soda studio is uncovered.

This thesis concludes by combining the theoretical and practical knowledge gained to present a vision for integrating experiential learning with organisational learning to broaden expertise. The findings suggests that, under the right conditions, experiential learning can help to identify the practical implications and strategic considerations involved in expanding expertise, laying the foundation for subsequent continuous experiential organisational learning. In formulating an organisational learning strategy (OLS), this thesis addresses the current lack of concrete and holistic learning structures in the theoretical field of organisational learning. To help practitioners bring the OLS to practice, a roadmap with guidelines and concrete steps is developed. Evaluation of this roadmap at Soda studio shows general enthusiasm towards the learning strategy and structure it proposes. Nevertheless, it also becomes clear that the roadmap still insufficiently mitigates the current highly conceptual nature of organisational learning. As such, more practical insights are needed to further validate and refine the roadmap and the OLS it presents.

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Terminology

AC	Abstract conceptualisation
AE	Active experimentation
AR	Augmented Reality
CE	Concrete experience
DOF	Degrees of freedom
FOV	Field of view
HMD	Head-mounted display
ILO	Intended learning outcome
KM	Knowledge management
MC	Museum conservator
MPEEE	Manager public engagement, education and exhibitions
OLS	Organisational learning strategy
OOUX	Object-oriented UX
RO	Reflective observation
SAE	Senior advisor education
SAED	Senior advisor exhibit design
UX	User experience
VR	Virtual Reality
XR	Extended Reality

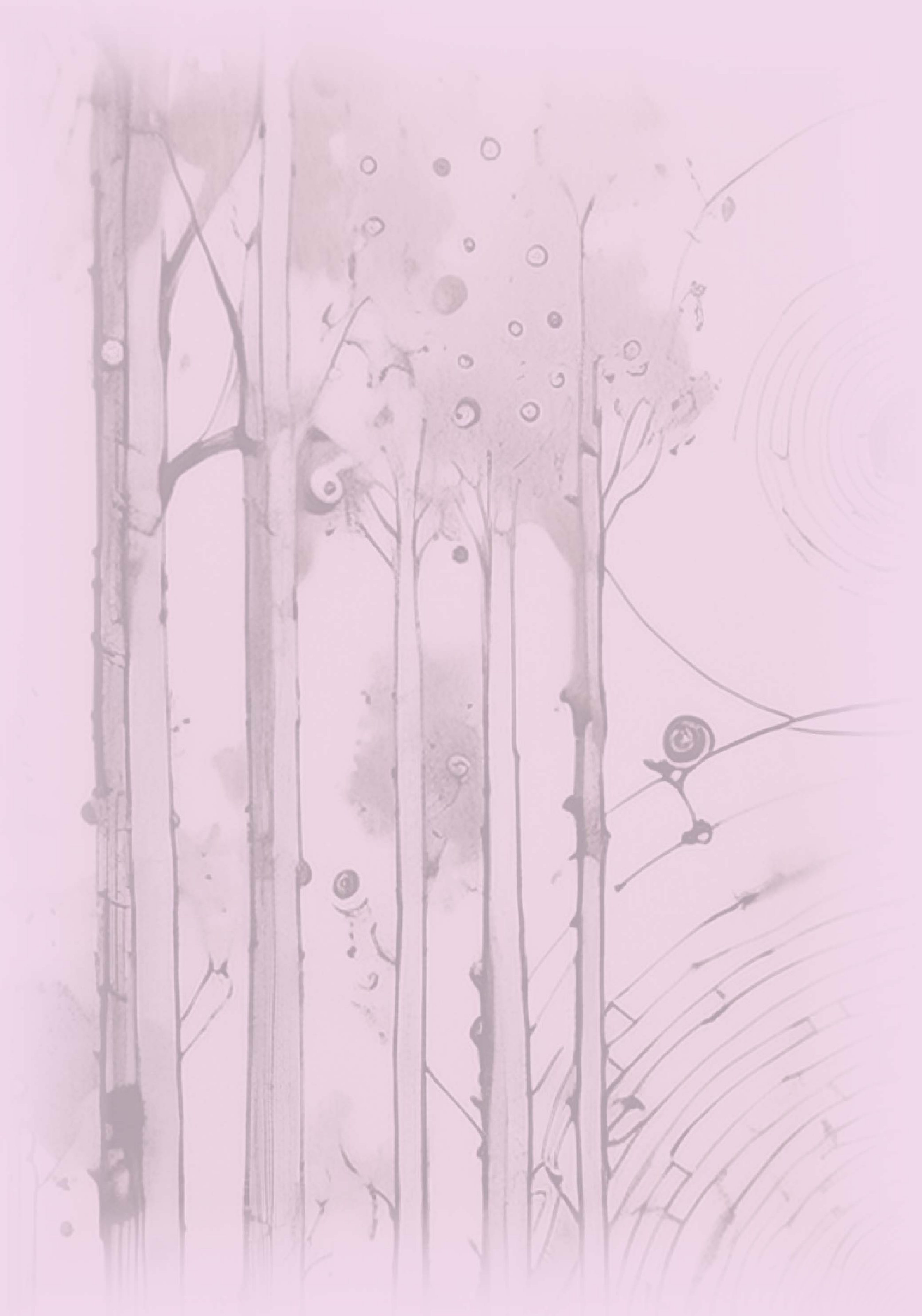
Autopoietic epistemology
The theory of knowledge that poses that knowledge is subjective: an individual interprets data and places it into context to give it meaning.

Competence
The ability of an individual or group to apply knowledge, skills, and behaviours to do the right thing at the right time.

Expertise
Domain-specific behaviour in which an individual or group consistently applies knowledge, skills, and behaviours to do the right thing at the right time with optimal effectiveness and efficiency, deploying an intuitive mode of cognition that relies on deep and tacit knowledge.

Experiential learning cycle
A deliberative approach to learning in which experience is transformed into knowledge through reflection, abstraction, and experimentation.

Organisational learning
A modification to the shared knowledge system of an organisation, either on a cognitive, emotional, or behavioural level.



Chapter 1

Introduction

1.1. Research motive

The fast-paced and ever quickly changing, i.e. dynamic, landscape of technological innovation requires organisations to adapt in order to remain competitive (Edmondson & Moingeon, 1998; Garvin et al., 2008). In other words, organisations and the individuals therein are dependent on their ability to learn. This especially holds true for project-based companies in which the temporary nature of projects demands they continuously adapt to changing market and client needs (Koskinen & Pihlanto, 2008). In such companies high level performance depends on the development of adaptive expertise, which allows employees to use their knowledge and skills across a wide variety of projects (Carbonell et al., 2014). For such expertise to be created for, and retained as, a source of an organisation's competitiveness, learning efforts need to be focused on enhancing the unique knowledge resources and capabilities of the organisation (Zack, 1999). In other words, learning needs to take place strategically and on an organisational level rather than on an individual level only. Despite its importance, the field of organisational learning still remains highly conceptual (Basten & Haamann, 2018) and is characterised by a lack of learning structures (Garad & Gold, 2019). To that end, this thesis aims to develop a concrete learning strategy for organisations to broaden expertise to emerging domains to be able to effectively adapt to and compete in the dynamic technological landscape.

For organisations to broaden their expertise to emerging domains, two things become clear: 1) the focus should be on learning from experience and 2) learning needs to be done in a deliberative manner. This has to do with the fact that knowledge in organisations only holds value when the right knowledge is applied at the right time to reach desired outcomes (North & Kumta, 2018). This ability of an individual or group to apply knowledge, skills and behaviours to do the right thing at the right time is called competence, sometimes also referred to as action knowledge (Dehnbostel, 2009; North & Kumta, 2018). Subsequently, competence can give rise to expertise, in which tasks are met effectively and efficiently (Herling, 2000). Dehnbostel (2009) poses that competence consists of two distinct elements: theoretical knowledge and experiential knowledge. Arguably, theoretical knowledge is often still lacking in emerging fields, requiring organisations that want to broaden their expertise to rely on the creation of experiential knowledge. Even as a field matures, the right interpretation of theory still requires certain learning from experience (Eraut, 2000). To ensure that the right kind of experiential knowledge is created to broaden expertise, organisations must approach learning deliberatively. Whilst learning according to a more emergent strategy also plays its role in organisations to uncover new or unexpected opportunities, having a deliberative strategic approach is key to be able to steer the development of competencies (North & Kumta, 2018). Moreover, having an intentional learning approach in place to steer learning efforts helps employees engage in learning more consciously (Eraut, 2000). This is key especially when desiring to build expertise, as expertise is more than the accumulation of knowledge or experience alone (Persky & Robinson, 2017) and requires mental effort when exploring complex situations (Bennet & Bennet, 2009). A potential strategy for organisations to structurally develop expertise in emerging domains surfaces: the strategic application of experiential learning where learners intentionally reflect on their experiences as a foundation for knowledge (Kolb, 2007).

1.2. Company profile

This graduation assignment was performed at Soda studio, a small project-based UX design agency in Amsterdam, the Netherlands. They design seamless digital user experiences that bring functional added value and are tailored to user needs. To do so, Soda studio looks at products holistically, using a variety of UX methods to discover user and business needs, align these in a digital product strategy and translate this vision to a pixel-perfect user interface design and validated prototype. Soda studio is pragmatic, as well as knowledge- and quality-driven. They are a specialist in their field and are part of a larger network of agencies under the name MakerStreet. Where Soda studio specialises in UX design, other agencies within MakerStreet specialize in other fields, such as visual design, copywriting and development. When working on MakerStreet-wide project, Soda studio works closely together with these agencies to create digital products from start to finish. In this case, Soda studio often puts forward both a UX lead that oversees the entire creative process and communication between all parties and a UX designer that is mostly practically involved in the executing of the UX design itself.

Where Soda studio currently offers UX services for web and app design, a field in which UX has proven its worth to optimise user experiences over the past years (Hillmann, 2021), they have expressed interest in broadening their expertise to the emerging domain of UX for extended reality (XR). With the introduction of XR, a new era of more immersive spatial technology is looming on the horizon (Hillmann, 2021). Soda studio recognises that the increasingly becoming user-friendly hardware, the Apple Vision Pro just recently released in 2024, signals upcoming market opportunities to create user-friendly digital experiences in this field. However, UX for XR still has a long way to go to accomplish and refine tools, standards and practices (Krauß et al., 2022). This lack of foundational theoretical support makes it difficult for UX designers and Soda studio as an organisation at large to quickly adapt to the changing landscape. Therefore, Soda studio indicated interest in gaining practical insights to help them better understand the complex domain of UX for XR. Over the course of this thesis, it became clear that the agency lacked a formal approach to learning to then build on such initial insights to broaden their expertise in this, or any other, new field. It was this realisation that gave rise to the main aim of this thesis.

1.3. Research aim and method

This thesis aims to contribute to the field of organisational learning. It does so by pursuing the development of an organisational learning strategy (OLS) that addresses the current lack of concrete learning structures in the field (Garad & Gold, 2019). In answer to the need of project-based companies like Soda studio to learn within the dynamic technological landscape, the way in which experiential learning can be applied to strategically broaden expertise is explored. To ensure the proposed strategy is actionable, this thesis aims to develop a practitioner-focused roadmap with guidelines and actionable steps to bring the OLS to practice. The main research question is:

"How can project-based companies in dynamic technological landscapes leverage experiential learning principles as foundation for the strategic broadening of organisational expertise?"

To answer this question (***Chapter 7***), this thesis adopts both a theoretical (***Chapter 2 + 3***) and practical approach (***Chapter 4 + 5 + 6***).

Chapter 2 contributes to answering the research question by creating a basic understanding on how to view of the concepts of knowledge and expertise on an individual and organisational level. After all, to understand the way in which expertise can be expanded, an understanding of what this concept entails is required first.

Chapter 3 dives into the concept of experiential learning and clarifies why it is in theory a suitable method to develop expertise. Moreover, a framework of organisational learning is explored to better understand how individual knowledge may be translated to knowledge on an organisational level. Without this translation, knowledge is not sustainable; it risks being lost if an employee leaves.

Chapter 4, 5, and 6 cover an experiential learning case study for Soda studio in the field of UX for XR. This case study was completed to analyse the potential of experiential learning as a means to shape the organisational learning process in practice. It is uniquely suited to contribute to answering the research question, as Soda studio is a project-based company operating in a dynamic technological landscape to which they want to adapt. From a more practical point of view, the case study enables the creation of experiential knowledge in the field of UX for XR for Soda studio to better understand the implications it might carry for the agency. ***Chapter 4*** introduces the case study and offers necessary background information on UX, XR and UX for XR. ***Chapter 5*** covers the UX for XR project experience. As Soda studio is a project-based company, an external collaboration partner was needed and found in Rijksmuseum Boerhaave in Leiden. In the project, a new exhibit is proposed for one of the key artefacts of the museum: the first artificial kidney. In ***Chapter 6*** learning insights are consolidated and abstracted in light of the larger organisational context.

Chapter 7 integrates theory with practice by synthesising a concrete vision on how experiential learning can be used as a foundation for the strategic development of organisational expertise. The findings are translated to guidelines and actionable steps in a roadmap for practitioners. This roadmap is subsequently evaluated at Soda studio in light of its understandability, actionability and the general appeal of the OLS it outlines.

The relationships between each of these chapters is outlined in ***Figure 1***.

1.4. Scope

The scope of this thesis is confined to the internal learning path within project-based companies. This leads to three key implications. Firstly, the term "internal" emphasises a focus on how a company's own experiences can inform the strategic development of organisational expertise, although new knowledge could be gathered from outside sources as well. Such an internal approach is crucial for the in this thesis considered companies within dynamic technological landscapes, as emerging fields often lack a sound theoretical basis which external sources would provide. Secondly, the term "learning path" implies that the scope of this thesis is limited to insights related to learning rather than those related to the subsequent application and optimization of learned skills in day-to-day operations. In other words, the focus of this thesis lies in understanding the process of experiential learning within organisations and which impact this can have on the strategic development of organisational expertise, rather than on the immediate application of this knowledge. The learning path is aimed at helping project-based companies develop the right competencies before they need to be applied in client projects. Thirdly, the emphasis on "project-based companies" highlights that the broadening of the organisational expertise in question should be adaptive in nature, meaning that it needs to be applicable to a variety of projects within the emerging field.

When it comes to the execution of the case study for Soda studio, some limitations apply too. Although Soda studio works closely together with other disciplines in their more complicated projects, the focus of this case study is on Soda studio's UX expertise that aligns user needs with business needs to form a strategic product direction which is subsequently translated to the "front-end" of experiences. Nevertheless, a complete concept cannot be designed without taking these other disciplines into account in some shape or form. Insights into communication and alignment with other disciplines is limited, as the case study is completed on an individual level.

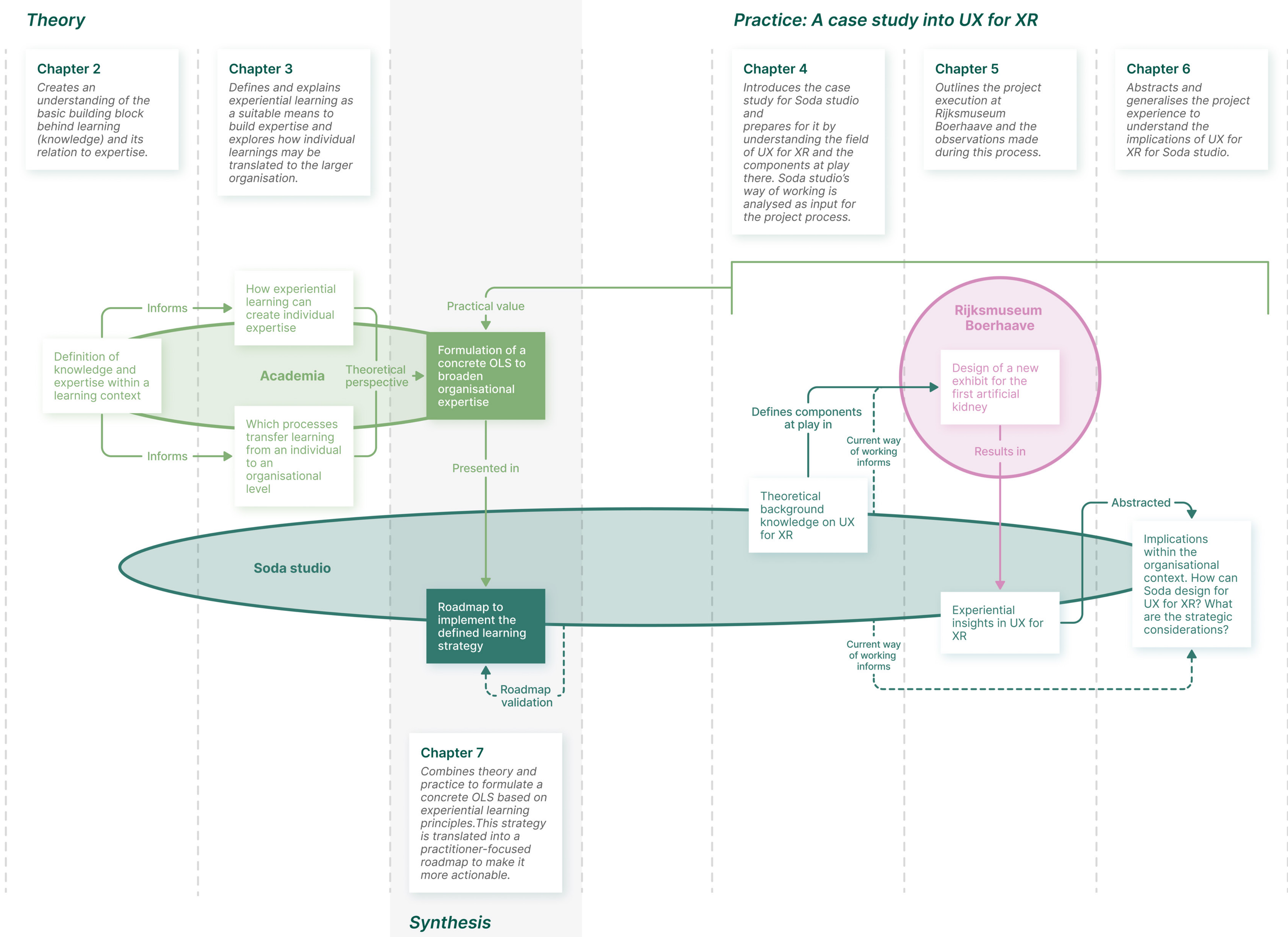
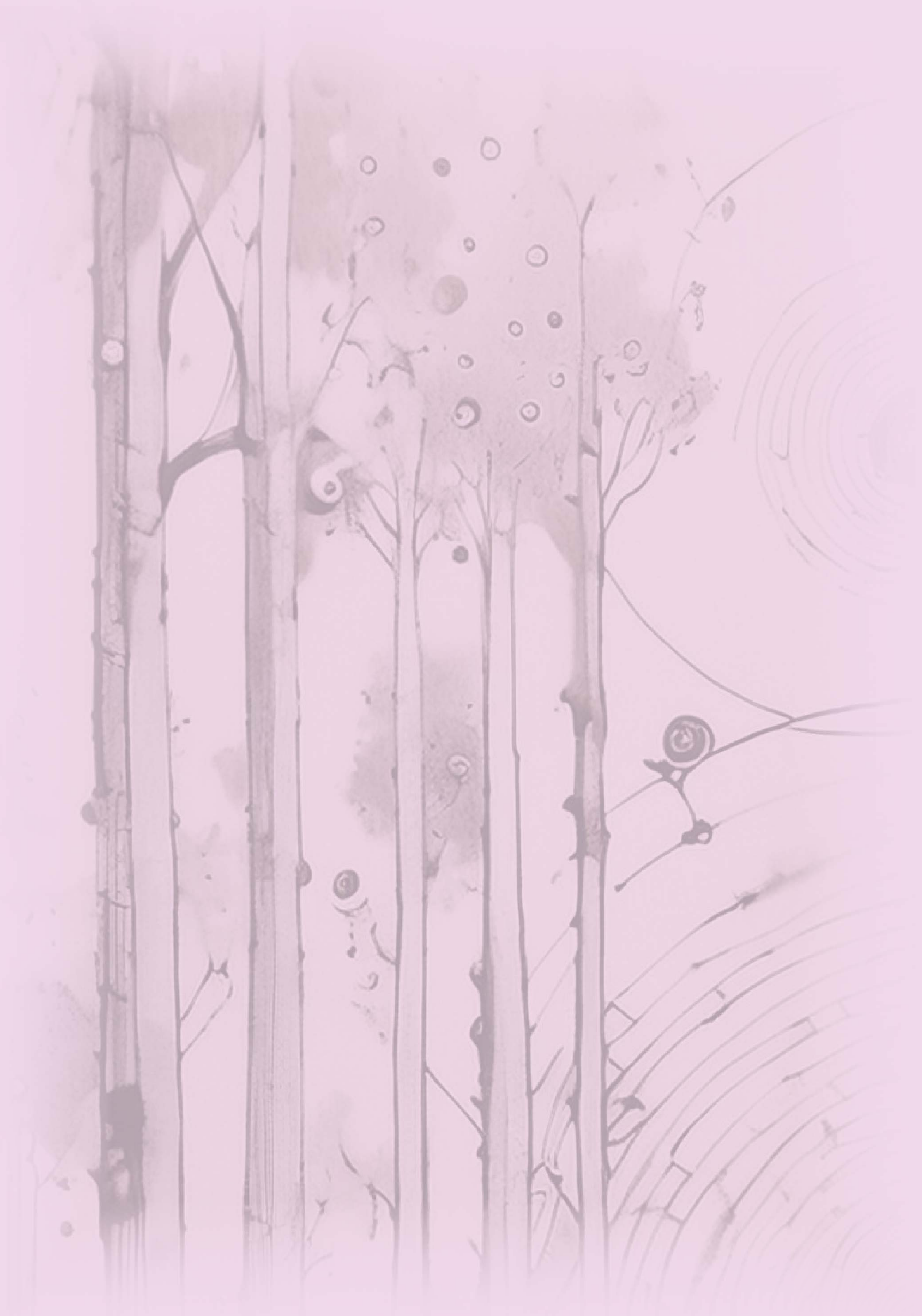


Figure 1
Chapter graphical overview



Chapter 2

Understanding knowledge and expertise

Before diving into the way in which organisational expertise can be broadened strategically, this chapter contributes to understanding the content of this learning process. It explores the foundational theories and principles behind knowledge and expertise and explains the relation between these two. The way in which knowledge and expertise are viewed will have implications for the learning processes that shape these concepts.

2.1. What is knowledge?

To understand the way in which new expertise can be acquired, an understanding of the basics building block behind learning is first required: knowledge. Learning and knowledge are two concepts that mutually reinforce each other – the act of learning provides new knowledge and understanding which can subsequently be applied for further learning (Ahmed et al., 2002). In this manner, knowledge is built. To better understand the learning process within organisational contexts, this chapter aims to clarify how the concept of knowledge should be understood, which knowledge holds value and what type of knowledge classifications can play a role in creating such value within the organisation.

2.1.1. The concept of knowledge

Epistemology is the theory of knowledge and refers to the ways in which the concept of knowledge can be viewed (Koskinen & Pihlanto, 2008). Rather than viewing knowledge as a 'fuzzy' concept, epistemology aims to define it to better understand knowledge development in both individuals and organisations. Koskinen and Pihlanto (2008) outline two different epistemologies based on the work of von Krogh and Roos (1995, as cited in Koskinen & Pihlanto, 2008).

A traditional approach to knowledge is based on the idea that the human mind is able to objectively represent reality. In this cognitivist epistemology, learning occurs through the interaction between an individual and their environment. The mental model of the environment a person has (their schema) is adapted based on their experiences and used to make sense of new incoming information. Based on this information, their schema is updated, and their understanding of the world improved. In other words, learners process received information (experience) and seek ways to relate it to what they already know (prior knowledge) to improve their world view. In contrast to the traditional cognitivist epistemology, the autopoietic epistemology states that incoming data enables individuals to construct their own world view. In other words, knowledge is a subjective process: incoming data is interpreted and placed into context to be given meaning.

To further clarify the difference between the cognitivist and autopoietic epistemology, consider the example of a teacher giving a course to two different students. According to the cognitivist epistemology, the same type of knowledge is transmitted to both students. They use this knowledge to improve their view of the objective world. However, according to the autopoietic epistemology, although the same data is transmitted to both students, their interpretation of this data determines what knowledge is constructed. In other words, their own personal worldview provides the context in which incoming data is given meaning, making knowledge subjective and context dependent. In contrast to the cognitivist epistemology, knowledge is believed to be created or produced rather than transmitted (Vicari & Troilo, 2000).

But why is the distinction between these two views on knowledge important? According to North and Kumta (2018) a process perspective of knowledge is at the heart of successful knowledge-based organisations. This perspective recognises that knowledge is not a fixed object that exists independent of people and that can be stored or transferred, but rather something that is dynamic in nature and created and applied by people. Bennet and Bennet (2009) further illustrate this process perspective, describing knowledge as consisting of two different components: knowledge (informing) and knowledge (proceeding). Whilst knowledge (informing) describes the raw information component of knowledge, knowledge (proceeding) relates to the process of selecting information from the situation at hand, combining that with prior knowledge and using that to drive action. Following this line of reasoning, this thesis adopts the autopoietic epistemology of knowledge. Organisational knowledge (informing) can then be defined the private knowledge of individuals that is collectively shared among organisational members (Pawlowsky, 2001). On Bennet and Bennet's (2009) knowledge (proceeding) level, incoming information of the current situation is combined then not only with individual information, but also with the behavioural, cognitive and affective components of the shared organisational knowledge system to guide action. The shared knowledge system thus enables members of an organisation to understand and interpret their environment, based on both their individual as well as shared organisational knowledge.

2.1.2. The knowledge ladder

Knowledge in organisations only holds value when the right knowledge is applied at the right time to reach desired task-related outcomes (North & Kumta, 2018). This ability of an individual or group to apply knowledge, skills and behaviours to do the right thing at the right time is called competence, sometimes also referred to as action knowledge (Dehnbostel, 2009; North & Kumta, 2018). In order to understand the development of competence in organisations, North and Kumta (2018) put forth the concept of the knowledge ladder (***Figure 2***). Each step of this ladder builds upon the previous, building its way towards competence. It further highlights the way knowledge is created following the autopoietic epistemology. A unique set of competencies, i.e. the knowledge skills and behaviours that form the foundation of competence, is the source of an organisation's competitiveness (North & Kumta, 2018).

The following components play a role in the knowledge ladder:

- ***Symbols:*** the letters, numbers or signs people use to communicate. *E.g. 7,3.*
- ***Data:*** symbols interpreted through clear rules of understanding (syntax). *E.g. 7,3° Celsius.*

- ***Information:*** data placed into context to be given meaning (Koskinen & Pihlanto, 2008). *E.g. 7,3° Celsius is hot or cold when talking about the winter air temperature in Greenland or Indonesia respectively.*
- ***Knowledge:*** people's understanding of relationships between certain phenomena, based on context, experience and expectations. It consists both of know-what/declarative knowledge and know-how/procedural knowledge, aligning with Bennet and Bennet's (2009) knowledge (informing) and knowledge (proceeding) respectively. *E.g. Knowing how to fix an error state of a printer by reading its manual.*
- ***Actions:*** putting know-what and know-why into action. *E.g. Fixing the error state of the printer when it occurs.*
- ***Competence:*** applying knowledge, skills and behaviours to do the right thing at the right time.

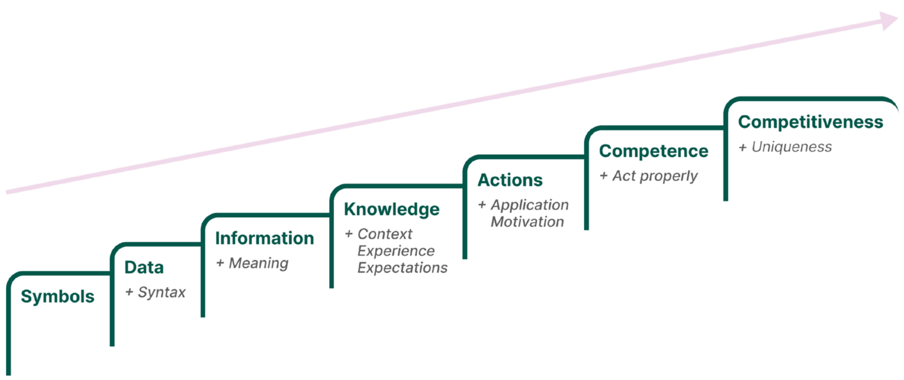


Figure 2
The knowledge ladder. Adapted from North and Kumta (2018)

2.1.3. Types and depth of knowledge

To better understand the way in which knowledge is used to take effective action, a distinction can be made in the type and depth of knowledge individuals hold. As such, these classifications may help to better define and understand expertise and how it may be developed. Broadly speaking, three different *types of knowledge* can be identified, relating to how knowledge is represented in memory and thus accessed during action.

1. ***Explicit knowledge:*** knowledge stored in memory which an individual can intentionally bring to mind (Bennet & Bennet, 2009). This knowledge can accurately be described and shared with others through an exchange of information. However, this information remains subject to alternative interpretations by the other party. On an organisational level, explicit knowledge can be captured in information systems to be shared (Greiner et al., 2007). *E.g. when first learning to ride a bike, a child learns through trial and error. Their parent gives them explicit instructions, and the child can articulate their actions.*

2. ***Implicit knowledge:*** knowledge stored in memory of which an individual is not directly aware (Bennet & Bennet, 2009). However, this knowledge may surface through certain triggers, either environmental or internal. Although an individual might not be aware that they possess this knowledge, it is not impossible to access. *E.g. After the child has practiced riding their bike for a while, some processes become automated. They are not consciously aware of the way they coordinate their movements anymore.*
3. ***Tacit knowledge:*** a type of knowledge that cannot be described in words (Bennet & Bennet, 2009). Even though an individual might know that they possess certain tacit knowledge related to a certain subject, they are unable to accurately explain or visualise this knowledge for others to understand. On an organisational level, tacit knowledge cannot simply be captured in information systems to be shared (Greiner et al., 2007). Nevertheless, most of an organisation's knowledge does reside at this level (Bennet & Bennet, 2009). E.g. After riding their bike to school along the same route every day, the process of cycling has become so automated for the child, that they can safely think about other things. They intuitively understand the traffic patterns they encounter.

   According to Bennet and Bennet (2009), an organisation's tacit knowledge can further be defined into four areas. In context of this thesis, especially intuitive tacit knowledge and affective tacit knowledge are important to understand. Both types of tacit knowledge are embedded deep in an organisation's culture and processes, shaping organisational norms.

   a. ***Intuitive tacit knowledge:*** unexplainable insights that guide actions, also known as intuition. *E.g. intuitively taking a left or right turn whilst cycling*

   b. ***Affective tacit knowledge:*** inarticulable emotional responses that guide actions. *E.g. feeling fear when having to cycle in the dark whilst seeing no identifiable threat.*

Another popular classification of knowledge is that of *depth*, referring to the level of understanding associated with the knowledge held. Again, three different levels can be distinguished (Bennet & Bennet, 2008):

1. ***Surface knowledge:*** predominately information combined with a minimum level of understanding of and meaning behind the subject in question. Low cognitive level activities are used to create this level of knowledge, with the focus on being able to memorize facts, definitions or concepts without comprehending them (Biggs & Tang, 2011). The information is stored as isolated facts, having little to no connection to another and other prior knowledge.

2. ***Shallow knowledge:*** information combined with some level of understanding and meaning. Whilst a basic understanding of the subject in question is created, this knowledge cannot be applied in complex or new situations.
3. ***Deep knowledge:*** information combined with a comprehensive level of understanding and meaning. High cognitive level activities are used to create this level of knowledge, requiring motivation and appropriate background knowledge that is well structured (Biggs & Tang, 2011). The expansion of this knowledge base signifies a wide range of patterns from which the learner can draw when encountering a new situation, enabling them to apply what they know in other contexts as well.

2.2. What is expertise?

Now that we have a thorough understanding of the concept of knowledge, and more specifically that of value-creating competence, one crucial link is left: expertise. This thesis, after all, aims to shed light on broadening organisational expertise for project-based companies. In Soda studio's case, this is in the domain of UX for XR.

2.2.1. The basic concept of expertise

According to Herling (2000), expertise is a domain-specific construct that can be characterised by outstanding knowledge, experience, and problem-solving skills in this domain. He poses that the presence of expertise can be recognised in an individual's actions: experts can consistently apply their knowledge, skills and behaviours to meet tasks both with optimal effectiveness and efficiency. Therefore, it is more complicated to become an expert in a field in where a smaller margin of error exists (Dreyfus & Dreyfus, 2005). Where one has ample time to make corrections and ensure a proper result when driving a car, making a mistake during a surgery can have grave consequences.

According to Carbonell et al. (2014) two different types of expertise can broadly be identified in the professional field: adaptive expertise and routine expertise. Where routine expertise enables individuals to meet standardized tasks efficiently and effectively, individuals with adaptive expertise can apply their knowledge more flexibly to meet novel tasks. This can be credited to having high levels of knowledge abstraction and an awareness of the context-specificity of knowledge. Translating this theory to project-based companies suggests that such companies need to rely on adaptive expertise in their work. After all, each project within their domain is unique in some way or another. However, this does not mean that such companies are exempt from learning. Adaptive expertise does not immediately ensure a high level of performance in new emerging fields, but rather makes it easier to overcome the novelty of it and perform at a high level more quickly (Carbonell et al., 2014). In fact, it is a willingness to learn and seek out challenges that can make the distinction between routine and adaptive experts (Chi, 2011). The question then remains, how can one move beyond competence to develop the necessary adaptive expertise?

2.2.2. From competence to expertise

The concept of competence is closely related to that of expertise. In fact, it can be interpreted as a subset of expertise, reflecting task-related actions within an individual's total domain of expertise (Herling, 2000). Having areas of competence are thus a necessary component within one's domain of expertise but is not sufficient to fully define it. What makes it that experts can consistently meet tasks with optimal efficiency and effectiveness, on top of doing the right thing at the right time?

As expertise develops, the way in which information is stored in memory and used for decision-making is changed. A popular model to understand this progression towards expertise is Dreyfus and Dreyfus (2005) model of skill acquisition. This model delineates how learners at different competence levels make decisions, moving from novices to experts (***Deep Dive: A model of skill acquisition***). Where a novice relies on surface knowledge to make decisions, experts rely on deep knowledge. Isolated facts are slowly transformed into a context-dependent network of information and decision-making processes (Persky & Robinson, 2017). This network is dynamic; experts can adjust and create knowledge processes to drive action according to the specific circumstances at hand, their prior knowledge and the available organisational knowledge (Bennet & Bennet, 2009). In other words, experts have a bigger toolbox to take effective action, encompassing both factual knowledge and the ways in which to process it given the external situation. This toolbox provides them with flexibility when making decisions in complex environments (Bennet & Bennet, 2009).

Progression beyond competence is further characterised by intuitive forms of cognition, i.e. intuitive tacit knowledge. Rather than relying on rules and analytical reasoning, experts can make decisions quickly based on what they intuitively know is right (Eraut, 2000; Persky & Robinson, 2017). Experts know what to do based on their substantial previous experience, without being able to justify their actions explicitly (Crossan et al., 1999). This tacit knowledge ensures experts possess greater problem finding, problem solving and prediction and anticipation skills (Leonard & Sensiper, 1998). Nevertheless, experts still need to apply deliberate forms of cognition to prevent tunnel vision, i.e. the unconscious adoption of a certain perspective when another might be more suitable (Dreyfus & Dreyfus, 2005). Thus, adaptive experts need to apply meta-cognitive skills to reflect on their actions, adjusting course where needed (Carbonell et al., 2014). To become and remain an expert requires a process of continuous learning (Herling, 2000).

Deep dive

A model of skill acquisition (Dreyfus & Dreyfus, 2005)

Dreyfus and Dreyfus' (2005) model of skill acquisition delineates five stages of competence: from novice to expert. Each stage is illustrated by explaining how one approaches decision-making when driving a car.

- ***Novice:*** At this level, individuals have little to no experience in the domain and rely on a set of rules and guidelines to make decisions. They lack an understanding of the context to make sense of these rules within different situations. They are often unable to do the right thing at the right time.

  A novice driver determines to shift gears based on the speedometer alone.

- ***Advanced beginner:*** Advanced beginners start to develop situational understanding by being exposed to clear examples and begin to recognise patterns. They combine both situational and context-free knowledge to make decisions. Although they can perform basic tasks, complex and unfamiliar situations may prove too difficult.

  An advanced beginner decides to shift gear based on both the sound of the motor and on the speedometer.

- ***Competence:*** At this stage, individuals start to adopt a perspective to look at the situation at hand. They can determine which elements are important for decision-making and which can be ignored, enabling them to appropriately deal with most tasks proficiently. Competence signifies a certain emotional involvement to the task at hand. Where rules and procedures could be blamed before, failure may now be credited to a personal choice that was made. It is the willingness to learn from mistakes, and ability to process them both on a cognitive and emotional level, that enables individuals to move past mere competence.

  A competent driver tries to pull out of a parking space with an oncoming bicycle approaching, taking a variety of factors into account. The bicycle approaches quicker than expected and an accident occurs. Only cognitively analysing this situation may lead the driver to believe that they should never pull out of a parking space when a bicycle is approaching. Whilst this will lead to safe driving in most scenarios, it will stop progression beyond competence.

- ***Proficiency:*** Proficient individuals start to tacitly understand situations. They naturally pick the right perspective to look at their current situation. However, they do not yet intuitively understand what the right approach to reaching their goal is. An analytic approach to decision-making, one that relies on rules and principles, is still adopted for this. Thus, proficient individuals can do the right thing at the right time effectively but are not yet optimally efficient in their decision-making process.

  A proficient driver feels based on experience that they are going to fast when approaching a curve on a rainy day. They must decide on the appropriate course of action to prevent an accident. Whilst this decision takes up time, a proficient driver is more likely to safely navigate the curve than the competent driver who is still deciding whether they are driving too fast or not.

- ***Expert:*** Experts not only intuitively understand what needs to be done, but also intuitively known which actions are required to meet this goal. They can navigate complex and uncertain situations by relying on their deep tacit knowledge. Experts cannot easily explain their actions because they have stopped explicitly relying on rules and procedures. They intuitively do the right thing at the right time with optimal effectiveness and efficiency.

  An expert driver feels based on previous experience they are going to fast approaching a curve on a rainy day and intuitively knows the appropriate amount to brake.

2.2.3. Defining expertise

Building on the theory above and on the definition as put forward by Herling (2000), this thesis defines expertise as:

"Domain-specific behaviour in which an individual or group consistently applies knowledge, skills, and behaviours to do the right thing at the right time with optimal effectiveness and efficiency, deploying an intuitive mode of cognition that relies on deep and tacit knowledge."

Recall that within organisations, incoming information is combined not only with individual knowledge, but also with the shared organisational knowledge system to decide on effective action. Organisational expertise can then be defined as:

"Domains-specific behaviour in which an individual or group within an organisation consistently applies knowledge, skills, and behaviours to do the right thing at the right time with optimal effectiveness and efficiency, deploying an intuitive mode of cognition that relies on deep and tacit knowledge housed in both the individual and within the organisation."

When it then comes to expanding such expertise, it can be concluded that the development of new competencies or the adaptive application of existing competencies in this new field is required whilst fostering a deep and tacit knowledge base (***Figure 3***).

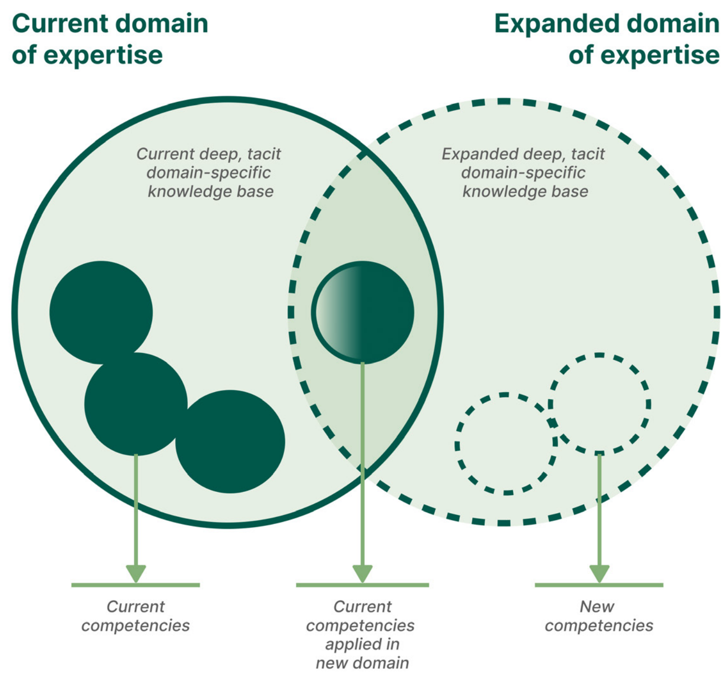


Figure 3

Broadening expertise. Based on the work of Herling (2000)

2.3. Chapter round up

In this chapter, the foundational theories and principles behind knowledge and expertise were explored. It has become clear that knowledge is subjective and context dependent. Within the context of organisational learning, this means that knowledge cannot be transferred like an object between individuals; every person interprets it in their own way. When it comes to the creation of expertise, it has become clear that deep and tacit knowledge needs to be developed, making it difficult to share with others. To broaden expertise, new competencies need to be developed and refined.

Knowledge is a dynamic process and is created in the minds of people. It can be viewed as consisting of knowledge (informing) and knowledge (proceeding).

- Knowledge (informing) describes the information, or content, component of knowledge. This type of knowledge relates to know-what.
- Knowledge (proceeding) relates to the process of selecting information from the situation at hand, combining that with prior knowledge (informing) and using that to drive action. This type of knowledge relates to know-how.

Knowledge can be classified according to its type (explicit, implicit, tacit) and depth (shallow, surface, deep).

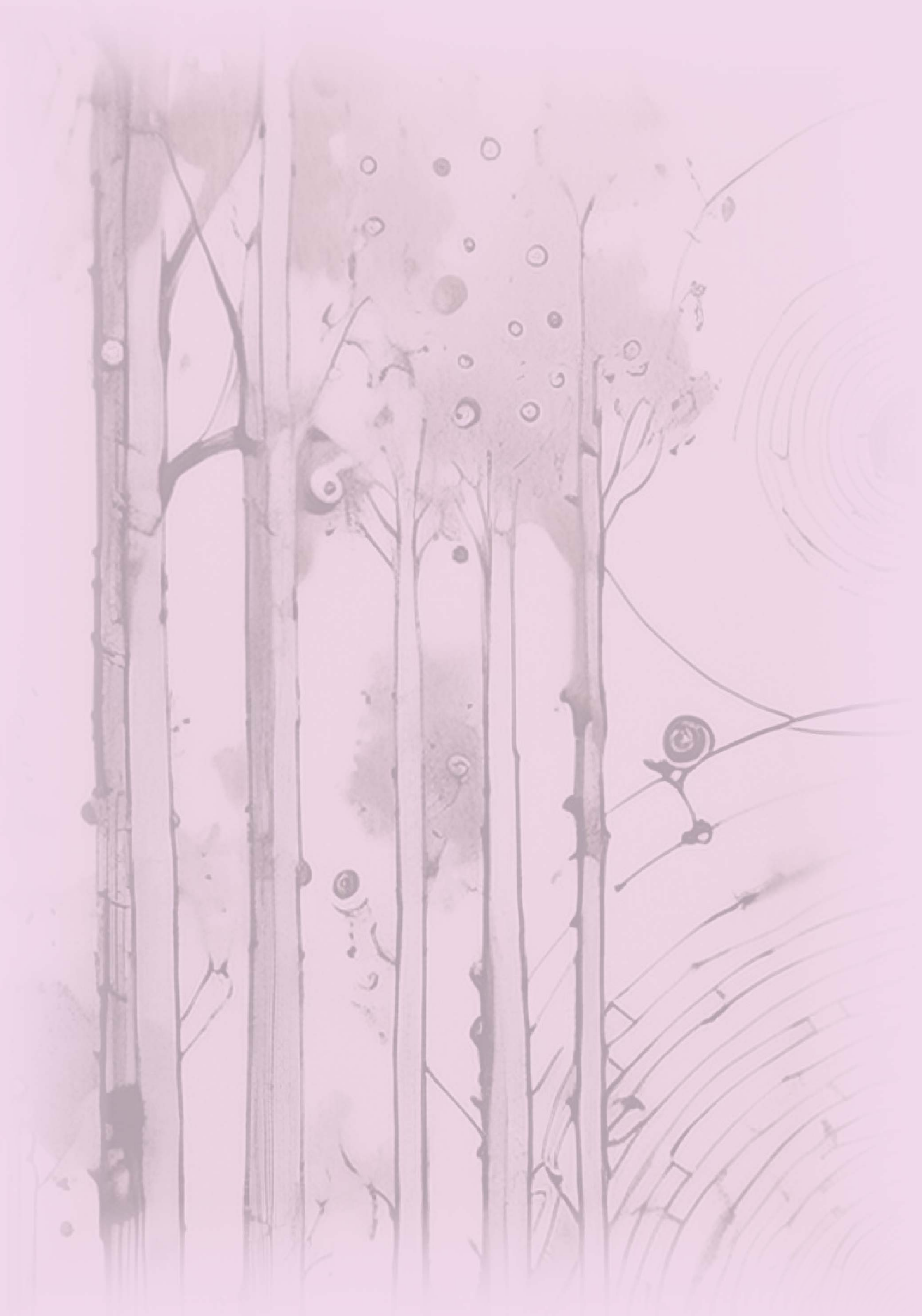
- The type of knowledge classifies how knowledge is represented in memory and can be accessed during action. The three knowledge types (explicit, implicit, and tacit) can be placed on a scale from conscious to unconscious storage and use.
- The depth of knowledge classifies the understanding associated with the knowledge held. The three knowledge depths (shallow, surface, deep) can be placed on a scale from minimum level of understanding/meaning to a comprehensive level of understanding and meaning.

Expertise relies on the development of deep tacit knowledge through continuous learning and reflection.

- Expertise is characterised by outstanding knowledge, experience, and problem-solving skills in a specific domain. These qualities are related to the development of a deep tacit knowledge that fosters intuition in experts.
- Where expertise is characterised by intuition, deliberate cognition creates awareness of the context-specificity of knowledge. To become and remain an expert, continuous learning and reflection are required.

Developing new competencies forms the foundation of broadening adaptive expertise.

- Knowledge in organisations only holds value when the right knowledge is applied at the right time to reach desired outcomes (i.e. competence).
- Within a domain of expertise, individuals demonstrate competence in various areas. Experts consistently meet their tasks with optimal efficiency and effectiveness, on top of doing the right things at the right time.
- Through the development of new competencies or application of existing competencies to emerging fields, adaptive expertise can be broadened.



Chapter 3

Understanding experiential and organisational learning

Having gained a basic understanding on knowledge and expertise, this chapter explores the role of experiential learning in the development and broadening of expertise. As it is understood that knowledge creation happens on an individual level, the subsequent sections delve into organisational learning to gain insight into how individual knowledge can be embedded in the wider organisation. A general framework and enabling conditions for the strategic development of organisational knowledge are discussed.

3.1. A learning approach for developing expertise

To form a deep tacit knowledge base that serves as the foundation for adaptive expertise, active learning is required (Carbonell et al., 2014; Koskinen & Pihlanto, 2008). After all, the key to acquiring tacit knowledge is experience (Nonaka, 1994). Experience based learning can lead both to the formation of experiential knowledge (know-how) and theoretical knowledge (know-what) that form the foundation of competence (Dehnbostel, 2009). Arguably, this makes learning from experience even more important in emerging domains where a sound theoretical basis is lacking.

However, expertise is more than the accumulation of knowledge or experience alone (Persky & Robinson, 2017). To refine competencies requires conscious effort (Persky & Robinson, 2017). Both mental effort and emotions need to be applied to embed knowledge in the unconscious mind (Bennet & Bennet, 2009). Individuals need to immerse themselves in their field of expertise, constantly practicing and being open to new experiences, whilst at the same time engaging in reflective processes to process the consequences of their actions, both on a cognitive and emotional level (Bennet & Bennet, 2008; Dreyfus & Dreyfus, 2005; Persky & Robinson, 2017). The relationships and patterns they discern overtime then become deep tacit knowledge and form the foundation for intuition (Bennet & Bennet, 2008).

In other words, a kind of continuous and intentional practice is required to build expertise. In such a practice, individuals deliberatively plan learning goals and learning opportunities, are actively engaged during learning and systematically reflect after the learning experience (Eraut, 2000). The need for such a practice in organisations is further supported by the notion that the strategic development of competencies cannot take place without direction (North & Kumta, 2018). In the professional field one cannot rely on implicit or reactive learning alone, both of which are characterised by a lack of learning intention (Eraut, 2000), to achieve such goals. But what would such a deliberative practice look like?

3.1.1. The experiential learning cycle

A deliberative approach to learning from experience is presented by Kolb (2007) in his experiential learning cycle (*Figure 4*). This cycle provides a means for learners to engage in concentrated, repeated performances that centre around self-reflective processes. It is driven by action/reflection and experience/abstraction to transform experience into knowledge. The cycle consists of four phases that form an upwards learning spiral (*Figure 5*), each new experience becoming richer and deepening understanding (Kolb & Kolb, 2009). In short, concrete experiences form the foundation for reflections from which learners can delineate abstract concepts (*Deep Dive: The experiential learning cycle*).

These concepts can be tested in and guide further experiences. By abstracting problems and their solutions in this way adaptive expertise is fostered (Carbonell et al., 2014).

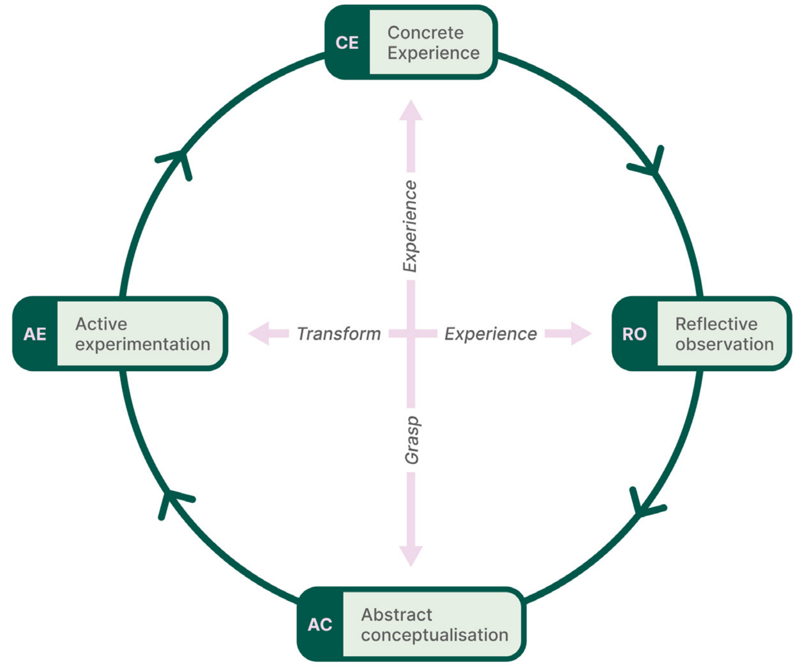


Figure 4
The experiential learning cycle. Adapted from Kolb (2007)

Deep dive
The experiential learning cycle (Kolb, 2007)

Kolb's (2007) experiential learning cycle provides a deliberate approach to learning form experience, consisting of four phases:

- ***Concrete experience (CE):*** Concrete experiences form the basis of the learning cycle and can be facilitated in variety of ways. A distinction can be made between experiences where learners engage real-life problems or situations over an extended period (e.g. project-based learning (Crawley et al., 2007), action learning (Revans, 1982), or internships (Dehnbostel & Schröder, 2017)) or where such situations are mirrored in a more controlled environment to offer short-term learning opportunities (e.g. professional development workshops (Brooks-Harris & Stock-Ward, 1999), role play and simulations (Crawley et al., 2007), or case discussions (Crawley et al., 2007)).
- ***Reflective observation (RO):*** Learners reflect on their experience, processing it on both a cognitive and emotional level. This process enables learners to internalize what they experienced (Myers & Roberts, 2004). To make the learning outcomes of the experience explicit, reflection can

take place in action and on action, by others or the self (Simons & Ruijters, 2001).

- ***Abstract conceptualisation (AC):*** In this stage, reflections are assimilated to be distilled into abstract concepts, such as generalizations, rules and hypotheses. Learners try to understand their experience by connecting it to what they already known. They become aware of the context-specificity of their knowledge and try to abstractly represent it. This enables learning to be transferred to and from other contexts, fostering adaptive expertise through the creation of high levels of knowledge abstraction.
- ***Active experimentation (AE):*** Learners test their new insights in other real-world situations. This stage starts the learning spiral, each new experience testing, and being perceived in light of, new knowledge.

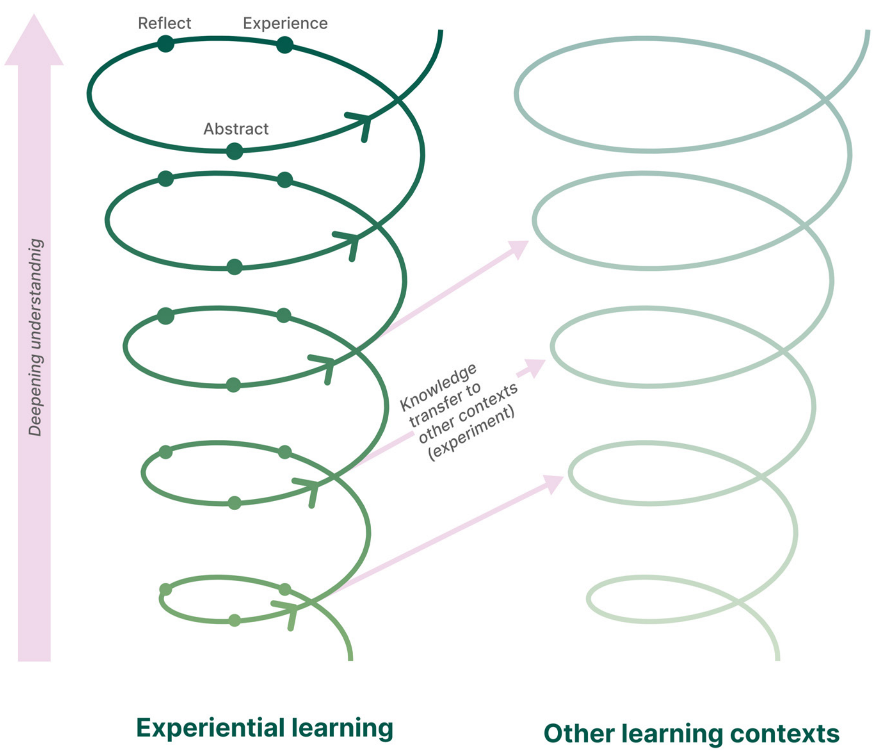


Figure 5
The upwards learning cycle of experiential learning. Adapted from New Zealand Ministry of Education (2004, as cited in Kolb and Kolb (2009)

3.1.2. Enabling experiential learning

To develop expertise through following Kolb's learning cycle, several factors ensure optimal effectiveness. The quality of an individual's deep tacit knowledge development is influenced by the inherent quality of the experience, as well as the way in which knowledge workers execute the learning cycle.

1. ***Personal commitment and involvement in the learning experience:*** Personal commitment and involvement to the learning experience can deepen learning. The deeper learners engage in the experience, the better the learning outcome may be (Biggs & Tang, 2011). To ensure this engagement, Nonaka (1994) poses that having a learning intention and autonomy is crucial. First, having a certain intention before going into a learning experience ensures learners have a lens through which to value it. A clear learning goal or objective enables learners to place their experiences into perspective, making the information important to fulfil their intention more salient. Second, having autonomy in the learning process provides a means to stimulate intrinsic motivation. When learners are given the freedom and independence to explore, they are likely to engage in the task because they want to, not because they have to (Gagné & Deci, 2005). Such intrinsic motivation drives deep learning (Biggs & Tang, 2011) which is a prerequisite for developing expertise. By devising their own solution strategies and making and learning from mistakes, learners are enabled to deeply understand the domain (Carbonell et al., 2014).
2. ***The completeness of the cycle:*** Being committed to and engaged in the overall learning experience alone does not guarantee optimal learning effectiveness throughout Kolb's learning cycle; learners should execute all four modes of the learning cycle skilfully (CE, RO, AC, AE) (Kolb, 2007). To complete the learning cycle in this manner, they need to perceive and process information in a variety of ways. Kolb (2007) characterises these as different learning styles. Diverging style learners, for example, have high levels of imagination and excel in viewing situations from a variety of perspectives. They like to observe the action rather than being in the centre of it. Learners with a Thinking style, on the other hand, thrive on abstracting their experiences and translating these to conceptual models. In total nine learning styles are characterised that enable learners to harness the experiential learning cycle. Although learners might habitually favour one style over the other, a person can develop the different ways of thinking characteristic of each learning style.
3. ***The variety and connectedness of experiences:*** Being exposed to a variety of experiences helps create elaborative cognitive maps, forming a flexible knowledge base that shapes adaptive expertise (Carbonell et al., 2014; Crossan et al., 1999). In other words, a certain level of chaos to the environment can help learners break their habits (Nonaka, 1994). Out of

their comfort zone, learners are prompted to question their automatic response to situations, preventing tunnel vision. Although fluctuation can positively influence the quality of the knowledge creation process, it is important to consider that high quality experiences that can be integrated are required to prevent this variety from being destructive (Nonaka, 1994). Without reflection on how experiences are connected, learning will remain fragmented. Coaching and supervision can help knowledge workers reflect on their learning process (North & Kumta, 2018).

4. ***The progressive nature of experiences:*** Aside from being exposed to a variety of experiences, learners should be confronted with experiences that are tailored towards their current level of expertise. Progressing through the different stages of competence to become an expert does not happen overnight. By engaging in progressively more challenging tasks, learners learn to solve increasingly complex problems, helping them to move towards building expertise (Persky & Robinson, 2017).

3.2. A framework for organisational learning

Knowledge starts at the individual level, at that of the "knowledge worker" (Nonaka & Takeuchi, 2007). Whilst the creating of individual adaptive expertise might be facilitated by the application of Kolb's (2007) experiential learning cycle, learning needs to take place not only on an individual level, but on an organisational level too to broaden an organisation's expertise. Recall that Pawlowsky (2001) defined organisational knowledge as knowledge that is collectively shared among organisational members. Organisational learning can then be defined as a modification to this shared knowledge system, either on a cognitive, emotional or behavioural level. To move beyond learning on an individual level, the group level forms a crucial stepping stone. It is at this level that individually acquired knowledge is mediated, from where it can be shared to other groups or people for future application in the organisation (Wiewiora et al., 2019). Thus, individual learning is embedded in team learning and subsequently in organisational learning (Koskinen & Pihlanto, 2008).

3.2.1. The 4I framework

Whilst a variety of frameworks exist to explain the organisational learning process in more detail, the 4I framework of Crossan et al. (1999) is adopted in this thesis (***Figure 6***). This framework is suited to this thesis especially, because it does not only consider learning at the individual, group, and organisational level, but does so with the core concept of strategic renewal in mind. Strategic renewal concerns changing organisational attributes to positively impact future organisational success, taking into account both the process, content and outcome of this change (Agarwal & Helfat, 2009). Evidently, this process aligns with organisations wanting to broaden their adaptive expertise in light of a

changing technological landscape to remain competitive.

Within the 4I framework, four different learning processes are identified across three levels (the individual, group and organisation). Between the different levels of learning, feedforward and feedback processes are present. Where feedforward processes focus on the progression from individual to group to organisational learning to embed new knowledge in the organisation, feedback processes signify how such knowledge in turn can influence the actions of the individual and the group (Crossan et al., 1999).

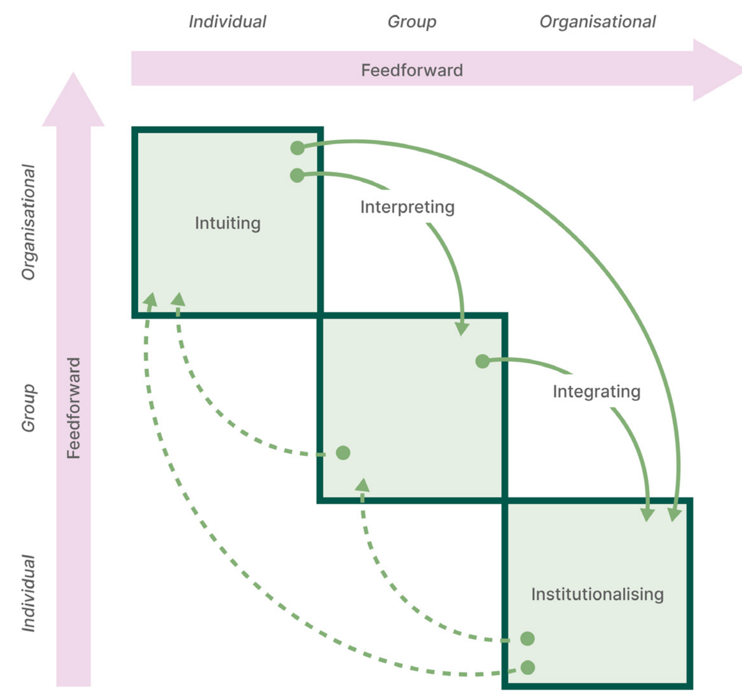


Figure 6
The 4I framework. Adapted from (Crossan et al., 1999)

1. ***Intuiting:*** Crossan et al. (1999) refer to the intuiting process as a subconscious process in which individuals recognise patterns and possibilities. Intuiting is a result of experience, stored as tacit knowledge, which surfaces as insights, intuitions or inspiration (Leonard & Sensiper, 1998). An individual subconsciously relates incoming information to what their already know (their schema) and recognises patterns based on their expertise. Although Crossan et al. (1999) define intuiting as a mostly subconscious process, it is important to note that, most learning in organisations involves the conscious observation of direct experience (Aponte & Zapata, 2013). As discussed before, experience does not

automatically lead to learning. Indeed, Hilden and Tikkamäki (2013) identify reflection as an important part of the intuiting process in order to bring hidden assumptions and knowledge (i.e. implicit knowledge) into the conscious mind, enabling learners to see new opportunities and create novel insights, rather than relying on their past patterns alone. Metaphors and imagery can play an important role in the early stages of knowledge creation by helping individuals to express their insights and to share these with others (Crossan et al., 1999; Koskinen & Pihlanto, 2008; Nonaka, 1994). Through metaphors, the inexpressible can be expressed by combining what is already known in new ways (Koskinen & Pihlanto, 2008).

2. ***Interpreting:*** Where intuiting largely relies on subconscious processes, interpreting centres around making sense of such insights explicitly (words) and implicitly (actions) (Crossan et al., 1999). Interpreting shapes an individual's cognitive map, whilst simultaneously being influenced by it through the way in which prior knowledge contextualises their insights. Although individuals can interpret insights themselves, conversation and dialogue with others plays a crucial role in enriching the process through the inclusion of different perspectives.

3. ***Integrating:*** In the integrating process, the change in understanding and actions of individuals as brought about in the interpretating phase, is translated to the larger group (Crossan et al., 1999). Individual interpretative processes come together and are consolidated to form shared understanding. Since knowledge is context dependent and can thus not easily be transferred from one person to another, practices like dialogue, joint action and storytelling in which individuals interact and share their experiences are crucial to this consolidation process (Crossan et al., 1999; Koskinen & Pihlanto, 2008; North & Kumta, 2018).

4. ***Institutionalising:*** The final step of organisational learning according to Crossan et al. (1999) is institutionalisation. In this step, the insights gathered, and knowledge consolidated by individuals and groups become part of how the organisation operates. When coordinated actions within groups find significant traction among members of an organisation, new routines and rules emerge. These procedures, and the structures and systems put in place to support them, then become part of organisational memory. A substantial amount of this memory is tacit with intuitive and affective aspects shaping cultural norms and guiding behaviour in an organisation without the explicit awareness of the individuals within (Bennet & Bennet, 2009). Even if members of the organisation leave, changes will endure to influence and guide the new members of the organisation.

3.2.2. Enabling organisational learning

For strategic renewal to take place, organisations need to focus on building new knowledge and innovation (feedforward) whilst concurrently applying their institutionalised learning from the past in practice efficiently today (feedback) (Crossan et al., 1999). A certain tension is thus inherent to organisational learning - one between exploration and exploitation. Knowledge management (KM) plays an important role in effectively steering these efforts within organisations. In short, KM comprises systemic practices used to manage both the acquisition and use of knowledge within an organisation to reach specific objectives (Britton, 2005; Jones & Leonard, 2009; Koskinen & Pihlanto, 2008). At its core, broadly two types of knowledge management can be defined: strategic KM and operative KM (North & Kumta, 2018). Where strategic KM is concerned with reaching the long-term knowledge goals and objectives of an organisation (approaching the knowledge ladder top-down), operational KM is more concerned with applying acquired knowledge successfully (approaching the knowledge ladder bottom-up) (***Figure 7***). This thesis is primarily concerned with the strategic exploration side of knowledge management, looking into the learning path that may enable organisations to broaden their expertise, by expanding their competencies into emerging fields, to remain competitive. To effectively shape and execute this learning path, organisations must balance an exploration and exploitation mindset, steer learning efforts, facilitate common understanding and cultivate a culture of trust and motivation.

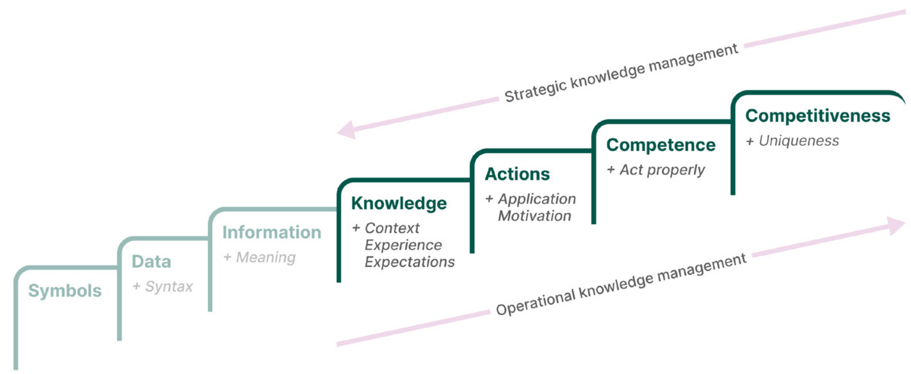


Figure 7

Strategic and operational knowledge management approaches. Adapted from North and Kumta (2018)

Balance an exploration and exploitation mindset

Whilst this thesis is primarily concerned with the exploration side of KM, it is important to realise that exploration and exploitation within organisations needs to be balanced. Failing to do so may result in organisations falling either into the failure trap or competency trap (Levinthal & March, 1993).

- ***Failure trap:*** exploration drives out exploitation through a dynamic of failure (Levinthal & March, 1993). An innovation fails and is replaced by another in the hope of a better outcome, but these fail in turn. The organisation starts over from square one every time.
- ***Competency trap:*** exploitation drives out exploration through a dynamic of (false) confirmation (Levinthal & March, 1993). As organisations develop and engage with procedures with positive outcomes, they keep engaging and investing in it. This cycle continues even if the procedure has become inadequate due to, for example, a changing environment. The organisation might enjoy good short-term performances but is not sustainable. In other words, knowledge in organisational memory becomes rigid and risks becoming outdated (Bennet & Bennet, 2009).

To prevent falling into these traps, organisations must strive for organisational ambidexterity – the execution of both exploration and exploitation processes within an organisation (Kassotaki, 2022). Achieving such ambidexterity is difficult because exploration and exploitation processes require different mindsets to excel (North & Kumta, 2018). In fact, they give rise to two different strategies to approach knowledge within organisations: personalisation and codification (Greiner et al., 2007). A personalisation strategy places people and their tacit knowledge at the heart of the KM processes (Greiner et al., 2007). It focuses on promoting networking, dialogue and creativity in order to solve problems, aligning with the experimentation and risk taking mindset required for exploration (Kassotaki, 2022; Koskinen & Pihlanto, 2008). Codification, however, focuses on improving processes and relies heavily on explicit knowledge to collect, store, and disseminate it across the organisation (Greiner et al., 2007). Whilst this approach leaves little room for creativity with only tried and tested problem solving procedures being promoted, it does align with the refinement and efficiency mindset required in exploitation (Kassotaki, 2022; Koskinen & Pihlanto, 2008).

Since adopting both these mindsets/strategies simultaneously is conflicting, organisations should consider separating processes over time and/or space (Kassotaki, 2022). When it comes to facilitating change that impacts an organisations competitiveness, setting up separate units with their own cultures, processes, and structures is recommended (North & Kumta, 2018). In this way, the language and logic that becomes ingrained in organisational memory over time, will not conflict with the other needs of the organisation. At any rate, organisations operating in dynamic environments should adopt a mindset of continuous learning, aiming to update and expand their competencies and learn from failure (Bennet & Bennet, 2009). Even if an organisation predominantly uses a codification strategy, learning is still required. After all, the creation of knowledge is affected by the learning context, making its application in other situations require further learning (Eraut, 2000).

In conclusion, to broaden expertise effectively, organisations must prioritize exploration alongside exploitation. Space must be made for exploration without forgetting exploitative efforts. An explorative focused learning path will require continuous learning and the application of a personalisation strategy that is distinct from day-to-day operations.

Steer learning efforts

To strategically steer organisational learning efforts, a deliberate learning strategy needs to be set to that defines an intended course of action. By setting concrete knowledge objectives, learners are provided with perspective. Without this perspective, their attention may be directed to intuiting and interpreting information in a way that does not contribute to the long-term goals of the organisation (Crossan et al., 1999). Moreover, having a meaningful shared vision for the future provides individuals within the organisation with the focus and energy needed to collaboratively build knowledge (Koskinen & Pihlanto, 2008).

However, providing objectives and vision statements alone is not enough to steer learning effectively. Leadership needs to provide the motive (why?), means (how and what?) and opportunity for learning (where and when?) (Darwin, 2017). In other words, an entire policy surrounding the knowledge creation process within an organisation should be made clear. To assess the effectiveness of a such knowledge creation processes within organisations, enabling continuous learning, Mitchell and Boyle (2010) define three measurement methods:

1. **Knowledge creation as a process** evaluates the engagement of knowledge workers in the initiatives and activities undertaken to form new knowledge.
2. **Knowledge creation as an output** gives insight into the effectiveness of the knowledge strategy. It evaluates the amount of new knowledge that is resultant of the knowledge processes.
3. **Knowledge creation as an outcome** measures the efficiency of the learning strategy. Which knowledge is proving valuable and reaches institutionalisation?

Whilst Mitchell and Boyle (2010) speak of knowledge measurements methods, it is important to take into account that these measures are often subjective, based on stakeholder and participant judgment, rather than being objectively perceivable.

Facilitate common understanding

Within the interpretation and integration process, knowledge workers must be able to explain their own cognitive maps and integrate them with others (Crossan et al., 1999). Forming common understanding is challenging, because knowledge is inherently "sticky", embedded in the mind of individuals (Day and Wendler, 1998, as cited in Koskinen & Pihlanto, 2008). This especially holds true for tacit knowledge, which cannot be articulated (Bennet & Bennet, 2009). Moreover, recall that knowledge is subjective, each person giving meaning to incoming information differently based on their prior knowledge. Thus, without having some kind of shared interpretations, learners struggle to understand one another and to apply another's insights to their own situation, limiting knowledge diffusion across the organisation (Koskinen & Pihlanto, 2008). Following this line of thought, Nonaka (1994) calls for redundancy of information in organisations. When part of the learner's cognitive maps overlap, implicit and tacit knowledge is more easily shared, as members can sense based on their overlapping what the other means (Nonaka, 1994). Several factors can contribute to such information redundancy and to the development of common understanding in general:

1. ***Share a language.*** As mentioned previously, the key to the integration process lies in practices such as dialogue and storytelling (Crossan et al., 1999; Koskinen & Pihlanto, 2008; North & Kumta, 2018). Herein, language functions as a tool that helps learners to shape and negotiate meaning (Whittle et al., 2023). Naturally, when learners share the same linguistic framework, having a similar understanding of words and their meaning, forming common understanding becomes easier. A persons own cognitive map, however, may still form a filter to this communication, making them hear want to what they believe rather than believe what they hear (Crossan et al., 1999).
2. ***Having rich means of communication.*** Distance (both in space and time) makes sharing tacit knowledge with others more difficult (Leonard & Sensiper, 1998). After all, knowledge is not only shared through language, but through other means of communication as well, such as body language. The richer the interaction, the less likely miscommunications are to occur. Face-to-face communication, which facilitates immediate feedback to check understanding, is thus preferred to facilitate the creation of common understanding (Lengel & Daft, 1984).
3. ***Have shared experiences.*** Joint action or experimentation creates a shared context for learners to share knowledge and form common understanding (Koskinen & Pihlanto, 2008). Such interaction is crucial, especially when it comes to sharing novel ideas and tacit knowledge (Crossan et al., 1999; Leonard & Sensiper, 1998). Knowledge is then not consolidation through language, but by sharing or mimicking behaviour. Within organisations, participation in communities of practice is a popular method to share tacit knowledge and facilitate common understanding. Within such a community, members of an organisation with similar interests or problems come together to interact and share knowledge on an ongoing basis (Wegner et al.). They provide a space for experimentation and learning (North & Kumta, 2018).

Although these factors can contribute to the effective sharing of knowledge among the group, having too many similarities may harm the innovation process. When each member of the group shares their worldview, the group is not challenged to explore different options within their consolidation process (Leonard & Sensiper, 1998). Having different interpretations will motivate learners to engage in processes to build consensus to resolve their conflict (Fischer et al., 2002). Nonaka (1994) further argues for such diversity in teams by drawing on the principle of requisite variety. This principle states that the greater the range of knowledge and skills within a team, the better they are equipped to deal with a variety of challenges.

Cultivate a culture of trust and motivation

Setting up a strategically steered learning path that is focused on and provides the means for creating common understanding, does not automatically mean learners will engage in the knowledge sharing process. In fact, knowledge hoarding often still remains the dominant strategy within organisations, because from an individual perspective it carries the least risk (Koskinen & Pihlanto, 2008). The right culture needs to be cultivated in organisations to ensure employees are comfortable and motivated to share their knowledge with others.

When it comes to motivating employees to share knowledge, a distinction can be made between extrinsic and intrinsic motivational approaches. Where extrinsic motivation makes use of external rewards, such as money or promotion, intrinsic motivation is resultant of the interest and enjoyment of the executing task itself (North & Kumta, 2018). Between these two, intrinsic motivation is the key driver of knowledge sharing (Koskinen & Pihlanto, 2008; North & Kumta, 2018). Rather than working with material incentives, organisations must work to undermine the common perception that hoarding knowledge is more rewarding than knowledge sharing and enable learners to enjoy the learning process. Generally speaking, management should make promote feelings of autonomy, competency, and purpose (Pink, 2011). In other words, learners must have some level of control over their learning process, be able to develop themselves through it and have the feeling they are contributing to something valuable. Within this process, the leaders of an organisation are responsible for modelling the right behaviour and learning mindset (Darwin, 2017). Management must, for example, value mentoring and assisting. When an organisation that regards expertise highly fails to do so, learners are unlikely to part with status that their expertise gives them within the organisation (Leonard & Sensiper, 1998). Moreover, space should be made to make mistakes. When learners are afraid to make mistakes, e.g. in trying to articulate their deep knowledge, they are likely to not do so at all (Leonard & Sensiper, 1998).

Aside from being intrinsically motivated to participate in the knowledge creation process, the work by Holste and Fields (2010) suggests that both affect-based and cognition-based trust is key in knowledge sharing. The greater the level of interpersonal trust, the greater the level of openness, and the better the opportunities for knowledge to be transferred (Koskinen & Pihlanto, 2008). Where affect-based trust is built on mutual care and concern, cognition-based trust is based on an individual's perceived reliability and competence (McAllister, 1995). Developing trust takes time and is the result of interpersonal relations (Koskinen & Pihlanto, 2008). Both affective-based and cognition-based trust can be promoted by having co-workers regularly work together, especially when collaborative projects highlight their interdependency and enables them to demonstrate their competence (Holste & Fields, 2010).

Overall, when considering the cultural elements necessary for organisational learning, it is important to recognise that cultural change requires time and commitment. After all, an organisation's knowledge, beliefs and values are deeply embedded in the tacit organisational memory and making changes to this memory is naturally met with resistance (Bennet & Bennet, 2009). Whilst leadership plays a crucial in modelling change, individuals within the organisation must show commitment to make the institutionalisation of new tacit knowledge a fact (Bennet & Bennet, 2009; Kotter, 2012).

3.3. Chapter round up

Based on this chapter, suitable learning structures to broaden organisational expertise start to emerge. Kolb's (2007) experiential learning cycle was identified as a fitting means to develop expertise. As knowledge creation always starts on an individual level, the processes involved in translating such knowledge to an organisational level were explored too. For this translation, a strategic approach to KM is key to assure value is created for the organisation. By understanding these learning structures and their enabling factors, an effective OLS can be created.

Expertise is created through experience and effortful practice.

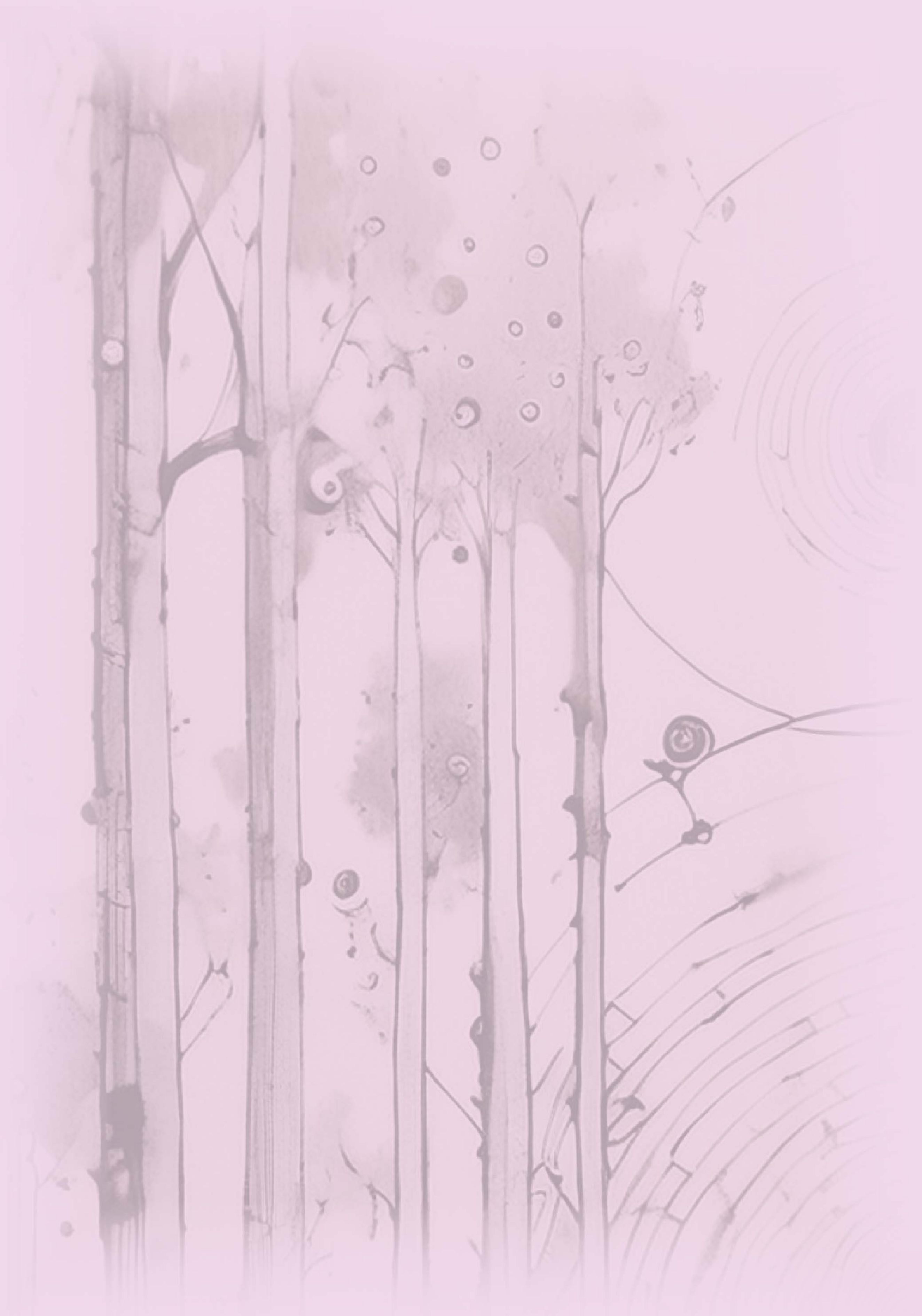
- Experience is the source of the deep and tacit knowledge on which the development of expertise relies.
- To embed knowledge in the unconscious mind, a continuous and intentional practice is required in which learners deliberatively plan, are actively engaged, and systematically reflect.

Kolb's experiential learning cycle offers a structured learning approach suited to develop expertise, particularly in emerging fields characterised by a lack of a robust theoretical foundation.

- Experiential learning promotes a structured learning activity centred around experience that fosters effortful practice. Based on experience, learners reflect, conceptualise and experiment.
- Competence, and thus expertise, relies on both experiential knowledge (know-how) and theoretical knowledge (know-what). Learning by experience may result in both knowledge types, even if theoretical information is not readily available.
- To facilitate learning through the experiential learning cycle, individuals must 1) complete the cycle as whole, 2) be personally committed and involved in the experience, 3) make connections across related experiences and 4) engage in progressively complex experiences that match their current knowledge level.

Individual knowledge can be translated to organisational knowledge through group interactions. By strategically managing the feedforward processes across these levels, exploitation is fostered, and expertise can be broadened.

- Organisational learning can be defined as a modification to the shared knowledge system, either on a cognitive, emotional, or behavioural level.
- Modification of this system starts at the individual and is translated to the organisation via the group through four processes: intuiting, interpreting, integrating and institutionalising.
- Strategic KM manages the feedforward processes in organisational learning and is concerned with reaching the long-term knowledge goals and objectives of an organisation (approaching the knowledge ladder top-down).
- To facilitate the strategic broadening of expertise, organisations must 1) balance exploration and exploitation, 2) steer learning efforts in the right direction, 3) facilitate common understanding between groups and 4) cultivate a culture of trust and motivation.



Chapter 4

A case study into UX for XR: Setting the stage

Up until now the concepts of knowledge, expertise, experiential learning, and organisational learning have been explored from a theoretical standpoint. To analyse the potential of experiential learning as a means to shape the organisational learning process in practice, a case study is completed. In this case study, an experiential learning cycle (CE, RO, AC) is completed for Soda studio in their field of interest: UX for XR. As Soda studio is a project-based company, an external collaboration was needed to provide a project based on which reflective observations and abstract conceptualisations could be made. Rijksmuseum Boerhaave in Leiden offered this project. In this chapter, the case study and necessary background information on UX, XR and UX for XR is introduced.

4.1. Introducing the case study

Recall that Soda studio is small project-based UX design agency in Amsterdam that pride themselves on their expertise. They possess specialised UX knowledge which they apply flexibly in complex projects. Although expertise is difficult to quantify, in ***Chapter 2*** it was established that experts can do the right thing at the right time effectively and efficiently, based on deep tacit knowledge. Such effectiveness and efficiency can indeed be seen on the work floor at Soda studio. Their UX designers know how to turn complex problems into easy-to-understand designs in mere weeks. When it comes to organisational learning as discussed in ***Chapter 3***, tacit knowledge is mostly shared between designers by pairing senior with junior designers in client projects. In this way, a shared experience is created in which junior designers can share and mimic the behaviour of their seniors. In turn, junior designers can offer fresh perspectives that prevent tunnel vision in the experts.

Although this approach to learning works for their current operations, Soda studio is now interested in expanding their expertise to a new emerging field: UX for XR. As mentioned previously, this field currently lacks practical guidance for organisations like Soda studio to navigate the complexities of its landscape. Given the lack of theoretical knowledge, UX designers might start to build expertise in this landscape by learning from experience.

4.1.1. Goal

The goal of this case study is twofold. When it comes to Soda studio, the aim is to gain experiential knowledge in the field of UX for XR, by conducting a single experiential learning cycle in this field. By aggregating and abstracting gained insights, an understanding of the implications that UX for XR might carry for Soda studio can be created. From a larger academic perspective, this case study helps to analyse the way in which experiential learning can be used as a foundation for the strategic broadening of organisational expertise together with the theory explored in ***Chapter 3***.

4.1.2. Approach

This case study follows Kolb's experiential learning cycle from concrete experience to reflective observation to abstract conceptualisation. Active experimentation was placed out of scope of this thesis, as it would require another project to test the gathered insights in a different context.

To ensure this learning experience would deliver actionable insights based on real-life complications and challenges, a client operating in a market in which the use of XR was established already was sought. A partner was found in Rijksmuseum Boerhaave, a scientific museum in Leiden. Whilst the museum context is more experience-oriented than Soda studio's regular utility-based UX designs, valuing both education and entertainment, XR already has a realistic use case in this market. At Rijksmuseum Boerhaave, a project with sufficient depth and breadth was formulated to mimic the complexity of real-world UX projects. This project offered a unique opportunity to gather insights across the entire design cycle whilst leaving ample room for exploration. Completing such a project was important to holistically understand the similarities and differences between Soda studio's current and potential future work processes for UX for XR. Moreover, the project allowed for stakeholder management and decision-making dynamics in the emerging field of UX for XR to be considered too. Overall, Rijksmuseum Boerhaave provided an ideal backdrop to gain insights into UX for XR in a holistic and complex project with real-life stakeholders that pushes the boundaries of Soda studio's regular projects.

Before diving into the project experience itself (CE and RO in ***Chapter 5***), and the implications this carries for Soda studio (AC in ***Chapter 6***), this chapter first explores the background knowledge required to even start the project. After all, to be able to design within the field of UX for XR, an understanding of both these terms is needed. In the following subchapters, UX, XR and UX for XR are defined. In the subchapter on UX design, Soda studio's way of working within this field is explained too. After all, this way of working will need to be followed as closely as possible during project at Rijksmuseum Boerhaave to understand how and why Soda studio's current knowledge, skills and behaviour needs to be broadened when it comes to the world of XR. It is important to note that throughout this case study, the experience at Rijksmuseum Boerhaave will be viewed from a UX designer's perspective. Whilst other disciplines like 3D modelling, sound engineering and development are crucial elements in XR design too, these disciplines will only be touched upon when encountered to make advances in the UX design of the exhibit.

4.2. What is UX design?

UX design is method that involves the creation and optimisation of user interaction with a design to meet their needs (Hillmann, 2021). In other words, it centres around designing quality user experiences. A definition of what this "user experience" entails exactly is still lacking, due to its association with a wide variety of fuzzy concepts, theoretical models, focal points and applications (Law et al., 2009). Nevertheless, the user experience can generally be understood as being a consequence of a user's internal state (e.g. expectations, needs, motivations), the characteristics of the product (e.g. functionality, usability) and the context in which the interaction occurs (e.g. voluntariness of use, social setting) (Hassenzahl & Tractinsky, 2006). Moreover, the experience a user has with a product is not fixed: it changes constantly throughout product interaction (Law et al., 2009). All in all, user experience is not a product attribute, but rather a perceived quality of a product interaction that is dynamic context-dependent and subjective (Law et al., 2009). Broadly speaking, users can evaluate the interaction with a product through its perceived pragmatic qualities and hedonic qualities (Hassenzahl, 2018). Where pragmatic quality refers to a user's perception of a product's potential to support them in reaching their goals, hedonic quality concerns a user's perception of a product's potential to support pleasure in use (Hassenzahl et al., 2010). UX design concerns itself with influencing both such perceptions.

On the pragmatic side, usability forms one of the key foundations of UX. According to ISO 9241-11, usability can be defined as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified use context" (International Organization for Standardization, 2018). Within UX, usability functions as a "hygiene factor": it enables great user experiences by removing barriers in interaction, enabling users to reach their goals (Hassenzahl et al., 2010). However, mere usability does not guarantee user engagement. While usability focuses on minimizing negative affect, it is not in and of itself a source of positive affect. Therefore, UX design must address non-utilitarian aspects of interactions too (Law et al., 2009). This is where a product's perceived hedonic quality comes into play. Acting as the "motivator", hedonic quality ensures the creation of a positive user experience and user engagement (Hassenzahl et al., 2010). Thus, alongside usability, more fuzzy concepts related to psychology, like flow (Nakamura & Csikszentmihalyi, 2002), gamification (Hillmann, 2021) and need fulfilment (Hassenzahl et al., 2010), play important parts in UX design too as a source of positive experience. Broadly understanding the factors involved in UX design from a theoretic standpoint begs the question: how do UX designers apply this theory in practice?

4.2.1. The five elements of UX design

To shed light on the practical implementation of UX design for digital products, Garret (2011) put forward a framework that divides a UX design across five layers or planes: surface, skeleton, structure, scope and strategy. Each plane is dependent on the planes below it, but dependencies do run in both directions. In UX design, designers move through the different planes from bottom to top, from abstract to concrete. Decisions on higher planes may force (re)evaluations on decisions on lower planes.

1. ***Surface:*** The surface layer represents the final visual design, the look of the finished product. In this layer, UX designers work together with UI designers (and copywriters) to develop high fidelity prototypes.
2. ***Skeleton:*** The skeleton layer represents the information design (the way information is presented to facilitate understanding), interface design (the way in which elements are arranged to help users reach their goals, i.e. the lay-out) and navigation design (the elements that allow users to move through the presented information). At this stage, UX designers typically concern themselves with wireframing and creating low-fidelity prototypes. Such prototypes can often be used to identify usability problems as effectively as high-fidelity prototypes, but require less effort to be created (Virzi, 1996). They thus provide a means to validate a design before moving to the surface layer.
3. ***Structure:*** The structure layer represents the interaction design (how the system responds to user actions) and information architecture (the way content is organised and structured in the design). Common methods applied at this stage of design are site mapping, visually representing the structure of the pages in a digital product, and the creation of user flows, a flowchart representing how a user flows through the different pages within a digital product. Thus, the structure layer is characterised by the creation of diagrams and charts.
4. ***Scope:*** In the scope layer, the functional specifications and content requirements of the product are set. In other words, the feature set of the product is determined.
5. ***Strategy:*** The strategy layer forms the foundation of the entire design, defining the why of the product. It centres around the identification of user needs and business goals. Appropriate methods to gather this information are stakeholder and target group interviews.

4.2.2. UX design at Soda studio

The design process at Soda studio is in alignment with the framework of Garret (2011). To move throughout the different planes in this framework, a Scrum methodology is applied. Sprints - short time boxed periods in which a project team works to complete a set number of goals - are at the heart of the design process. At Soda studio, each sprint takes up 2 weeks. However, before diving into these sprints, an internal and external kick-off at the client is organised. These kick-offs ensure that everyone is on the same page when it comes to the general content of project and the amount and type of sprints included. Often a key performance indicator (KPI) is identified that sets the main objective of the project. For example, increasing the conversion rate of an eCommerce website.

Whilst each project at Soda studio differs, a typical team composition and way of working can be identified. UX designers of Soda studio often work together in a scrum team with visual designers, copywriters, and developers of MakerStreet to design a digital product from start to finish. In this case, Soda studio puts forward both a UX lead who oversees the entire creative process and communication between all parties and a UX designer who is mostly practically involved in executing the UX design itself. The client is responsible for delivering a product owner – the key stakeholder and point of contact for the project.

After the internal and external kick-off, the design sprints itself start. At the beginning of each such a sprint, a sprint planning is created that defines the sprint goals. At the start of each day during the sprint, a short 15-minute daily scrum occurs in which the entire team discusses how the work is progressing, and obstacles are identified. After each sprint, a review and retrospective take place. Where the scrum team showcases and discusses the result of the completed sprint during the sprint review, the process to get to that result is evaluated during the retrospective. Subsequently, a new sprint is initiated, and the cycle starts back at the beginning. At Soda studio, a general sprint structure can be identified. In parallel to the sprints as described below, the designated UX researcher oversees the user testing process (as described in *italics*). During the external kick-off, the date of the test and target audience has often already been set.

1. ***Sprint 0: Research***
   The first two weeks of a project centre around defining user needs and business goals (strategy plane). Depending on the project, a variety of methods might be applied to identify needs, wishes and potential product features, such as customer journeys and in-depth interviews with stakeholders or potential users. When needed, designers also use the time in this sprint to familiarise themselves with the industry in question from a UX perspective. The research sprint at Soda studio is almost always concluded with a product vision workshop with the most important stakeholders. The insights gathered up until this point are used to finalise the vision on the target group, their needs, potential product features meeting those needs and business goals. Based on these factors a product vision statement is set up (scope). This statement serves as a point of reference during the entire design process to help make decision-making easier. In consultation with the product owner, user stories are then formulated. A user story is a short simple description of the need of a user and describes product features. These stories are prioritised by the product owner and in doing so form a prioritized list of work for the upcoming sprints, also known as the product backlog. When user stories are picked to be part of a sprint's goals, they are made part of the sprint backlog.

   Whilst the main UX team is busy mapping user and client needs, a recruitment agency is hired based on the criteria of suitable respondents as determined during the external kick-off. These respondents should represent the target audience of the product. On average 6 respondents are required for the user test to appropriately determine potential usability problems.

Sprint 1-2: Concept sprints
During the concept sprints, the scrum team works on designing a basic vision for the product. This idea is first abstractly mapped and structured (structure): Which pages do we envision? What features belong on which page? How does the user move between them? This abstract mapping is subsequently translated to a black and white wireframe and prototyped within Figma, the leading design tool when it comes to interface design (skeleton). In this manner, the concept direction can be communicated and approved by stakeholders. Often, the visual designer on the team works closely together with the UX lead and UX designer to refine the design to fit the brand (surface). The final prototype resultant of these sprints is used for the concept test.

Whilst the concept design often directly follows after the product vision has been formulated, a strategic step is sometimes taken in between: the formulation of a product concept. The product concept is focused on answering the "how" of the design, before moving into the "what". Based on the product vision and other completed analysis, a set of principles is defined that are central in the to-be-designed experience. In other words, a guiding content strategy is determined.

After the first of two concept sprints, a script session is organised with the UX lead/designer and product owner. The content of the concept test is determined together, specifically the main research questions. In other words, what are the uncertainties that we want to have answered? A set of scenarios are set up that respondents will run through during the test day. For each of these user flows, points of interest in relation to the main research questions are marked. Based on this script session, the UX researcher types out the script for the test day and sends these to the product owner and UX lead for approval.

2. ***Concept test***
   The concept test is often hosted remotely, enabling respondents from all over the country to participate, diversifying the pool of candidates. During the test, the respondents walk through the determined scenarios and are asked to think out loud. The UX researcher can observe their laptop or phone screen and asks them a set of questions to help them reflect on their experience. Often a sidekick is present in the same room as the UX researcher and listens along. They are responsible for making elaborate notes during the test. The client and UX designers can observe the test remotely via a livestream and can send additional questions via a private chat with the UX researcher when necessary. The client and UX designers are also asked to take notes in an online environment. Here, each scenario/user flow is visualised through its screens and post-its with remarks can be placed underneath the screens in question. At the end of the test day, all those that conducted or observed the test come together to draw conclusions: What are the things that stood out most for everyone?

   After the testing day, the UX researcher spends a day creating the final report. A summarised answer to the research questions is provided. For each *screen, it is further explained what went well using a colour scheme: good (green), neutral (grey), difficult (orange), and bad (red). Recommendations on how to improve the design are mentioned as well.*

3. ***Sprint 3-7: Detailing sprints***
Depending on the recommendations of the user test, changes to the global design might be implemented. Once the final global concept has been established, designers finalise the product design during the detailing sprints. The core of the work during these sprints consists of designing for all edge cases: all possible flows and screens within the product are thought out based on the potential actions users can take within (structure and skeleton). Again, the visual designer is involved throughout to appropriately apply the brand (surface). Similarly, a copywriter is involved in this stage to make the copy user-friendly and in compliance with the brand voice (surface). Once a page or feature is done completely, refinement sessions are hosted with the development part of the team. These sessions ensure a smooth hand-off towards development and are aimed at clarifying any questions they have. Based on these refined designs, developers code the final product.

After the sprints for the design part of the team is completed, development often still has a lot of work to do to finalise the actual build of the project. A UX designer often stays associated with the project in an advisory role to be able to answer any questions the development team might encounter during this process that have not yet been answered in the refinement sessions.

Although this process describes a general project at Soda studio, each project is unique. Some projects have run for a year already, consisting of sub-projects where one part of a website is designed, tested and build each time. Sometimes, projects also take on smaller forms: a UX designer might be hired to provide expertise in an existing design team at a client. An individual designer then becomes part of the day-to-day design work at the client, rather than being part of a MakerStreet design team tasked with developing a new digital solution. In this thesis, however, the approach to projects as described above is taken as starting point, as it is generally represents the design work Soda studio does best.

4.3. What is XR?

Extended reality (XR) is an umbrella term for a set of immersive technologies. Immersion refers to the objective sensory fidelity a system provides and is an objective and measurable attribute of a system (Slater, 2003). The higher the level of immersion, the more closely the system mimics real-life sensory inputs. To mimic such sensory inputs, a wide variety of input and output devices can be used in different set-ups to reach the desired level of immersion. An important distinction within input devices is whether or not they make use of tracking technology (Kim et al., 2020). Examples of input methods include e.g. eye tracking, hand tracking, a Quest controller or touchscreen interactions. Output devices can be categorized based on their sensory cues: visual (e.g. a see-through screen), auditory (e.g. headphones), haptic (e.g. haptic gloves), olfactory (e.g. an atomizer) or motion-based (e.g. a motion platform) (Kim et al., 2020). The main benefit of using such immersive technologies is the user's subjective psychological response to it, known as the feeling of presence (Slater, 2003). A study by Weinstein et al. (2009) suggests that when users feel physically present in a virtual context, its content is more effectively transferred to their real world-thinking and behaviour (Przybylski et al., 2010). In other words, the experiences users have with the digital content in immersive technologies can have a strong impact on their thoughts, attitudes, and behaviours in the real world. Aside from physical presence, a feeling of truly being in the digital world, users can also experience emotionally presence, where they perceive that their digital experience is emotionally significant, and narratively presence, where they feel involved in and engaged with the story being told (Przybylski et al., 2010).

Immersive technologies are often placed along the reality-virtuality continuum (Milgram & Kishino, 1994). In the space between real and virtual, digital information and real-world information can mix. The extent to which they do so defines different XR categories. Broadly speaking, two main categories of XR technologies exist, divided by whether the physical environment plays, at least visually, some role in the experience: virtual reality (VR) and augmented reality (AR).

4.3.1. Virtual reality

In virtual reality, users are transported to and immersed in a virtual environment with which they can interact. Thus, VR is characterised by telepresence: the degree to which a user feels present in the virtual rather than the physical environment (Rauschnabel et al., 2022). Based on the degree of telepresence a VR system provides, a distinction can be made between atomistic VR and holistic VR. Where in atomistic VR the quality of the user experience is secondary to some other goal e.g. training, holistic VR is characterised by a virtual experience that is nearly indistinguishable from a real-world experience (Rauschnabel et al., 2022). Thus, holistic VR, per definition, consists of a high-fidelity system in which real-life sensory inputs are mimicked closely. The use of VR is especially beneficial when a real life context does not exist, is not accessible or not desirable (Rauschnabel et al., 2022). According to Bekele et al. (2018), three types of VR can be distinguished which can be placed on the atomistic -holistic VR axis:

- ***Non-immersive VR:*** The virtual environment is viewed through a desktop or handheld display and interactions with the environment are mediated by devices such as mouse and keyboard.

- ***Semi-immersive VR:*** The virtual environment is partially immersive, presenting the visual world through large screen displays or projections. Tracking is not required if the experience is intended for multiple users.
- ***Fully-immersive VR:*** The virtual environment is fully-immersive, displaying a virtual environment from the user's perspective. Fully immersive VR is the most well-known type of VR and is often achieved through a head mounted display (HMD) in which a user's sight is completely taken over.

4.3.2. Augmented reality

As opposed to virtual reality, augmented reality supplements rather than replaces the real world (Azuma, 1997). The technology combines the real and a virtual world and offers real time interaction possibilities between users and virtual content (Azuma, 1997). In other words, AR is aimed at enhancing perception of, and interaction with, the real environment by augmenting it with virtual information (Bekele et al., 2018). Therefore, it is characterised not by telepresence, but by local presence: the extent to which users perceive AR content as being part of reality (Rauschnabel et al., 2022). According to Rauschnabel et al. (2022), AR can in fact be placed on a spectrum based on the degree of local presence it stimulates: from assisted reality to mixed reality. Where assisted reality is aimed at assisting the user in gaining a better understanding of the real world through the virtual content that is provided, mixed reality prioritizes a high fidelity to integrate virtual objects seamlessly and realistically into the real world. Whilst this distinction creates a clear division within AR technology based on its primary goals, AR can also be characterised based on different display techniques and methods used to combine the virtual with the real world.

When it comes to display techniques, broadly three categories can be identified (Rauschnabel et al., 2022):

- ***Video see-through***: Virtual content overlays the real world on an untransparent screen (e.g. HMD with see-through mode or an AR mirror where users see themselves instead of the environment). Real-world objects are digitised through recordings.
- ***Optical see-through:*** Virtual content is displayed on a transparent screen through which users can also view the real world (e.g. AR glasses).
- ***Projection-based AR:*** Virtual content is overlayed on the real world through digitally controlled projections (e.g. beamers). The difference with semi-immersive VR is that the projection does enhance a real-world object rather than creating the virtual world itself.

When it comes to display methods used to identify target objects in the real world, Hillmann (2021) makes a distinction between:

- ***Marker-based AR:*** Virtual content is anchored in the real world by the recognition of physical markers, such as QR codes or images.
- ***Markerless AR:*** Virtual content is placed in the real world by recognition of surfaces and objects. In other words, the real world is interpreted to determine where virtual content can be placed.
- ***Location-based AR:*** Virtual content is anchored to a specific real-world location.

4.4. UX for XR

Every interaction a user has with an XR application inherently results in a user experience. Combining the discussed theory on UX design and XR, leads to an initial understanding of the fundamental components involved the design for such interactions. Whilst these fundamentals are not difficult to understand, UX designers face a variety of challenges when designing the user experience for XR applications.

4.4.1. UX for XR fundamentals

Although AR and VR exhibit significant differences and thus facilitate distinct experiences (Rauschnabel et al., 2022), it is possible to identify the common components that need to be considered in their UX design (***Figure 8***). Recall that the user's internal state, product characteristics and context of use are of key influence in user experience (Hassenzahl & Tractinsky, 2006). When it comes to XR applications, it follows that this product consists of a certain ***system*** set-up with input and output devices, through which the ***user*** can ***interact*** with virtual ***content***, e.g. through viewing, modifying or accessing it. When considering the design of a VR experience, the physical environment does not play a role on a content level. However, an interface or relation between the content and the ***physical environment*** does exist in AR applications (e.g. through AR markers). It is important to note that the physical environment alone does not constitute the entire context of use. Within the ***larger context of use***, other factors such as voluntariness of use, the amount of interaction partners and the perceived meaningfulness of the task, can play a role (Hassenzahl & Tractinsky, 2006; Kim et al., 2020). Considering these fundamentals, it is important to realise that UX design, at least at Soda studio, often takes on a more goal oriented rather than entertainment approach. The focus of UX designers will thus most likely not lie on creating experiences with the highest possible fidelity, but on aligning each component to help users reach their goals best. Therefore, UX for XR is likely to centre around atomistic VR and assisted reality with a more prominent focus on the pragmatic, rather than hedonic, quality of the system (Rauschnabel et al., 2022). Still, XR technology more naturally lends itself to experience-based goals (hedonic quality) as opposed to web and app due to its immersive quality.

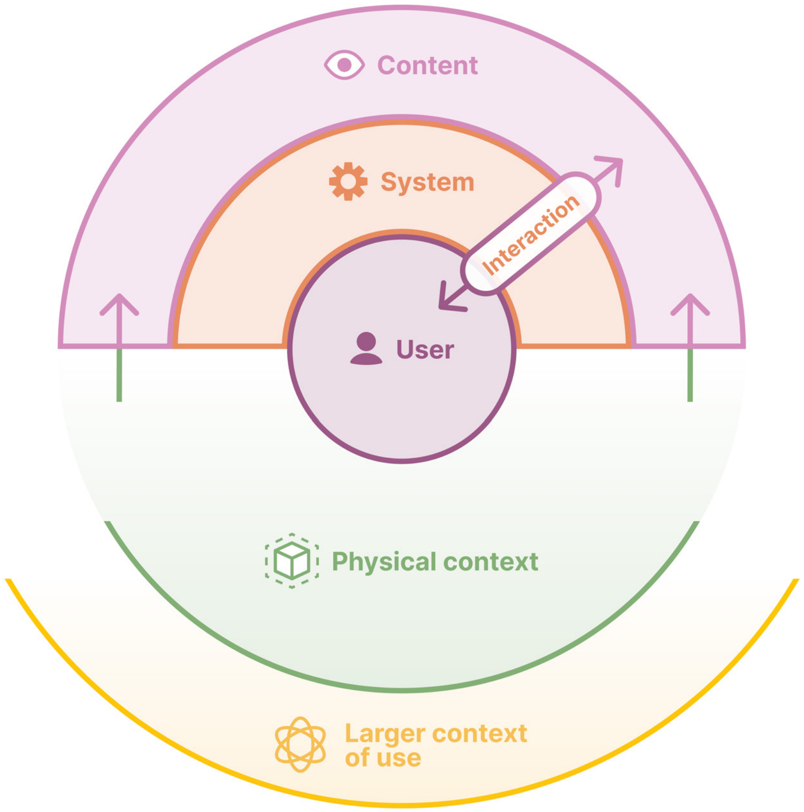


Figure 8
UX for XR fundamentals

4.4.2. Known challenges

UX design for XR still has a long way to go to accomplish and refine tools, standards and practices to reach a similar level of efficiency and positive impact on spatial user experiences, as traditional UX design has accomplished for web and app (Hillmann, 2021; Krauß et al., 2022). Nevertheless, the stakes for UX designers are high: failing to design a proper user experience will have a much greater impact on an immersed user than one using web or app (Hillmann, 2021). The challenges UX designers currently face when designing experiences for XR can be boiled down to four main problem areas.

1. ***A lack of guiding principles and patterns***
   Whilst designing an experience, UX designers are used to relying on proven principles and patterns that have been developed over time, especially when it comes to design in the skeleton plane. Principles are basic design guidelines that have been accepted as true, such as providing users with the option to undo unwanted actions (Crumlish & Malone, 2009). The most famous set of principles are arguably of Jakob Nielsen who provides 10 rules of thumb to improve the usability of a system (Crumlish & Malone, 2009). Whilst principles don't prescribe specific solutions, they are the foundation for design patterns. A design pattern signifies a common, recognisable, and proven design solution for a specific problem in a specific context (Crumlish & Malone, 2009). They are the basic building blocks UX designers use to develop their design. A common navigation pattern, for example, is the hamburger menu in app design. As valuable as design patterns are anti-patterns, that describe bad design solutions to known problems (Crumlish & Malone, 2009). Sometimes it is easier to formulate a good design by knowing what not to do, e.g. using too many pop-ups to confirm actions.

   When it comes to XR, there is still a lack of principles and patterns to guide designers. Some general principles, such as Nielsen's heuristics (***Deep Dive: Jakob Nielsen's 10 heuristics***), could be transformed to design for XR environments, providing basic support for designers (Hillmann, 2021). Nevertheless, concrete, and robust patterns are lacking. Available ones are superficial and not focused on complex interactions (Ashtari et al., 2020), such as the use of curved screens and radial menu's for VR and the use of off-screen cues in AR (Hillmann, 2021).

Deep dive
Jakob Nielsen's 10 heuristics (Nielsen, 1994)

- ***Visibility of system status:*** Keep users informed about what is going on by providing them with appropriate feedback.
- ***Match between system & real world:*** Speak the user's language and follow real-world conventions. By leveraging existing mental models, users can focus on the task at hand rather than having to learn new models. In other words, form follows function.
- ***User control and freedom:*** Provide users with the possibility to undo any unwanted actions they have taken by accident.
- ***Consistency and standards:*** Stay consistent throughout the design (internal consistency) and with other similar products the user is familiar with (external consistency). Users transfer the expectations they have based on previous experiences.
- ***Error prevention:*** Help prevent users from making mistakes, either consciously or unconsciously. Elements in the design can limit user interactions and steer them in the right direction, e.g. the use of radio buttons over checkboxes ensure users can only pick one item in a list.
- ***Recognition rather than recall:*** Keep information that is required to take certain actions visible or easily accessible when the user needs them.

- ***Flexibility and efficiency of use:*** Provide users with the possibility to personalize and customize their experience based on their needs.
- ***Aesthetic and minimalistic design:*** Present users with essential information only and prioritize content that supports their primary goals.
- ***Help users with errors:*** When presenting the user with error messages, use plain language and suggest concrete solution directions.
- ***Help and documentation:*** Provide documentation to users to help them carry out their actions.

2. A lack of holistic spatial tools and practices

Whilst UX designers have established practices for creating user interfaces for web and apps, new interaction possibilities resultant of the new system possibilities in XR are so different from current UX design that these methodologies might fall short (Keating et al., 2011). UX designers might, for instance, have difficulty addressing the physical aspect of immersive experiences, e.g. how to deal with the influence of user posture and movement (Ashtari et al., 2020). Moreover, current UX-focused tooling is often tailored to design for specific XR systems or facilitates only a certain type of practice (Ashtari et al., 2020). For example, the software Shapes XR (Shapes Corp., 2021) requires designers to design with a HMD on and mainly focusses on the storyboarding process.

3. The influence of new hardware possibilities

Aside from the many unanswered questions that the authoring process of XR prototypes raises, the unfamiliarity of end users with XR hardware makes it hard to test the designed experience too (Ashtari et al., 2020). Not only might users need a lengthy introduction to the system before the core of the experience can actually be tested, for users, there is little distinction between the user experience related to the hardware and software (Ashtari et al., 2020; Hillmann, 2021). Whilst UX designers often have little control over this hardware design, it can still negatively influence the experience they are trying to create (e.g. VR motion sickness).

4. A rapidly changing landscape

The rapidly evolving landscape of XR hardware and software makes it extra difficult for designers to understand the interaction possibilities and the right tools to design for those (Ashtari et al., 2020). Traditional UX designers can rely on widely accepted and well-documented tools, such as Figma, and known hardware specifications, such as accepted screen resolutions. In contrast, the current landscape of XR authoring tools is disjointed and online resources and conventions become outdated quickly as technology is maturing (Ashtari et al., 2020; Hillmann, 2021). As designers familiarise themselves with XR hardware and software pitfalls and possibilities, these might have already become outdated in the process.

All-in all, there are many challenges to navigate within the world of UX for XR. Although the rapidly changing landscape, available tooling and the influence of new hardware possibilities on user interaction may be beyond the direct control of UX designers, principles, patterns, and practices are within their world of influence. When it comes to these, it is important to recognise that usability issues often stem from factors rooted in human cognition and the limitations thereof. By having a fundamental understanding of how the brain learns and processes information, a foundation for the project at Rijksmuseum Boerhaave is created to tackle usability problems, regardless of the specific technology in play (***Deep Dive: Human cognition for dummies***).

Deep dive
Human cognition for dummies

In its most simplified form, incoming information can be said to be processed through three different types of memory: sensory memory, working memory, and long-term memory.

- ***Sensory memory:*** a cognitive structure that enables us to perceive new information (Mayer, 2014). Here, incoming stimuli from the outside world are briefly stored and organised into meaningful patterns through the way in which they are perceived (Hodent, 2017). This perception is subjective and not only works bottom-up, but also top-down, being influenced by one's prior knowledge and experiences, one's expectations and goals and by the current environmental context (Hodent, 2017). If incoming information is given attention, it can subsequently be processed into working memory. It is important to note that when attention is focused, it works like a spotlight that causes inattentional blindness: it prevents unattended elements from being perceived consciously even if they are surprising or unexpected (Hodent, 2017). Moreover, whilst perception is subjective, it is in part governed by biases that are common for everyone. Take for example the well-known Gestalt laws of perception that denote how the brain is wired to perceive the environment and recognise patterns (Wertheimer, 1938). The task of UX designers is thus to guide attention to the right elements in a design and to navigate perceptual biases well.

- ***Working memory:*** a cognitive structure which enables us to temporarily store and process information consciously (Mayer, 2014). In working memory, selected information is organised in coherent mental models, requiring heavy attentional resources (Hodent, 2017; Mayer, 2014). According Mayer (2014), two assumptions are key when it comes to understanding working memory: the dual channel assumption and the limited capacity assumption. The dual channel assumption states that humans possess separate channels for processing verbal and visual information, called the phonological loop and the visuospatial sketchpad respectively. The limited capacity assumption states that humans are limited in the amount of information that can be processed in each of these channels at one time. To signify the load that is imposed by presented information on the working memory, the term cognitive load is used. In total, three types of cognitive load can be distinguished (Mayer, 2014):

1. ***Intrinsic load:*** the load placed on working memory that is intrinsic to the task. The more complex a task is for someone, the higher the intrinsic load. Thus, especially when dealing with new and complex information, working memory is severely taxed (Hodent, 2017).
2. ***Extraneous load:*** the load placed on working memory as introduced by the way a task is presented or structured.
3. ***Germane load:*** the load placed on working memory that is dealing with the process of learning or understanding.

All in all, the goal is to manage essential processing (intrinsic load), minimize extraneous processing (extraneous load) and support generative processing (germane load) to optimally use the limited resources available in working memory (Mayer, 2014). In other words, the workload that a product imposes should be dedicated to helping users reach their goals, not figuring out, e.g. the menu and controls (Hodent, 2017).

- ***Long term memory:*** a cognitive structure that stores information (Mayer, 2014). Whilst this storage is infinite in theory, we are only aware of the contents of long-term memory that are transferred to working memory for processing (Mayer, 2014). Here, prior knowledge may be integrated with newly incoming information to form new mental models. But like working memory, long term memory has its limitations. Without repetition, information stored becomes hard to recall, resulting in memory lapse (Hodent, 2017). By making information meaningful to the user, the forgetting rate can be slowed (Hodent, 2017)

4.5. Chapter round up

In this chapter the case study for Soda studio in the field of UX for XR was introduced and the concepts of UX design (at Soda studio), XR and UX for XR were explored. In doing so, this chapter sets the stage for deep engagement with the project experience and provides a lens to place the experience in the right perspective.

UX design concerns itself with the creation and optimization of user interaction with a design to meet user and business needs. It concerns itself both with pragmatic and hedonic factors.

- Pragmatic qualities, primarily usability, act as a "hygiene factor" to help users reach their goal through removing barriers in interaction.
- Hedonic qualities act as a "motivator", making the user experience a positive one and promoting engagement.

Within UX design five different planes can be recognised: strategy, scope, structure, skeleton and surface. Soda studio moves through these planes by applying a Scrum methodology.

- The five planes of UX move from abstract to concrete, moving from the identification of user and business need (strategy) all the way up to top layer in which UX designers collaborate with UI designers to create the final visual design (surface).
- At Soda studio sprints are at the heart of the design process. Broadly speaking, designers engage in three types of sprints: research, concept design and detail design. In between the concept and detail design, a concept test is often completed to validate the general design direction with potential end users before diving into its details.

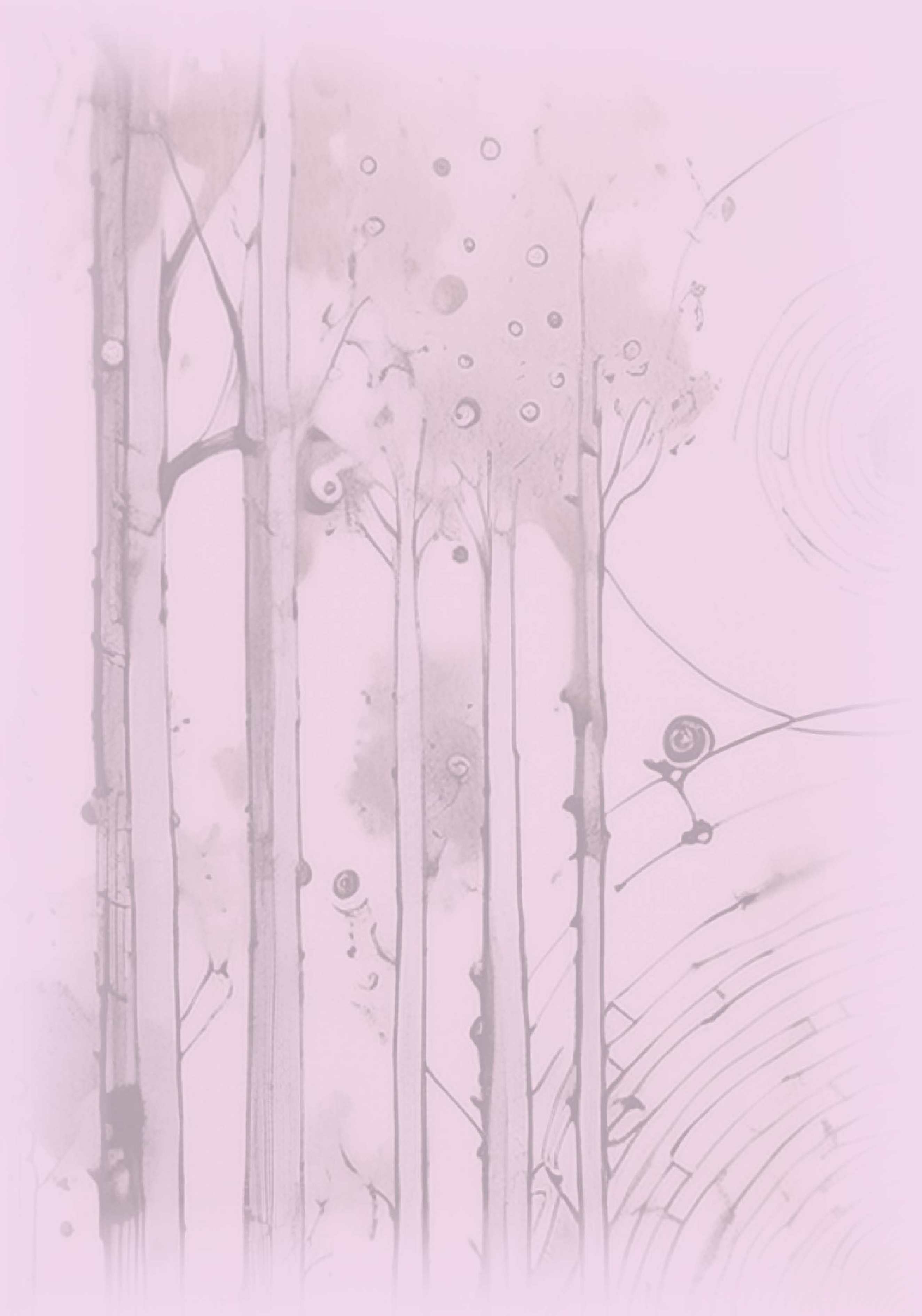
Extended reality (XR) is an umbrella term for a set of immersive technologies, broadly speaking consisting of two categories: VR and AR. Where VR is characterised by telepresence, AR offers local presence.

- Within XR, a wide variety of input and output devices can be used in different set-ups to reach the desired level of immersion.
- Telepresence is the degree to which a user feels present in a virtual environment.
- Local presence is the degree to which a user perceives AR content as being part of reality.

Whilst the fundamentals of UX for XR are not difficult to understand, UX designers must navigate a variety of challenges to design in this emerging field.

- The user experience in XR is a result of the user, the system, the virtual content, the physical environment, the larger context of use and the interaction itself.
- UX designers face four main challenges: 1) a lack of guiding principles and patterns; 2) a lack of holistic spatial tools and practices; 3) the influence of new hardware possibilities and 4) a rapidly changing landscape.

- Even though XR lends itself to experience-based goals well when compared to web and app due to its immersive quality, pragmatic quality remains key in UX design. Reasoning from a basic understanding of human cognition can help tackle usability problems, regardless of the specific technology in play.



Chapter 5

A case study into UX for XR: Project experience

Now that the goals of the case study have been set and a fundamental knowledge of UX for XR has been created, it is time to dive into the project at Rijksmuseum Boerhaave itself. In this chapter, the museum and project are introduced and the methods, software and decision-making processes used to reach the final design explained (CE). Through the design process description, reflective observations (RO) are placed in insight boxes. These will later be aggregated and generalized in ***Chapter 6*** to understand the implications UX for XR might carry for Soda studio (AC).

5.1. A new exhibit for Rijksmuseum Boerhaave

5.1.1. About the museum

Rijksmuseum Boerhaave was founded in 1931 and recently underwent major renovations to make the museum more accessible for a larger target audience, specifically families. Where the museum first showcased their collection with little other than labels only, interaction and storytelling now play an important part in the museum design. The mission of the museum is to enthuse and inspire as many people as possible for science, tailoring towards a target group from 8-years-old and up. To achieve this goal, a wide variety of artefacts and the inspiring personal stories associated with them are placed in the spotlight at the museum. Within the museum, XR technology is already applied at a variety of exhibits to provide unique interactions and to engage visitors.

5.1.2. About the project

This project set out to design a new exhibit for one of Rijksmuseum Boerhaave's most treasured artefacts, the first artificial kidney, focussing on the user experience "front-end" of the design. Invented by Willem Kolff during World War II, the artificial kidney could filter the blood of patients with kidney failure through a cellophane tube wrapped around a rotating wooden drum that was submerged in dialysis fluid.

Despite its remarkable history, the artificial kidney is currently displayed very minimally with a few signs (***Figure 9***). Rijksmuseum Boerhaave therefore decided to move the kidney to another exhibition hall, *Ziekte & Gezondheid*, that discusses the emergence of modern healthcare. They believe this hall could provide a better backdrop to tell the artefact's story. Although the location of the new exhibit was clear, a lot of questions remained unanswered. Which story should the artefact tell specifically? In what way could this best be accomplished? And how could this exhibit connect with the other exhibits in the larger exhibition hall? Additionally, the museum was eager to explore if XR technology could play a role in the new design, turning this project into an ideal means to experience and reflect on UX for XR.

The key stakeholders involved in this project were: the Manager Public Engagement, Education, and Exhibitions (MPEEE); the Museum Conservator (MC); the Senior Advisor Education (SAE) and the Senior Advisor Exhibit Design (SAED). Upon project completion, a design document detailing the most critical findings was created for these stakeholders' future reference (***Appendix C***).

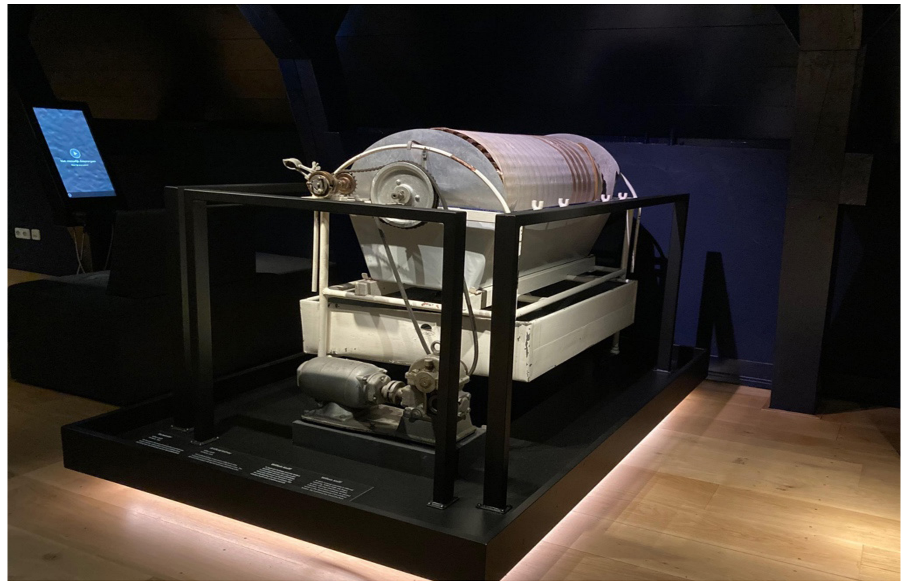


Figure 9
The first artificial kidney at Rijksmuseum Boerhaave

5.2. Exploring the design space

To kick-off the project at Rijksmuseum Boerhaave, the design space was explored first. Although the use of XR technology was seen as an interesting solution direction from the start, the project was approached from the ground up, starting with the product strategy and scope. The goal? Formulating a concrete product vision to guide the upcoming design process.

5.2.1. Understanding the context

To understand the design context and challenge associated with the artificial kidney exhibit better, in-depth interviews were conducted with the key stakeholders. To match each stakeholder's unique knowledge of and needs within exhibit design, each interview script was adapted slightly. In general, the interviews were aimed at forming an understanding of: 1) the general context and target group of the museum; 2) exhibit design and the style thereof in the museum specifically; 3) the unique aspects of the artificial kidney; 4) the context in which the artefact would be placed; and 5) the wishes and restrictions that should be considered in the exhibit design. Some of the key takeaways regarding the museum context include:

- The artificial kidney is to be placed in the *Ziekte & Gezondheid* exhibition hall which mirrors a ***hospital ward*** (***Figure 10***). It explores the ***emergence of modern healthcare*** by showcasing an important innovation at each "hospital bed". Every bed is equipped with a ***digi-magazine*** that provides more in-depth information (***Figure 11***).

- The exhibit on the artificial kidney is to replace one bed in the *Ziekte & Gezondheid* exhibition hall. This means that there is only ***limited floor space*** to tell visitors a story.
- The artificial kidney exhibit needs to tell a ***unique narrative*** that does not thematically double with the existing iron lung exhibit. That exhibit already discusses how medical machines that could take over bodily functions were developed.
- The ***collection is the basis*** of all stories told in the museum. Personal stories are key. In the exhibition hall *Ziekte & Gezondheid* specifically, the ***patient perspective*** plays a particularly important role.
- ***Inclusivity and diversity*** are important themes in the museum right now. The exhibit should not display the inventor Willem Kolff as a "heroic white man", but showcase a more diverse group of people, preferably women too.

Throughout the interviews, it became clear that each stakeholder had a very different view on what the central message and emotional approach to the exhibit should be. Although the context in which the exhibit should be placed became quite clear, a concrete goal for the exhibit was still lacking. For example, where one stakeholder highlighted the common-or-garden materials the artificial kidney was made of, others mentioned that team effort was key in the creation of the kidney and that the time in which it was made (World War II) is quite unique and provided many challenges.

Aside from conducting interviews with key stakeholders, a small desk research on the artificial kidney was completed too to gain more insight into its background, the team behind it and how dialysis works. This information was gathered in preparation of the upcoming design process to be able to discuss content and storytelling more in-depth with the MC.

Restrictions

Although a vision for what the exhibit should be could not yet be clearly formulated based on the in-depth interviews, an image of the limitations that would need to be considered started to surface. Restrictions were formulated related to the exhibit fitting into the operational space, physical space, and educational space within the museum. Here, a distinction could be made on restrictions on the overall system (interactions, technology, and visual appearance of the exhibit) and that on the content itself (the amount and type of information presented). For example, considering the operational space, the exhibit would need to provide a stand-alone experience, not requiring personnel to actively monitor it. Within the physical space, it became clear that the exhibit should align with the hospital metaphor of the exhibition hall. Within the educational space, it was recognised that a museum is a place for collective and

Figure 10
Exhibition hall Ziekte & Gezondheid (Bink & Ernst, n.d.)

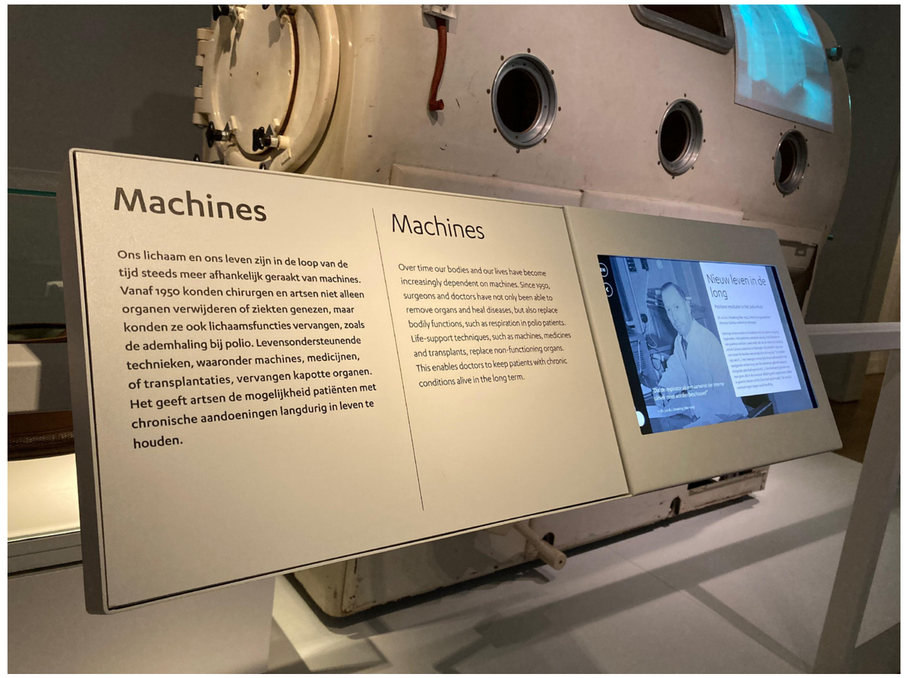


Figure 11
A digi-magazine in Rijksmuseum Boerhaave

social learning. Based on the formulated restrictions, viable XR technologies for this project were narrowed down to: video see-through AR, in either stationary or mobile capacity (no personal devices), as well as projection-based AR. VR technology would provide experiences that are too individualistic (immersive VR) or run the risk of overshadowing the other exhibits in the exhibition hall (semi-immersive VR), whilst also having less inherent focus on the artefact itself. The full list of restrictions can be found in ***Appendix C, p. 34***.

Insight #1: Setting the toolbox
Before scoping a project, it is important to gain insight into what technologies are available in the design space. Not every XR technology is suitable for a project.

Insight #2: The importance of context
The context in which the experience takes place is an important factor in the design process, more so than for web and app. Whilst the context might influence a person's state of mind for web and app design, the technology in and of itself is fixed. When it comes to XR, context restrictions can influence the system design. As shown, in-depth interviews with stakeholders (and clients) could be used to formulate these restrictions.

Insight #3: The level of predictability
When considering the context of an XR experience, the level of predictability of the external environment is an important consideration. In context of the museum, the environment is relatively static. Clear restrictions could be established to dictate how the physical design and digital design should fit into this environment. However, if an XR application is intended for use across a variety of locations, system and content requirements would need to keep varying environmental conditions into account.

5.2.2. Understanding the target audience

Aside from understanding the business context, UX designers familiarise themselves with the target audience to formulate a product strategy. When it comes to museums, an effective exhibit design is accessible and tailored the needs of the target audience. To represent the target audience that visits the museum, Rijksmuseum Boerhaave makes use of personas. However, during conversations with stakeholders, it became clear that the current personas, although being insightful, can be limiting too through the bias they introduce. For example, the SAED mentioned not resonating with the division of "thinkers" and "doers" within learning that the personas represent. According to her, what motivates people to come to the museum and the composition of the group in which they do this, largely determines what they are open to experiencing.

Mindsets, a UX tool proposed by Lino and Bazoli (2020) (***Appendix A***), provide an alternative to personas that reflect this sentiment better.

To formulate Mindsets for Rijksmuseum Boerhaave, 20 short interviews were conducted with a total of 28 people across two days. Interview questions were aimed at uncovering reason of visit, group constitution, visitor frequency, likes and dislikes and experience strategy. Insights from these interviews were combined with the existing personas and background literature on this topic that describes visitor engagement styles (Sookhanaphibarn & Thawonmas, 2009) and visitor roles (Falk, 2006). As a result, four Mindsets were drawn up: Enrichment seekers, Explorers, Facilitators and Entertainment seekers. These Mindsets can be found in ***Appendix C, p. 24***.

Insight #4: Technology-second, pt. 1
During the research sprint, UX designers should prevent themselves from adopting a technology-first perspective aimed at finding use cases for XR. Designers should focus on identifying and familiarising themselves with user needs, business goals, and the larger context of use. The technology best suited to meet these needs should be identified later.

5.2.3. Defining a product vision

Through in-depth interviews with stakeholders and the creation of Mindsets, the needs of the target audience and museum itself were mapped. Moreover, a set of restrictions for the design was identified. Once these global design parameters were clear, efforts were steered into formulating a concrete vision for the desired experience, clarifying the final strategy and scope of the exhibit.

Product vision workshop

To identify a general design direction for the exhibit design, a one-hour long product vision workshop was conducted in person with key stakeholders. Recall, that such a workshop is standard practice for Soda studio to end the research sprint. Up until this point, stakeholders had not yet reached consensus on the story the exhibit should convey and the emotions it should provoke. Therefore, an extra category of "experience" was added to the product vision workshop. Explicitly addressing this central message separately, rather than viewing it as part of the existing product feature category, provided the necessary space to consolidate stakeholder views. The product features category was then used to determine which specific functionalities or content that met user needs could help convey the desired message. In preparation of the workshop, a variety of such features were already thought out and linked to the identified mindsets to help stakeholders in their creative process.

At the end, stakeholders agreed on the following product vision statement: "The artificial kidney exhibit revolves around the central question: *"How are inventions created through teamwork?" The exhibit is a stimulating storyteller that attracts curious adults and children, fits into their world of experience, and allows them to discover fresh perspectives in a surprising way through interactive visual attention for the artificial kidney, exciting in-depth stories and conversation and reflection starters."* It is important to note that the digi-magazine (***Figure 11***) would need to be taken into account in the physical set-up of the exhibit design but was otherwise considered out of scope when it came to fulfilling this product vision. The results of the entire workshop were digitised (***Appendix C, p. 33***) and sent to stakeholders for sing-off before continuing the design process.

Insight #5: Addressing experience-based goals
XR technology more naturally lends itself to experience-based goals (hedonic quality) as opposed to web and app due to its immersive quality. During the research phase, UX designers should pay attention whether such experience goals surface and consider incorporating related decisions in the product vision workshop (as a separate category). Although UX for XR is likely to focus more on the pragmatic qualities of a product, factors such as enjoyment and engagement can still work as a motivator for user goal achievement. XR environments are uniquely equipped to address such needs.

The use of AR in museums

Based on the formulated product vision, XR was confirmed as a viable solution direction for the exhibit to be explored. This conclusion was drawn based on the wish for "interactive visual attention for the artificial kidney" and the desire of the museum to bring the artificial kidney to life. Recall that based on the restrictions set, only the use of video see-through AR and projection-based AR are considered in the design space. A short desk research was conducted to further substantiate the value of AR in museum education and the design opportunities it affords.

Value of AR

Research shows that the use of AR experiences in (museum) education generally can have a positive effect on learning (Akçayır & Akçayır, 2017; Goff et al., 2018; Zhou et al., 2022). This can likely be attributed to AR's ability to place learning in meaningful contexts and to promote active learning through interactivity (Pritchard, 2017; Zhou et al., 2022). Whilst such benefits for constructing knowledge are important, Rijksmuseum Boerhaave is mainly concerned with inspiring and enthusing a wide audience for science. A variety of studies show that the use of AR in museums can contribute to such goals as well, enhancing perceptions like enjoyment, engagement, motivation and interest (Akçayır & Akçayır, 2017; Dunleavy & Dede, 2014; Goff et al., 2018; Zhou et al., 2022). Moreover, visitors tend to spend more time engaged at exhibits that contain novel technology (Sandifer, 2003).

Design opportunities

A variety of existing exhibits was analysed to better understand the design opportunities AR affords in museums. A selection of the most inspiring exhibits is shown in ***Figure 12.*** The key take-aways from this process include:

- Altering the shape of a handheld device away from a regular phone or tablet, might make the intended interaction easier to understand for users (Ridel et al., 2014)
- Fixing a screen in place can streamline the user experience by taking away variables that could cause usability issues, such as empty batteries or the user looking from the wrong point of view.
- In tangible experiences, as opposed to screen-based interactions, users can intuitively manipulate virtual content through physical objects (Bekele et al., 2018).
- Natural gesture-based interactions with virtual content can form an intuitive interaction pattern and way to build a personal connection with the narrative or artefact on display.

Insight #6: Technology-second, pt. 2
After the product vision workshop, an estimation can be made on whether XR technology could play a role in meeting user needs. Whilst a specific XR product feature might surface during discussion of the product feature category, the focus of designers should be on what functionalities or content deliver value, not necessarily through which technology this can best be met.

Insight #7: Understand the industry
Research into the use of XR technology in the industry in question is required to inform decision-making. Is it reasonable to assume that the use of XR technology truly provide a means to add value in fulfilling business and user needs? Analysing existing XR products in the industry can serve as a source of inspiration and help UX designers gain insight in what is potentially feasible and desirable on a system level.

Figure 12
Existing AR museum exhibits

Natural projection-based AR in Rijksmuseum Boerhaave (Studio Louter, 2017)

A projection is placed on the visitor's own arm to learn about dissection

Stationary screen-based AR in Riga Motor Museum (Design studio H2E, 2016)

Car parts are brought to life through a mounted AR tablet.

Tangible projection-based AR in Emily State Garden (IJsfontein, n.d.)

Visitors dig in sand to discover the "science" of soil.

Natural projection-based AR in Noord-Hollands Archied (Bink, n.d.)

Visitors create "rainfall" with their hands to see the effect on the landscape.

Mobile screen-based AR in the National Museum of History (Waag Futurelab, n.d.)

Artefacts are brought to life with an AR magnifying glass.

5.3. Defining a product concept

Having defined a concrete product vision to guide the upcoming design process, the next steps in the process centre around translating this vision to a more concrete product concept, defining the "how" of the design. This product concept builds a foundation for the final concept design in which the product concept is prototyped and visualised. A first step towards this is taken in this chapter by structuring the experience.

5.3.1. Concept pillars

Recall that Soda studio defines a set of principles to formulate a product concept on which the to-be-designed experience is based. These principles translate the product vision into a guiding content strategy. Based on the completed research at Rijksmuseum Boerhaave, a variety of principles were agreed upon with stakeholders for the artificial kidney exhibit. For example, *Principle 3: Based on curiosity* states that the curious nature of visitors is used as motivator to explore the artificial kidney. Information is presented such that it draws the attention of visitors and capitalizes on their curiosity. Whilst such concept pillars normally provide UX designers with a strong foundation to start the design process in Figma, for the exhibit at Rijksmuseum Boerhaave a critical question remained: How exactly would the AR experience be facilitated?

Insight #8: A need to define the system set-up
XR introduces a new variable into the design process: the system set-up. After having created a clear starting point for the experience through the definition of concept pillars, the system which facilitates this experience remains unclear. Thus, aside from devising a content strategy, a system strategy is required too.

5.3.2. AR system exploration

To develop an appropriate system strategy for the exhibit, three concept directions were created, each with a different approach to how visitors could interact with the content surrounding the artificial kidney: artefact first, people first or interest first (***Appendix B***). To gather new design input, both on a system design and content strategy level, the concept directions were presented and discussed with the SAED and the MC. Each concept direction was purposefully made to be distinct, both in its interpretation of the content pillars, as in their use of AR technology, to work as a conversation starter with these stakeholders. As such, more insight could be gathered into any underlying restrictions and wishes that had not yet surfaced in the design process so far. To present the concept directions to stakeholders, 3D sketches were created overlayed on an image of a current exhibit "hospital bed", providing a reference for the available space and scale. Aside from aiding in the design process in this manner, this approach helped stakeholders more easily assess whether the form language of a design would fit into the exhibition hall. Unfortunately, due to unforeseen circumstances, a meeting was held with these stakeholders separately rather than together.

An aggregation of all feedback started to form a clearer design direction for the system set-up. In an ideal world, the exhibit would: 1) make use of screen-based AR to overlay animations over the artificial kidney, 2) combine these visuals with an audio narrative, 3) limit the interaction possibilities (DOF) for the user, and 4) bring the stories of different contributors of the artificial kidney into one in a more linear experience.

Insight #9: Make the set-up concrete and diverse
Drawing in 3D helps to see new challenges and arrive to new insights. It forces UX designers to think "outside" the system before diving into the content design. A variety of system directions that push the boundaries of the product vision and restrictions in different directions should be made. Presenting stakeholders with such concrete and diverse offerings is likely to draw out previously implicit content requirements and functional specifications.

Insight #10: Focus on the UX implications of a system set-up
When presenting concept to stakeholders, focus on the UX thought process behind them, rather than explaining the visible elements of the sketch. This ensures the right type of feedback at this stage of the design process. For example, in one of the concepts a tablet was placed on a railing to ensure it would always be powered and that visitors would not get physically exerted from holding the tablet at awkward angles. Without such explanations, designers risk getting non-UX related feedback, such as "this railing looks a little thin", that is not relevant yet at this stage of the design process.

Insight #11: Involve other disciplines
In a professional setting, the system set-up would ideally be completed with the involvement of other disciplines as well. This team can estimate the general feasibility of a design from different perspectives before sharing concept directions with stakeholders. In this case, it was difficult to estimate whether there could have been a technical solution to the conservator's concern of having projections on the side of the artificial kidney in one of the concept directions, without having access to a technological expert.

Insight #12: Workshop it
Looking back, the different concept directions were best to be presented in a workshop setting to spark discussions among stakeholders, rather than in separate meetings as was done now. A workshop offers space to consolidate different perspectives immediately.

Insight #13: Consider the system and content strategy holistically
The content and the system set-up are intrinsically linked. The content strategy has implications for which system set-up might be appropriate and the system set-up influences which content can be presented and through which interactions it can be navigated. Only considering one or the other risk misalignment in the design. In this case, a concept pillar needed to be adjusted, because the physical manifestation of it in a system set-up made clear that visitors would spend too much time exploring a non-linear content strategy.

5.3.3. Aligning the system & content strategy

Based on initial concept pillars and the feedback gathered from the AR exploration, the focus of the design process was shifted towards creating a well-aligned system and content strategy.

On the system set-up side, a new a concept direction was sketched: "A moving narrative" (***Figure 13***). Instead of being artefact first, people first, or interest first, this concept takes a more linear approach to storytelling. With this system set-up, multiple collaborators could tell a story together through audio, a story that would unfold whilst visitors move a big AR screen from left to right across the artefact. As such, this final concept direction focuses on the application of AR to facilitate narrative presence, supporting visitor engagement with the educational content of the exhibit. In its initial design, this AR screen consisted of two parts to enable visitors to view each part of the artificial kidney ergonomically. The system set-up was envisioned to be a lot more robust than previous concept directions and provided only one DOF to users (moving the screen left to right). When presenting this concept to stakeholders, detailed questions surfaced, such as "Will the screen be see-through?" and "What happens if users move the screen in the wrong direction?", suggesting global acceptance of the design.

With this overarching concept direction in mind, an extra layer of the concept strategy was thought out in supplement to the previously defined principles. The system set-up provided inspiration for this by raising the question: "What would drive visitors to move the screen from left to right across the kidney to inspect it?". The answer? Using the linear narrative to trace the journey of a patient's blood throughout the kidney. This journey would allow the dialysis process to be brought to life by having digital overlays displayed on the AR screen. The physical components of the artificial kidney could serve as a marker for this experience. Moreover, a system is required that recognises the location of the AR screen in space to drive the journey.

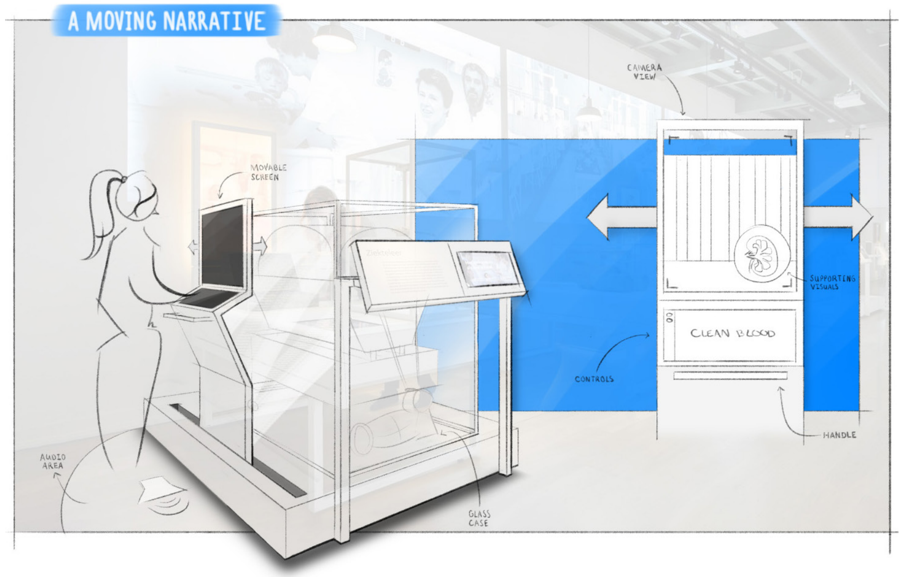


Figure 13
Final concept direction. Sketch drawn over original image Rijksmuseum Boerhaave (n.d.)

Insight #14: Start and reflect
Whilst the system and content strategy should be considered holistically, designers need to make progress in one to be able to reflect on the other. By consciously observing the interplay between these two strategies and their implications on interaction and content possibilities in relation to the product vision, proper alignment can be achieved.

Insight #15: Interface strategy
When considering the content of the experience, the relation between the physical environment and digital content plays an important role, especially in AR. It is important to consider which information from the physical environment will be used as basis for the virtual world and how this information will enter the experience. Based on the interface strategy, the need for additional devices/sensors might be uncovered.

Insight #16: Redefine the scope
Looking back at this stage in the design process, the final functional specifications and content requirements could have been made more explicit. This is especially important when working in a team, as requirements are translated to a set of user stories for the team to work on in the product backlog. Whilst these stories are normally already set up at the end of the product vision phase, when working with XR, a holistic vision of the product that considers its system set-up and content strategy has not yet been achieved by then. Thus, after having formulated an aligned product concept, the scope of the project must be redefined accordingly.

5.3.4. Structuring the experience

Before delving into visualisation and prototyping, the experience needs to be structured through the definition of an information architecture and interaction design. These are closely related to the content strategy and system strategy respectively. Throughout this project, four different methods, or lenses, were applied to formulate an experience structure. Each lens provided unique insights that contributed to the overall structure.

The lens of the narrative

The envisioned experience relies on storytelling to get across a central message of some educational value (following the blood through the artificial kidney). This narrative in large part drives the structure of the experience, turning part of the content into narrative devices, rather than items needed to reach a user goal. To determine which narrative content would play a role in the experience, and which would distract from the overall message, a content mapping was made and workshopped with the MC. The key narrative content of the educational experience was determined to consist of the following:

1. ***The team behind the kidney:*** Recall that the central message of the experience should convey teamwork. The decision was made to anchor this message around the team behind the artificial kidney that worked at Stadsziekenhuis Kampen, because of their close relation to the dialysis process with this artefact. Other important but more indirectly involved contributors, such as the German internist George Haas, who discovered heparin as effective anticoagulant for haemodialysis in 1928 (Paskalev, 2001), were placed out of scope.
2. ***Key artefact components:*** During the content mapping, it became evident that by tracing the blood's path through the artificial kidney, visitors could be readily introduced to many of its different components: the rubber tubing, cellophane, drum, and dialysis fluid. The motor, however, was excluded from the narrative since it does not directly interact with the blood like the other components do.
3. ***The patient:*** To frame the narrative, a key question remained: whose blood would be running through the kidney via AR? Rather than creating a fictional scenario in which the visitor could see "their" blood being filtered, Sofia Schafstadt was chosen as patient. She was the 17^{th} person to receive treatment with the artificial kidney and the first for whom it was successful, providing a compelling narrative that could contribute the emotional presence of visitors by taking them back to this pivotal moment in 1945. By immersing visitors in the chosen storyline, the importance of patients and the challenges and risks involved in innovations such as these are inherently highlighted. Moreover, a more inclusive image is created by placing a woman at the heart of the story.

Based on the completed content mapping, it became clear that the aligned chosen content strategy and system set-up could satisfy stakeholders from both an interaction and educational perspective. By excluding the motor of the artificial kidney from the narrative, the system set-up could be simplified: from two screens to one.

The lens of space

Typically, web and app products are organised hierarchically. Within UX design, their structure is often represented through a process of site mapping. A site map is a visual representation of every page within a website or app, showing the relations between them to define overall site structure. However, for XR experiences, a kind of spatial mapping is required to determine how the virtual information is organised in 3D, rather than 2D, space. To abstract an experience in terms of space, Schell (2008) proposes a variety of questions (***Appendix A***). Based on the exploration of these questions, the following main spaces were defined for the exhibit:

1. ***Exhibition hall:*** The exhibition hall in Rijksmuseum Boerhaave represents the physical environment in which the experience takes place. This space has three dimensions.
2. ***Stadsziekenhuis Kampen:*** Stadsziekenhuis Kampen is the overall virtual world and narrative context in which the AR experience takes place. This space has three dimensions and can be viewed by visitors through the AR screen. The viewing boundary is determined by the length of the rails of the AR screen.
3. ***Discrete story segments:*** The overarching audio narrative is divided across four discrete story segments: connecting the patient, the blood starting to flow through the cellophane over the drum, the dialysis process itself and the blood being fed back to the patient. A story segment is triggered when the user moves the screen to a segment location. Each segment takes up a quarter of the total viewing axis.
4. ***The space between:*** The viewing axis, whilst discrete for the audio narrative and continuous in viewing Stadsziekenhuis Kampen, holds a more intricate relation with the flow of blood through the kidney. Between each story segment, when the user moves the screen, the digital blood flows with it. During a story segment, the blood flow is halted. By aligning this blood flow with the speed of movement from the AR screen, a feeling of control is given to the visitor. By keeping the flow of blood static during story segments, regardless of screen movement, the user is motivated to keep the screen in place to follow the audio story.

Through the mapping of these spaces, an interesting relationship emerged between the exhibition hall and the virtual world of Stadsziekenhuis Kampen. As AR technology is used to overlay information over the artificial kidney, the main mechanism at work is local presence. Nevertheless, in service of narrative and emotional presence, a feeling should be created for visitors that they are looking at the artefact in use at Stadsziekenhuis Kampen, rather than in the exhibition hall. The current spatial design of the exhibition hall might support this suspension of disbelief, as it has already been designed to reflect a hospital ambience.

The lens of the object

In his book on UX for XR, Hillmann (2021) puts forward the design philosophy of object-oriented UX (OOUX) by Sophia V. Prater as a valuable means to design digital products for spatial computing. OOUX is an object-oriented approach that addresses core content as objects before considering procedural actions. It is proposed that such an object-oriented approach fits UX for XR well, as XR per definition includes virtual worlds (either stand-alone or overlayed on the physical environment) that are populated by 3D objects. OOUX provides a means to structure core content into a clear information architecture that reflects user's mental models. An object formulation helps to provide consistency within experiences, as each instance of the same object is expected by the user to behave in a similar way. Moreover, an object-oriented approach offers a natural alignment with object-oriented programming, providing a means of communication between designers and developers. The OOUX process is detailed further in ***Appendix A***. Throughout this process, the key artefact is the object map. In this map, each object is represented in a (ranked) column in which its relationships to other objects, calls-to actions and attributes are captured (Prater, 2015).

During the project at Rijksmuseum Boerhaave, the creation of a first object map was attempted directly after the product vision had been determined, marking the end of the research sprint at Soda studio. After all, OOUX normally takes place between research and design (Prater, 2022). However, it quickly became clear that a more specific vision for the product, both on a system and content level was required before specific objects could be mapped. Therefore, a second object map was attempted again after the aligned system and content strategy was formulated, focusing specifically on the AR narrative. In that instance, the OOUX process helped to further define and differentiate between the different components in the experience, such as the narrators (Willem Kolf, inventor, and Maria ter Welle, head nurse), the patient, digital parts of the artificial kidney, physical parts of the artificial kidney and the blood flowing through it. Moreover, it was recognised that some of the components that were originally part of the artificial kidney are currently not part of the physical artefact, i.e. the rubber tubing and in large part the cellophane. To truly bring the kidney to life, digital counterparts of such physical components could be created.

Aside from this component definition, the OOUX process led to the realisation that an important attribute of each of these components was the different states they could have. The drum, for example, needed two different states in the narrative: static and rotating. Where its static state could be represented by the physical artefact, a digital 3D model would need to be overlayed to be able to animate a rotation. Moreover, OOUX provided a means to explore the use of different modalities in the system to create an immersive experience (e.g. the inclusion of sound effects could contribute to creating a hospital ambiance) and enabled further insights into user actions (e.g. selecting a part of the dialysis procedure, changing the language settings, and turning subtitles on or off). Lastly, this object-oriented approach prompted reflections on the relation of objects not only to each other, but also to the defined spaces. For example, where narrators are intrinsically linked to the discrete story segments, other sound effects are continuous as part of the virtual space of Stadsziekenhuis Kampen.

Whilst the OOUX process resulted in some valuable insights, navigating it was occasionally challenging. This is most likely due to the linear storytelling nature of the envisioned experience. The user is not called to action by all objects in the system; instead, many serve as narrative devices. Although this narrative content had in large part been determined in the *Lens of the narrative* already, the OOUX approach did help to recognise which of these were in fact instances of the same object, having similar attributes and needing similar behaviours. All in all, whilst thinking in an object-oriented manner might provide some insights and a means for UX designers to communicate with developers, its applicability is limited depending on the XR experience envisioned.

Insight #17: OOUX after system and content strategy
OOUX might be used to inform a product's information architecture after a concrete system and content strategy have been defined. This ensures that the object mapping process is better informed and guided by a clear core understanding of the functionality and content of the product. OOUX may subsequently clarify these functionalities and content further through defining the modalities and distinguishable states of objects in the experience.

The lens of flow

To structure the way in which a user navigates through the different parts of the experience, UX designers regularly create a user flow. A user flow maps the journey that a user takes in their interaction with the system, outlining their actions and the content they encounter. User flows are part of a task-oriented approach to UX design, focusing on the workflows included to help users reach their goal.

Throughout the structuring of the artificial kidney exhibit, the creation of a user flow proved itself especially useful to determine which content was required around the AR experience itself. Where the *Lens of the object* was used to zoom in on the AR experience specifically, the *Lens of flow* was used to zoom out to the supporting components surrounding this experience. A variety of 2D screens were identified to frame the spatial experience appropriately.

1. A ***stand-by screen*** to draw users into the exhibit, driven by curiosity. By adding a motion sensor to the system set-up, the next screen may be displayed automatically when visitors are within interaction range of the exhibit.
2. An ***introduction screen*** to set the right stage for the AR experience, introducing the kidney, the context and the narrators. The AR experience is started from here.
3. A ***conclusion screen*** to offer a space for reflection and conversation starters.
4. An ***instruction screen*** that clarifies users should move the AR screen towards the next story segment once another story segment has ended.

In an ideal scenario (happy-flow) users would finish the entire experience start to finish. However, experience teaches us that visitors might leave halfway through the experience or refuse to put the screen back to its starting position. These less-than-ideal flows, call for two other screens:

5. An ***instruction screen*** that clarifies users should move the AR screen to the first story segment, if the AR experience was started with the screen in a wrong position.
6. A ***general AR overlay*** that enables users to adjust the settings and leave the AR view at any time.

Aside from facilitating the definition of these 2D screens, the task-oriented approach helped raise a variety of upcoming design challenges related to user flow. What would motivate users to continue to the next story segment within the AR experience? How could users be motivated to place the AR screen back at the end of the experience? How do visitors know in what part of the story they are? And how can visitors be guided to put the screen back to its starting position at the end of the experience?

Insight #18: A structure of lenses
Structuring an XR experience is likely to require more than the regular site mapping and user flow creation. After all, spatial content is probably not structured in pages or screens alone. By critically assessing which elements play

an important role in the experience, the right combination of perspectives to structure the experience can be found. In this project, the *Lens of space* helped define the world of the experience and the spaces within. The *Lens of the object* and *Lens of the narrative* in turn helped to determine which content was needed within these spaces, keeping the central message, consistency and desired immersion in mind. Lastly, the *Lens of flow* helped to define how users should and could move through these spaces and which support they would need to do so.

5.4. Crafting the user experience

In this subchapter, the defined and structured product concept are translated into a concept design, as part of the skeleton and surface layer of Garret's (2011) UX framework. Following Soda studio's way of working, this concept design was prototyped for testing with potential end users.

5.4.1. Picking the right software

Challenge #4
A rapidly changing landscape

When it comes to prototyping in UX for XR, recall that the current landscape of authoring tools is disjointed (Ashtari et al., 2020). In other words, an industry standard has not yet been set in UX for XR. This means that there was not one obvious XR design tool available to prototype the exhibit experience with. This is in stark contrast to the 2D UX world where Figma is widely established. To start off the skeleton and surface design, a conscious design tool decision thus first needed to be made. The key factor that played a role in this decision relates to the concept of fidelity. The fidelity of a prototype refers to its level of realism compared with that of the final product and can be placed on a spectrum with four dimensions: breadth of features, degree of functionality, similarity of interaction and aesthetic refinement. (Virzi et al., 1996). In the case of UX for XR, this can concern visual, auditory and tactile components. When picking a design software, the level of prototyping fidelity it affords should align with the fidelity required to reach certain design goals. The user-friendliness of this software in turn determines the ease with which the desired prototype fidelity can be achieved.

To prototype the exhibit design for the artificial kidney, three different goals were identified, each with their own fidelity needs:

1. ***Stakeholder management:*** When it comes to stakeholder management, the main goal of the prototype is to explain and convince stakeholders of the concept direction. Thus, the design's main features and their functionality need to be presented clearly. This can still be achieved with a low level of interaction similarity. However, having a high level of aesthetic refinement is key to make it easier for stakeholders to imagine the final product. This helps manage expectations and makes the concept design more persuasive. One of the key considerations for stakeholders would be the way in which the design would fit into the larger exhibition hall. In this regard, the visual refinement of the prototype is especially important.

2. ***User testing:*** When it comes to testing the exhibit design, both a physical and cognitive interaction can be considered. Before investing in the creation of a functional tangible prototype, it is key to investigate whether users would understand how to explore the artificial kidney (pragmatic quality) and if they would show engagement in the experience (hedonic quality). After all, usability issues often stem from factors rooted in human cognition. Although a low-fidelity prototype focused only on the breadth and functionality of features might suffice to test such understanding, a degree of similarity of interaction and aesthetic refinement are required too, due to their influence on engagement. It is furthermore important to consider that the envisioned experience makes use of AR technology, factually making the artificial kidney part of the content of the experience as well.

3. ***Communication with other disciplines:*** Although this project was completed individually, a variety of other disciplines would otherwise be included in XR projects, such as spatial engineers (design of tangible components of the exhibit), installation technicians (realisation of tangible components) and audio engineers (narrative and sound effects). Keeping the case study goals for Soda studio in mind, a tool was sought that could facilitate communications with such disciplines, whilst feeling familiar to UX designers. This combination could help to create more streamlined processes.

Based on the above considerations, a variety of XR design tools were explored. Ultimately, Figma was chosen for 2D aspects and the beta-software Bezi for the 3D experience. When it comes to communication with other disciplines, Bezi's integration with the game engine Unity Figma offers connections with developers and UI designers alike. Moreover, the 3D environment offers spatial information for spatial engineers and installation technicians and allows team members to leave comments in the 3D space for one another. Aside from these communication benefits, Bezi is uniquely suited for UX designers. It offers a recognisable user interface, does not require extensive knowledge on 3D modelling or coding, and is operated from the browser rather than requiring designers to always wear an HMD, like many other XR design tools do. When it comes to this project, Bezi also offered adequate fidelity opportunities. Through its animation and basic 3D modelling capacity, a variety of exhibit features and their functionality could be explained and modelled adequately with sufficient aesthetic refinement.

The main downside of using Bezi for this project was its lack of audio support and support for AR features in virtual environments. After all, since the artificial kidney was not readily available in the right environment in real life, it had to be modelled virtually to simulate the AR experience and effectively test user engagement. Despite these disadvantages and its lack of stability due to its beta status, Bezi shows great potential for UX designers needing to prototype for XR.

Challenge #4

A rapidly changing landscape

Insight #19: The right software
When picking the design software for a project, designers need to consider the prototyping fidelity this software offers, its user-friendliness and collaboration possibilities. Whilst XR tooling is still disjointed, software like Bezi tries to bring multidisciplinary XR teams together and integrates with known UX tools like Figma.

Insight #20: Reaching a higher fidelity
The maximum prototyping fidelity a UX designer can reach is limited by the design software they use. When high fidelity prototypes are required for user testing, for example containing complex interaction patterns or tangible components, close collaboration with the development team (2D and 3D) or installation technicians is needed for their realisation.

5.4.2. Prototype components

To guide the prototyping process, the component features to prototype were distilled from the defined concept structure. In short, the protype could be divided into three categories, each giving insight into the disciplines (aside from UX) and software involved in their design:

1. ***2D screen design:*** The standby-screen, start screen, conclusion screen, instruction screens and AR screen (overlay). Throughout these, the user should always have access to the settings of the experience, being able to change the language and turning on/off subtitles.
   Disciplines: 2D visual designer, copywriter
   Main software: Figma

2. ***AR module:*** The AR experience itself in which the dialysis process is explained by following the blood of Sofia Schafstadt through the artificial kidney. The experience is divided into four story segments that tell a single story. The artificial kidney is augmented with 3D component models, 2D object labels and sound effects.
   Disciplines: 2D/3D visual designer, copywriter, audio engineer
   Main software: Bezi

3. ***The system:*** The physical design of the exhibit itself, including the AR system-set up.
   Disciplines: spatial engineer, installation technicians (technical expertise)
   Main software: Figma

Although the focus of this project is on UX design, a complete concept design cannot be created without taking the other mentioned disciplines into account to some extent. Whilst insight could not be gathered across all disciplines, an internal expert review was conducted with several UX designers, a visual designer and a copywriter to improve the first iteration of the design. Naturally, such feedback would normally take the shape of a consistent collaboration throughout the project. Throughout the expert review, it stood out that UX and UI designers primarily commented on the prototyped 2D screen designs that aligned with their known frame of reference. However, they were able to translate some 2D principles to 3D space too, albeit in more limited capacity.

Challenge #1

A lack of guiding principles and patterns

Challenge #2

A lack of holistic spatial tools and practices

The main design challenges encountered during the creation of the defined prototype components and the most insightful expert feedback therein, is explained in more detail below. To navigate the lack of available guiding spatial principles, patterns and practices, inspiration was sought in other fields such as game design. In general, it became clear that the design and animation of interactions in Bezi required significantly more time in comparison to Figma. The completed design can be viewed in ***Appendix C, p. 44***.

Insight #21: A new language
UX designers are required to learn part of other disciplines' language. Whilst some current knowledge UX designers have might translate into other domains already (e.g. ability to translate 2D principles to 3D space), efficient communication requires some familiarity with the terminology of these domains.

Insight #22: Impact/effort
To protect impact/effort in the prototyping process, a good rule of thumb is to prototype (and test) in 3D where needed and prototype in 2D where possible. Where do spatial elements play a role in the user experience and where would a 2D representation suffice?

Insight #23: XR user flow
The completed design for the visual experience that takes place on the AR screen was documented for stakeholders in a user flow. This conventional UX approach effectively communicates the overall structure and dependencies of the experiences, despite its inability to capture animations. To document the audio design of the experience, the narrative script and start and end of audio effects are marked under their corresponding screens.

General lay-out considerations

When starting the prototyping process for the 2D screens, the first obstacle that was encountered was the size of the canvas in Figma. Where 2D UX designers often work on predetermined canvas sizes according to web and app conventions, the screen size for the exhibit did not adhere to such standards. To determine the canvas size, a 3D model of the system first needed to be created in Bezi, keeping in mind the design conventions set in the larger exhibition hall. Quick iterations of the spatial exhibit design were made in Bezi using a grayboxing technique. This technique stems from game design and entails creating a simplified version of an environment in basic shapes to test the layout of a design (Hillmann, 2021). By viewing grayboxed in VR, a quick assessment could be made on whether the spatial set-up of the exhibit felt right (***Figure 14***). Ideally, this set-up could then have been discussed with a spatial engineer. To navigate the challenge of not having an AR feature readily available in the designed virtual environment, the modelled AR screen was made to be see-through (***Figure 14***). Although this does not capture the feeling of AR completely, it was deemed to be a sufficient fidelity for the required testing purposes.

Challenge #2

A lack of holistic spatial tools and practices

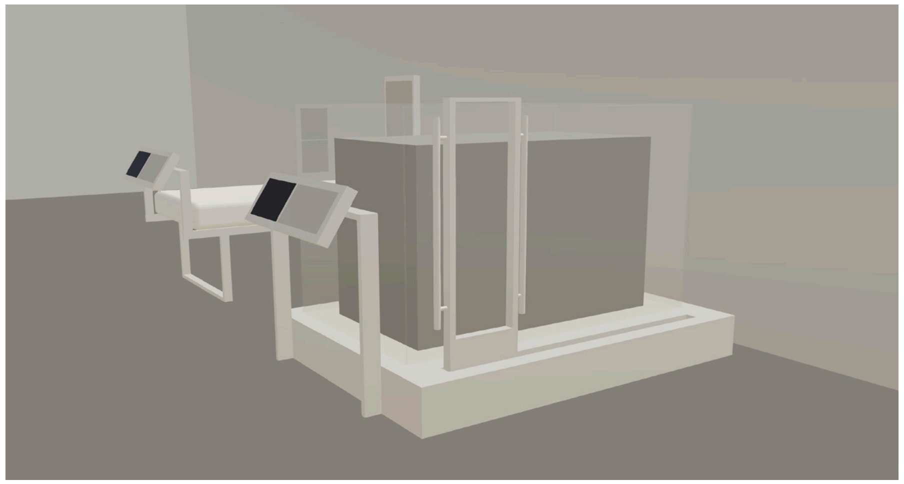


Figure 14

A grayboxed design with "AR" screen

Having created a 3D model of the exhibit, the approximate sizing of the AR screen could be determined and subsequently translated to pixels via a converter, informing canvas sizing in Figma. Knowing this sizing, the next design challenge concerned the formulation of an appropriate lay-out for the different screens. In creating such layouts, it quickly became clear that the unique canvas sizing would alter a UX designer's regular interpretation of pixels. To illustrate, where a 64-pt. header is appropriate for web design, this sizing was too small for the AR screen that needed to be viewed from a distance. The spatiality of the experience influenced lay-out considerations in other ways too. For example, according to the restrictions determined in the research phase, the screen design needed to be accessible for wheelchair users as well. To ensure accessibility, field-of-view (FOV) calculations were completed according to anthropometric measurements. By overlaying these calculations on the canvas, an ideal and acceptable area of the canvas was determined to place important information (***Appendix C, p. 59***). To place interactive elements, such as buttons, the common area of reach, as identified by Giannasca (2014), was applied too.

Although the general spatial and screen lay-out was determined at this point, one more lay-out consideration remained: the mapping of interface elements within the AR experience. When it comes to the spatial mapping of such components in the user interface, a distinction can be made between non-diegetic, diegetic, spatial and meta UI (Fagerholt & Lorentzon, 2009) (***Appendix A***), offering different spatial canvasses. Although these concepts are normally used to describe UI components in the game industry, they can provide valuable approach for UX designers working in 3D space too.

Insight #24: Grayboxing
The technique of grayboxing can be used to quickly validate spatial designs.

Insight #25: A shifting frame of reference
Even when working on 2D design components, the spatial experience can be of influence. Previously unencountered design variables include FOV, different (spatial) canvasses (diegetic, non-diegetic, spatial and meta) and diverging screen sizing. Such sizing alters the known meaning of pixels for UX designers.

Onboarding

When it comes to UX for XR, arguably one of the most important aspects is onboarding: "the sum of methods and elements helping a new user to become familiar with a digital product" (Renz et al., 2014). Providing onboarding is essential, as XR technology is likely to contain new or unfamiliar interaction schemes that differ from the way users interact with web and app (Alptekin & Temmen, 2019; Chauvergne et al., 2023), thereby introducing a high intrinsic load.

Challenge #3

The influence of new hardware possibilities

For the onboarding experience, rather than providing users with a single explanation on how use the AR screen at the start of the exhibit, specific instructions are included in the experience when a user is required to act (***Appendix C, p. 50***). Such an approach is cognitively less demanding, as instructions need not be accessed from long term memory at a later point in time. Moreover, this onboarding process ensured visitors could start to engage with the exhibit design at any stage, continuing where a previous visitor might have left the experience. To design the onboarding screen, several screen iterations were placed in the 3D environment in Bezi, making it possible to

Heuristic

Recognition rather than recall

evaluate the design in context. Through a grey overlay, users are kept aware of the fact that they are still in the 1945 narrative in Stadsziekenhuis Kampen, whilst enough distance is created to communicate that an action in the real world is required of them. By placing the instruction at the top of the screen, the area that is best visible for standing adults, it is less likely to be missed.

Heuristic
Consistency and standards

Whilst onboarding is critical for new interaction patterns, it is desirable to have to explain as little as possible to users, making use of their existing cognitive maps to help them make sense of the system. Within the exhibit design, this principle was used by keeping the general menu consistent with that of the other menu's used in the museum, such as also presented in the digi-magazine (***Figure 11***).

Insight #26: Spatial onboarding
Onboarding is more critical in XR experiences, as they are likely to contain unfamiliar interaction schemes for users. Known heuristics may be applied to design this experience. By evaluating onboarding in its spatial context, the effectiveness of the design can more easily be assessed. Where possible, familiar interaction patterns should be used.

Affordances

Clear affordances enable users to understand how to interact with a system, reducing extraneous processing. The two most crucial types of affordances are physical and cognitive affordances (Hartson, 2003). Where physical affordances communicate which actions can be taken with an object (e.g. a big red button affords pushing), cognitive affordances help users think and understand the information presented in a system.

Heuristic
Match system & real world

In the exhibit design, the key physical affordance is pulling the AR screen to explore the team behind, and workings of, the artificial kidney. The AR screen features large sidebar handles to indicate this interaction possibility. Based on the expert reviews, several improvements were made. For instance, padding was envisioned on the handles to enhance their grip, and the instruction screens were updated with an animated icon representing the screen itself, replacing the original static arrow (***Figure 15***). Matching the system with the real world in this manner improves cognitive affordance. Hodent (2017) emphasises this, recognising the principle of form follows function: what you see is what it does. To further signify the desired screen movement, each story segment was deliberately ended with a cliff-hanger. After completing the AR narrative, the screen should also be moved back to its starting position. Initially only a top-screen instruction indicated this action possibility. To improve this, the conclusion screens were brightened to signal new content, contrasting with the dark/sepia UI design throughout the AR experience; a visual hint was added to the carousel with conversation/reflection starters that more content can be discovered on the left and the copy was adjusted to better communicate further exploration possibilities (***Figure 15***).

On a purely cognitive level, users should be supported in understanding the narrative and educational content in the AR experience. To achieve this understanding, a variety of visual and auditory components were included, such as footstep sounds to signal the introduction of a new narrator and lighting changes to signify the passing of time (***Appendix C, p. 55***).

Insight #27: Spatial affordances
Whilst the core principles of affordances are similar in traditional UX design and UX for XR, affordances related to spatial and potentially physical interactions need to be added to the list of considerations. Moreover, a wider variety of modalities may be applied to convey affordances appropriately, such as sound effects and tangible components. The most important rule to follow for visual elements is form follows function.

Attention

Recall that according to the ***Deep Dive: Human cognition for dummies***, guiding a user's attention to the right components in an experience is critical. Arguably, this especially holds true for XR experiences where sensory memory must deal with a wider variety of incoming stimuli. To make attributes stand out, colour, motion, orientation and size play a key role (Wolfe & Horowitz, 2017). The animated instruction icon, positioned within the user's comfortable field of view, exemplifies a prominent attention-drawing element in the exhibit design.

However, arguably the most critical component when it comes to managing attention in the exhibit design, is the fact that multiple modalities are involved in the AR experience. Aside from visual components, a large part of the experience relies on the narrative told through localized audio. To manage user cognitive load appropriately in this situation, Mayer (2014) Principles of Multimedia Design were consulted. Whilst these principles are normally applied in educational situations to support learning in multimedia settings (words + pictures), they are based on the general theory of human cognition and can therefore inform XR experiences as well. According to the signalling principle, cues should be added to guide learner's attention to the relevant elements of the learning material. Moreover, according to the temporal contiguity principle, words and pictures should be presented simultaneously. Based on these principles that aim to minimise extraneous processing, an effort was made to ensure alignment between the narrative and the corresponding visual components in the AR module of the exhibit design. For example, when the cellophane tube is mentioned in the

Figure 15
Clarified screen movement affordance

Initial design

Updated design with animated icon

narrative, its AR label appears connected to it. Aside from guiding attention in this manner, the modality principle, stating that people learn better from graphics and narration than from graphics and printed text, informed the decision to have the subtitles turned off by default. When users require subtitles, these can still be turned on.

Insight #28: Spatial attention
To guide attention appropriately, designers can make use of a variety of techniques. Attributes that play a role in these guiding processes are: colour, motion, orientation and size (Wolfe & Horowitz, 2017). Within XR, these attributes need to be managed in an additional dimension.

Insight #29: Managing cognitive load
Users are more likely to get cognitively overloaded within XR experiences as opposed to web and app experiences, due to the additional modalities it affords. To manage cognitive load, managing attention is key. Mayer's (2014) Principles of Multimedia Design could serve as a guide in this process.

Wayfinding and feedback

Aside from onboarding, affordances and attention, wayfinding and feedback play a crucial role in the usability of an experience. After all, users have an extra dimension they need to interpret correctly and can potentially get lost in.

Heuristic
Visibility of system status

For the artificial kidney exhibit, the key challenge related to this topic was ensuring user's understanding of the discrete story segments and their location on the viewing axis. Rather than confining such information to the limited space on screen, the viewing axis itself was divided in four segments with the so-called segment indicator screen. When a story segment is active, or if the user is instructed to move to a segment, its title on the indicator lights up, directing attention. Colours were strategically used to further enhance wayfinding: the dark segments aligning with the dark UI of the AR experience and the white segment aligning with the bright UI of the conclusion screen. Other navigational elements were deliberately placed on the non-diegetic canvas outside the fictional world of 1945, to emphasise their separation from this environment.

Heuristic
Consistency and standards

Aside from wayfinding challenges, feedback on user action needed to be considered too, the main action being screen movement. How do visitors know they are moving the screen in the right direction? After placing the instruction screen design in Bezi, the idea of using the grey overlay as a feedback mechanism was sparked. If users move the screen in the right direction, this overlay turns less and less opaque, making the artificial kidney appear on screen more clearly. If users move the screen in a wrong direction, it is made opaquer.

Heuristic
Error prevention

Insight #30: Spatial wayfinding
Wayfinding is key in XR experience, as users have one more dimension to get lost in. To prevent this, users must always be able to recognise where in the (virtual) world they are. By evaluating the experience in its spatial context, the most appropriate positioning for wayfinding cues can be determined. Moreover, the different spatial canvasses can be used strategically to indicate what kind of navigation can be expected.

Insight #31: Spatial feedback
Feedback is key in XR experience, as users have one more dimension to understand. By evaluating the experience in its spatial context, new ideas for feedback mechanisms might be sparked.

Stakeholder management

Throughout the prototyping process, regular update meetings were held with the SAED to showcase the progress of the design. Based on these meetings, adjustments or additions were discussed and made to the concept design where needed. The SAED, for example, indicated that the younger target audience is likely to play with the AR screen. Rather than restricting play entirely, which could lead to frustration, the decision was made to gently nudge users to display the desired behaviour through appropriate feedback. The progression of blood flow is halted and a grey overlay appears that gradually grows darker the further away the screen is moved during narrative segments.

Where these regular update meetings formed an informal check-in during the design process, a real UX design process at Soda studio would entail sprint reviews. To validate the finished concept design more formally, one such demo was given at Rijksmuseum Boerhaave. Given the occasional instability of Bezi, screen recordings were made inside the software and placed in a slide deck to walk stakeholders through the exhibit experience. The prototype used for this demo not only contained a model of the exhibit design, but also a simplified version of the museum environment to provide context (***Figure 16***). Whilst some practical questions about realisation and electricity costs remained, stakeholders received the exhibit design enthusiastically, calling it a well thought out and enchanting experience.

Figure 16
Exhibit prototype with museum environment

Insight #32: A recorded demo
By taking screen recordings within the virtual environment of an XR prototype and placing these within a slide deck, a demo can be given independent of software stability. In a linear XR experience, this method also lets designers skip to the most relevant of the experience for the specific demo.

5.4.3. User testing

As a final step in the prototyping process, the finished concept was validated through a user test with the target audience. Rather than testing the ideal happy flow, two more complex scenarios were chosen that were expected to uncover more potential usability issues. The main goal of the test was to uncovers such issues (pragmatic quality), as well as assessing engagement with the exhibit (hedonic quality). The test was designed with input from Soda studio's UX researcher who also served as sidekick during the test day itself, taking notes of the entire process. Whilst Soda studio normally tests remotely, this test was completed in person, as user movement was determined to be a key component of the experience. The specific research questions and limitations of the test can be found in ***Appendix C, p. 62***.

Test set-up

To evaluate the exhibit design, a copy of the exhibit design in Bezi (build around the happy flow) was made and adjusted for the user test. Whilst the museum environment that was modelled in the original file proved valuable in stakeholder management, this environment was purposefully disabled for the user test. After all, such a complete VR environment would have completely isolated respondents from their physical surroundings and the researcher. Without this environment, the VR headset could be placed in pass-through mode, ensuring respondents could view the 3D model of the exhibit in context of a black and white view of their physical surroundings. This contributed to a feeling of safety for respondents and made it more natural for them to answer the questions asked by the researcher throughout the experience.

To simulate the exhibit experience, a variety of animations in the prototype could be triggered through keyboard inputs. Connecting a wireless keyboard to the VR headset ensured these animations could then be triggered from a distance. To ensure the right keys were pressed at the right time according to respondent actions, and to be able to contextualise their movements, the display of the VR headset was streamed to a laptop. In this way, a high-level "Wizard of Oz" prototype was created. Whilst all screen movement in the exhibit design had to be facilitated in this manner, some components could respond to respondent actions directly. Respondents could, for example, press the start button on the virtual screen. To simulate the auditory experience of the exhibit, a phone was used to play sound files. The narration belonging to each story segment had been recorded previously and sound effects were added with GarageBand.

Before the actual testing day took place, the entire test set-up was tested with a co-worker internally. Based on this test, small mistakes in the prototype could still be remedied and practical insights were gathered. One such insight was the need for an extension cord to connect the headset to a charger during testing, as the VR headset's battery drained quickly.

The entire test set-up is depicted schematically in *Figure 17*.

Insight #33: Test in-person
XR testing needs to take place in-person. Being able to see physical user movements is an integral part of understanding the usability of an XR system. Testing in-person is likely to limit potential candidate pools.

Insight #34: Pass-through mode
Placing a 3D model in pass-through mode for evaluation ensures respondents remain aware of their physical surroundings, contributing to a feeling of safety and facilitating a connection between the researcher and respondent during the experience.

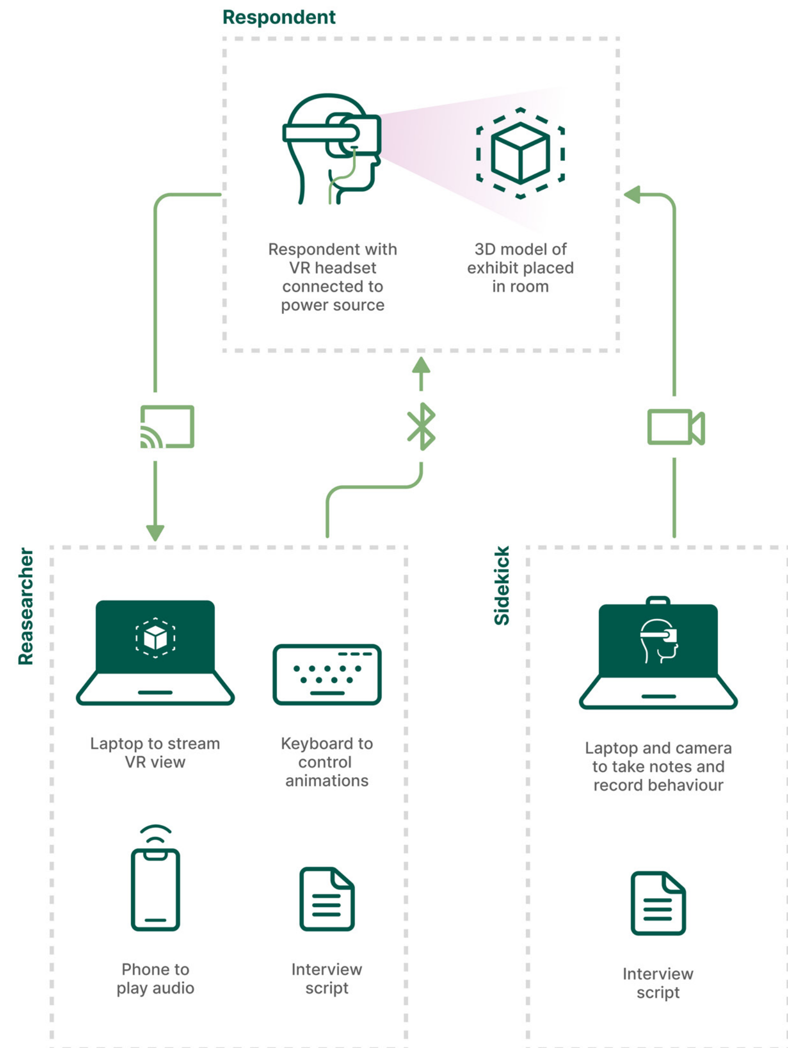


Figure 17
Test set-up schematic

Test results

Recall that Soda studio normally reports user test findings by colour coding each screen in the experience according to a colour scheme: good (green), neutral (grey), difficult (orange), and bad (red). A similar method was used to report on the findings of this XR test. All in all, the aggregated test results showed the concept design to be promising. To further improve the concept design, several recommendations were made. All user test results and recommendations can be found in ***Appendix C, p. 64***.

Insight #35: User testing documentation
User test results can be reported according to the standard way of working, at least when it comes to screen-based AR experiences. In this instance, screenshots of the artificial kidney model were taken inside the virtual Bezi environment and placed in Figma to provide high resolution images of the AR screens.

Test evaluation

Aside from looking at the test results for Rijksmuseum Boerhaave, the testing experience was evaluated with Soda studio's UX researcher as input for future XR testing for the agency. The key elements that stood out are summarised in the insights below.

Insight #36: Incremental prototyping
Rather than developing a single prototype, incremental prototyping and testing is recommended for XR to more effectively test the influence of the different design components in the experience. In the current test, it became clear that capturing all variables at once (displayed behaviour, attempted interactions, verbal responses) and discerning how each variable was influenced by which design component (UX design, visual design, copy, spatial design, narrative) proved to be a challenging task.

Challenge #3
The influence of new hardware possibilities

Insight #37: A virtual AR experience
Prototyping AR in a virtual context seems like a viable solution direction when the physical context of an envisioned AR experience is not readily available. By remotely connecting a keyboard to the VR headset, a high level "Wizard of Oz" experience can then be created. In this instance, respondents showed clear immersion and engagement with the prototype. However, the way in which VR technology mediates test outcomes needs to be researched more closely. Can this prototyping and testing approach truly identify the majority of usability issues, or is there a more suitable method available?

Insight #38: The real deal
While XR prototypes utilizing software like Bezi can be helpful in testing concept designs, it is imperative to also build and test functional prototypes that involve actual coding and construction of the experience. After all, the way in which the concept design is translated to a functioning XR experience affects the real user experience. Usability issues could, for instance, be caused by unstable marker recognition software.

5.5. Chapter round up

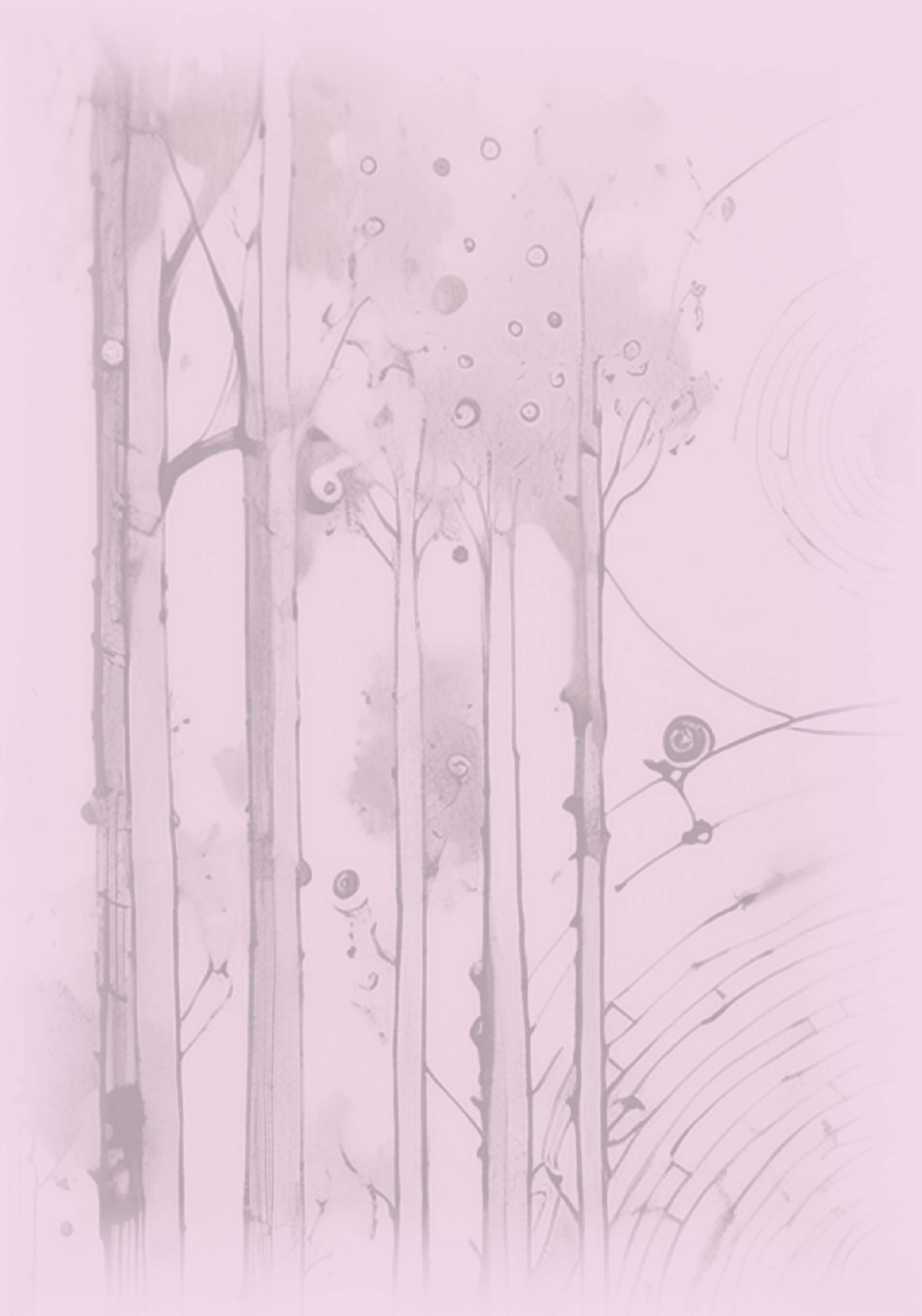
In this chapter the methods, software and decision-making processes used for the project at Rijksmuseum Boerhaave were discussed and its resultant observations listed. Through the documentation of this process in this manner, an understanding of the situationality of the observations made is preserved to some extent. Given the positive response from stakeholders and the promising results of the user test, it becomes clear that value can still be provided for clients throughout the learning process in new domains.

A product vision was formulated and translated to a concept design for the new artificial kidney exhibit in Rijksmuseum Boerhaave. The concept design makes use of AR technology to bring the artefact to life.

- The defined product vision for the exhibit stated that the exhibit should revolve around the central question: "How are inventions created through teamwork?" The exhibit should be a *stimulating storyteller* that attracts curious adults and children, fits into their world of experience, and allows them to discover fresh perspectives in a surprising way through interactive visual attention for the artificial kidney, exciting in-depth stories and conversation and reflection starters.
- The final concept design fulfils the product vision by presenting a pivotal moment in history in AR: the first successful haemodialysis of patient number 17. To uncover this journey, visitors move a large AR screen from left to right, following the blood of the patient throughout the dialysis procedure. Two members of the design team narrate the story and make references to other important team contributions, providing a unique perspective on the artefact. At the end of the AR experience, visitors are brought back to the here and now to uncover conversation and reflection starters whilst placing the AR screen back to its original position.

The project at Rijksmuseum Boerhaave afforded the practical exploration of the UX for XR domain holistically, spanning strategy to surface design and including a concept test. A total of 38 concrete reflective observations were made.

- The project incorporated a wide variety of process steps to transform abstract visitor and museum desires into a concrete concept design. These steps included, but are not limited to: stakeholder interviews, interviews with the target audience, the design and review of a variety of system set-ups, the creation of an abstract experience structure and an elaborate prototyping process. This process involved the use and integration of multiple design tools to explain the exhibit design to stakeholders and to simulate the exhibit experience for user testing.
- The reflective observations made, contain reflections across varying levels of detail and concern both operational and strategic affairs. For example, where "XR insight #4: Technology-second, pt.1" warns against the adoption of a technology-first perspective, "XR insight #18: A structure of lenses" offers four concrete methods for UX designers to structure XR experiences with.



Chapter 6

A case study into UX for XR: Implications

Recall that the aim of the case study was to gain experiential knowledge in the field of UX for XR to better understand the implications it might carry for Soda studio. Therefore, this chapter consolidates and generalizes the reflective observations from the project experience at Rijksmuseum Boerhaave in light of the larger organisational context. From an operational point of view, the differences between Soda studio's current way of working and an approach suitable for UX for XR are analysed. From a strategic point of view, various factors are discussed that Soda studio must consider before venturing into this new field, including the identification of competencies UX designers must develop to take on this new expertise.

6.1. Operational implications

The inclusion of XR technology in Soda studio's UX services signifies a change in the potential digital solutions the company could provide for their clients. To gain insight into the operational implications of UX for XR at Soda studio, the completed case study at Rijksmuseum Boerhaave is abstracted through the formulation of a UX for XR framework (***Figure 19***). The developed framework is based on the five layers of UX design (Garret, 2011) as discussed in chapter ***4.2. What is UX design?***, and tailors it to represent UX for XR specifically, consisting of the following layers: strategy, scope, set-up, structure, skeleton and surface. By contextualising the gathered insights into this familiar structure, a visual overview is created that may help individual UX designers, both at Soda studio and beyond, to quickly grasp the unique elements that need to be considered when working with XR compared to their regular work. On an organisational level, the adapted framework can also be used to inform a UX for XR design process for Soda studio, similar to how the original framework by Garret (2011) can be recognised in their current way of working. The operational implications of adopting this framework are reflected upon in relation to the agency's existing agile processes, resulting in the definition of a UX for XR workflow that fits the company (***Figure 20***). As such, the workflow can guide management in identifying operational changes required when expanding expertise to XR. Moreover, it forms a foundation for identifying relevant competencies UX designers need to effectively design for XR (see chapter ***6.2. Strategic considerations***) and can be used as communication tool to help them comprehend and discuss their new responsibilities. In other words, the adapted framework and workflow provide both UX designers and their management with a structured overview to more strategically explore the components and design processes associated with the implementation of XR technology in future projects. However, it is important to take into account that the adapted framework and workflow concern a first iteration. The more experience the organisation gains in the field of UX for XR, the more these may be refined. For now, the following considerations are important to contextualise and understand the developed UX for XR workflow:

1. ***Project complexity:*** As the formulated UX for XR framework was based on the completed project at Rijksmuseum Boerhaave, it inherently reflects the complexity of this project. The key to this complexity in large part lies in the design of a custom system set-up that includes tangible artefacts, placing it outside the scope of traditional digital web and app experiences. Moreover, collaboration with other disciplines to design and develop the product from start to finish is assumed. By reflecting on such a scenario, rather than assuming e.g. a scenario in which an XR feature is added to an existing mobile app, or a website is built to be experienced in a VR browser, more potential implications on Soda's way of working can be uncovered.
2. ***Role of the UX designer:*** The role of Soda studio within the project is assumed to be similar as in their projects now, providing an UX lead and UX designer to steer the project in the right direction, both strategically and on a more practical level. In other words, UX design is placed at the centre of collaboration efforts.
3. ***Timing:*** The defined way of working assumes a scenario in which Soda studio would move towards UX for XR soon, thereby considering the current UX for XR landscape and the challenges designers face within.

The resultant way of working structurally overlaps with many parts of the original design process and consists of a research sprint, a concept foundation sprint, concept sprints, detailing sprints, testing and realisation. Whilst the global set up of sprints and UX layers does not differ significantly from Soda studio's original way of working at first glance, their interpretation offers important nuances. Components that align with a traditional UX approach within these sprints are marked in ***pink*** where new ones are marked in ***purple***. It is important to consider that it is not only the act of designing itself that the inclusion of XR technology touches, but also the way in which one communicates during and about this design process. Throughout a project, UX designers are responsible for effective communication, substantiating design choices, and managing expectations. It is not enough to create a user-friendly design that meets user and business needs - it is of equal importance to ensure the client is convinced of the design direction too. The UX lead is not only responsible for ensuring this alignment with the client, but also within the internal design team to bring the design to fruition efficiently. For both internal and external communications, the right tools, methods, and visualisations need to be chosen. Below, each part of the UX for XR workflow and correlated layers of the UX for XR framework are discussed.

6.1.1. Research sprint

The design process starts with a research sprint covering the strategy and scope layers of the UX for XR framework. Conclusions are drawn and a product vision is defined. The product backlog is filled with user stories based on this initial product vision.

Strategy

As with regular UX design, UX for XR start with an identification of ***user needs and business goals***. A critical part of this process is to ***set the toolbox*** with the client: which technologies are available in the solution space of this project? Is the client even open to exploring XR solutions to meet business and user needs? And does the budget allow for such potential explorations to take place? If XR technology is determined to be a potential part of the project, designers should prevent themselves from adopting a technology-first perspective aimed at finding use cases for XR. Rather, the focus in this stage should lie on uncovering user behaviours, attitudes, and pain points. These need to be understood without

Insight #1
Setting the toolbox

Insight #4
Technology-second, pt. 1

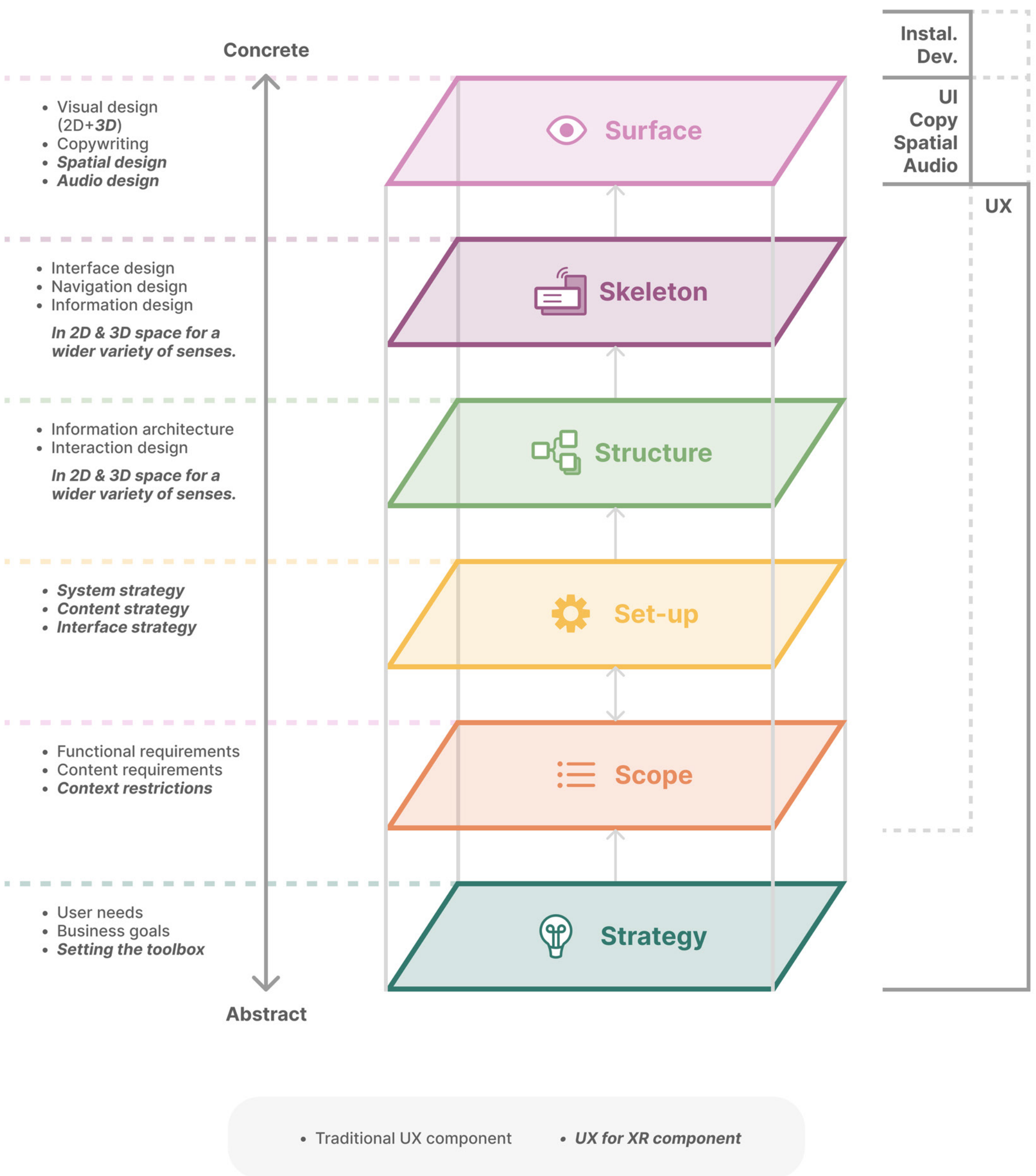


Figure 18

UX for XR framework. Based on the work of Garret (2011)

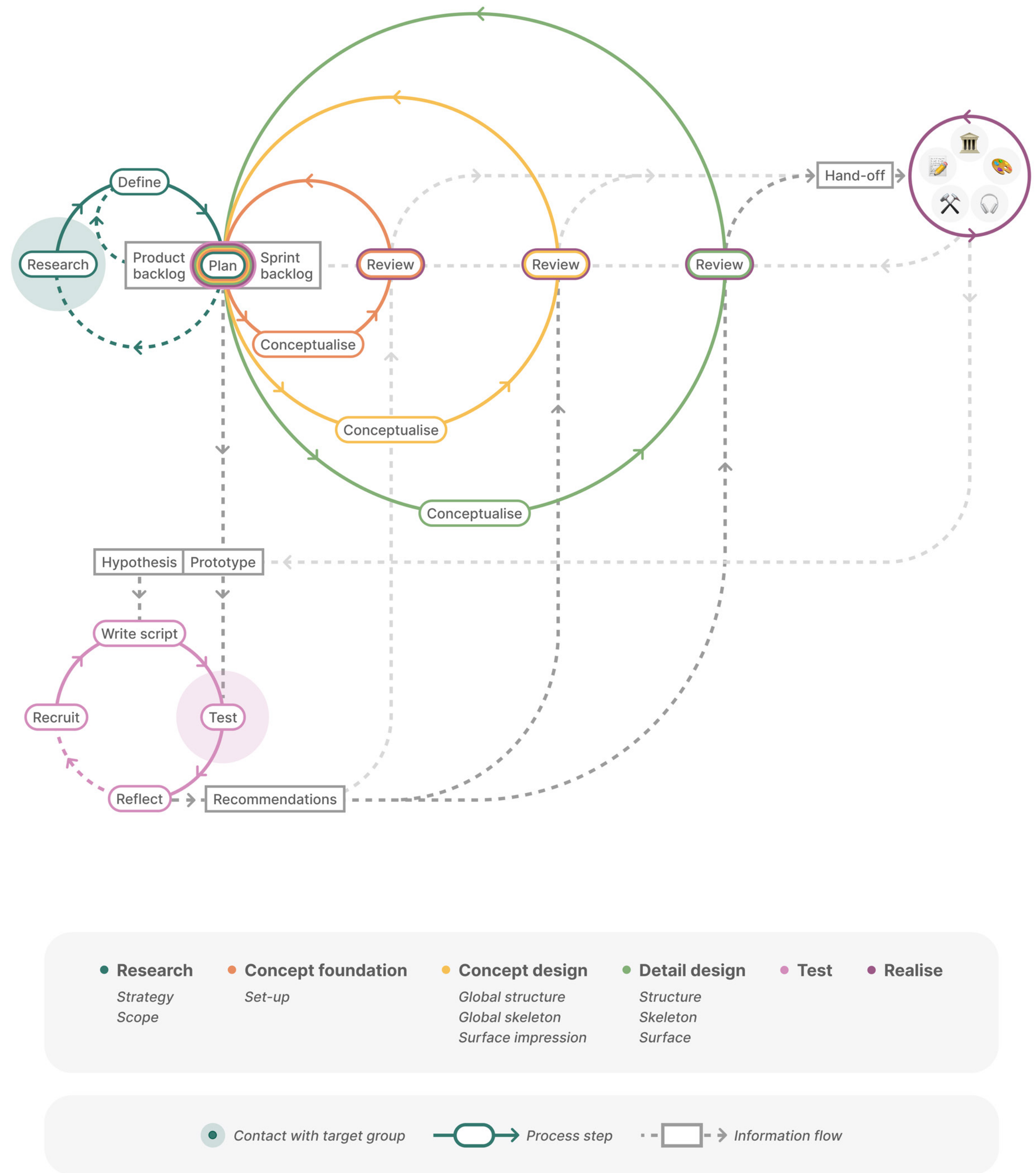


Figure 19

UX for XR agile workflow

being guided by a specific solution direction already. In other words, XR should be a tool in the total toolbox used to solve problems.

Scope

Once user and business needs have been identified, the project can be scoped. Recall that this layer of UX concerns itself with the identification of ***functional and content requirements***, identifying concrete product features. Traditionally, Soda determines these features through a product vision workshop. During/after the formulation of the product vision, an estimation can be made whether XR technology could play a role in meeting user needs. Are there any desired product features that would meet user needs better through making use of XR technology? To answer this question, UX designers need to understand how XR technology is already used in the industry in question, necessitating research in this field. The more experience a UX designer with XR, the easier it becomes to make this assessment (based on gut feeling) and to see interesting design opportunities. Generally speaking, opportunities for XR lie in the way in which it can meet experience-based goals due to its immersive quality.

Insight #6 *Technology-second, pt. 2*

Insight #7 *Understand the industry*

Insight #5 *Addressing experience-based goals*

If it is agreed upon to explore solutions making use of XR technology, the physical context in which the experience takes place becomes a more important factor in the design process. Therefore, the ***restrictions which the context enforces*** on the design should be scoped. The central question is: which restrictions does the context place on the entirety of the system? Not only the digital design but the physical manifestations of the technology and potential other structures that could enable the experience need to be considered. In other words, the restrictions that are placed on the parts of the experience that happens on screen and those parts of the experience that happen off screen need to be identified. An important consideration in these restrictions is the degree of predictability of the outside environment and integration with this environment. Which environmental conditions need to be considered during the design process? Is the system part of one specific controlled environment or is it to be used anywhere?

Insight #2 *The importance of context*

Insight #3 *The level of predictability*

In general, the adoption of XR technologies in the project toolbox is likely to result in a longer scoping process. For one, more research efforts are required to understand the implications of the context of use and the way in which XR can be beneficial in meeting user and business goals. Moreover, in UX design for web and app, many product features might be implicitly assumed based on existing patterns. For example, at Soda studio, when a client wants to increase the conversion rate on their eCommerce website, designers know features such as a shopping cart, filtering products and product detail pages need to be part of the design. The focus in scoping such projects is then on additional features that can set the client apart from the competition and that fit their brand. Currently, the field of UX for XR is characterised by a lack of such guiding patterns, warranting a more conscious scoping process.

Challenge #1 *A lack of guiding principles and patterns*

6.1.2. Concept foundation sprint

During the concept foundation sprint, the set-up layer of the UX for XR framework is considered. This layer has been newly introduced to the original framework defined by Garret (2011), because a new unknown has been introduced: the system. Whilst UX design for web and app can rely on the fact that interactions take place via mouse/keyboard/screen or touchscreen with known interaction patterns, the inclusion of XR opens a whole new level of interaction possibilities. The concept foundation sprint is aimed at defining a clear global concept direction for the experience based on initial scoping, before moving into structuring the content. In this way, the largest uncertainties between the research phase and concept phase are be bridged. After all, a system, and the potential interactions it affords, need to be clear before one can dive into the UX details of the design. To formulate a concept foundation, input is required from other disciplines of the team, as well as the client. The input of other disciplines is crucial to make a holistic general estimate of the feasibility of the designed set-up. By presenting the client with various of diverse and concrete set-up directions, previously remaining implicit content requirements and functional specifications are likely to surface. Such directions are likely to be best presented in a workshop setting that focuses on the UX implications of each direction. Based on the final set-up design, the product backlog can be clarified and updated, allocating more specific user stories to the involved disciplines.

Insight #8 *A need to define the system set-up*

Insight #11 *Involve other disciplines*

Insight #9 *Make the set-up concrete and diverse*

Insight #10 *Focus on the UX implications of a system set-up*

Insight #12 *Workshop it*

Set-up

To determine an appropriate set-up, the following needs to be considered:

- ***System strategy:*** Within the system strategy, the components constituting the system are determined. What is the desired level of immersion? And what input (e.g. Quest controller, gaze-based, hand tracking, pedals) and output devices (e.g. haptic gloves, speakers, AR headset) are used to realise this? Whilst choosing such devices it is crucial to consider what interaction possibilities they afford, what degrees of freedom (DOF) they introduce and how user movements may influence the system. Moreover, UX designers should be aware that for users, there is little distinction between the user experience related to the hardware and that related to software (Hillmann, 2021). Thus, when deciding on a system strategy, its inherent technological limitations of need to be considered. More custom system configurations may help better target UX pain points.
- ***Content strategy:*** Within the content strategy, a global vision for the types of content and its dependencies on the system is set. What story does our product tell? Which modalities of content play a role (e.g. audio, visual)? How does this align with our envisioned system and how does it fit the

Challenge #3 *The influence of new hardware possibilities* brand? Elements such as storytelling and gamification can play a role here.

Insight #15
Interface strategy

- ***Interface strategy:*** Within the interface strategy, a global vision for the relation between the outside world and digital world is created. This strategy is specifically important for AR applications, where part of the context becomes part of or informs the content. Which information from the environment do we need to bring our vision for the product alive? How will this information enter our system? And how might content be affected based on this information? Based on the interface strategy, additional devices/sensors might be needed as part of the system design.

Insight #16
Redefine the scope

Insight #13
Consider the system and content strategy holistically

Insight #14
Start and reflect

It is important to note that the set-up layer is closely related to the scope of the project. Whilst certain desired features can imply an appropriate system direction, the system itself imposes restrictions or gives rise to possible interactions. The clearer the set-up, the more specific the content and functional requirements can be identified and the better these can be divided amongst the right disciplines in the team. A similar synergy is also visible between the system and content strategy: the chosen input and output devices have an influence on the content that can be included, and the content to be included can influence which interactions are desirable. By consciously observing the interplay between these two strategies, proper alignment can be achieved. Progress needs to be made in one to be able to reflect on the other.

These interactions at play in this part of the design process highlight the significance of the set-up layer in maintaining an appropriate impact-to-effort balance in UX for XR. Where UX for web and app allows website pages to be shuffled or new content to be added relatively easily, a system change in XR might warrant an entire new design. By considering the global system, content and interface strategy and their implications on the scope of the project holistically first, this risk may be mitigated.

6.1.3. Concept and detailing sprints

During the concept and detailing sprints, the product vision is brought to life. Each of these sprints starts with planning, transferring user stories from the product backlog to the sprint backlog. In the concept sprint, a global vision for the structure, skeleton and surface layer of the product is designed and reviewed with the client and other involved disciplines. The product backlog is subsequently filled with the edge casing scenarios that need to be considered in the upcoming detailing sprints. In these sprints, the global product vision is refined towards a final and detailed vision for the structure, skeleton and surface layer of the product. As with all other sprints, results should be reviewed with the client and other disciplines part of the team. The design decisions that need to be made across the concept and detailing sprints are described below, whilst the more practical visualisation and prototyping approach of the design is discussed under the upcoming subchapter ***6.1.4. Prototyping, testing, and realisation***.

Structure

Within this layer, the ***information architecture*** and ***interaction design*** are determined to form an abstract overview of the structure underlying the experience. The information architecture concerns itself with the way in which content is arranged. Whilst this normally is an expression of 2D space (e.g. a site map), UX for XR requires an ***arrangement in 3D space***. Within this space, the interface elements within the experience need to be mapped. These elements now not only include visual components as seen in web and app but could also include ***other senses*** like sound and touch. How are these elements related to one another and to the 3D space? What is their modality (e.g. sound effect, image) and do they have certain distinguishable states (e.g. selected yes/no)? The objective is to structure information in such a way that users can best reach their goals. To achieve this structure, a variety of perspectives may be applied. Where a space-oriented perspectives can help to abstractly define the world of the experience and this spaces within, an object-oriented approach at this stage may help determine which objects (2D/3D) form the central content of the experience and how they might contribute to immersion.

Insight #17
OOUX after system and content strategy

Insight #18
A structure of lenses

On the interaction design side, decisions then need to be made on how users can navigate the different elements in the information architecture. In other words, how does the system respond to the different decisions and actions users take? By creating a user flow, the way in which users should and could move through the defined content and spaces can be considered. In essence, this process, often abstracted in flow charts, does not need to differ much for UX for XR compared to web and app, as long as temporal or spatial dependencies are clearly mentioned.

Insight #18
A structure of lenses

Insight #23
XR user flow

Skeleton

Once a solid foundation has been created for the experience through the determination of all features, content and their structure, a skeleton design can be created. This stage includes working out the specifics of the ***interface design, navigation design and information design***. In other words, UX designers work on visualising and prototyping components (in a low fidelity manner) that will enable users to experience, navigate and understand the defined structure.

Challenge #1
A lack of guiding principles and patterns

Challenge #2
A lack of holistic spatial tools and practices

When it comes to these elements, the following factors play essential roles: onboarding, guiding attention, creating the right affordances, and guiding users through wayfinding and feedback. Although these factors play roles in UX design for web and app too, the additional dimension of XR results in new possibilities and pitfalls. Given the current lack of principles, patterns and practices in UX for XR, designers need to more consciously address and design for these factors in both 2D and 3D space and across a ***wider variety of modalities***. Where in web and app the presentation of information in the experience is largely limited to text and images, sound and haptics can play an important role in XR experiences too. Albeit discussed below as separate elements, onboarding, attention, affordances and feedback and wayfinding are interconnected elements that together help shape the user experience. For example, an effective onboarding experience cannot be designed without attention being guided in the right direction.

- ***Onboarding:*** Designing the right onboarding experience is more critical in UX for XR experience when compared to traditional UX design, as users are likely to be confronted with unfamiliar interaction schemes that introduce high intrinsic load. The question then becomes how to best introduce users to these interaction possibilities? Known heuristics, such as recognition over recall and the need for consistence, may be applied to design a pleasant onboarding experience. By subsequently evaluating onboarding in its spatial context, the effectiveness of the design can more easily be assessed.

Insight #26
Spatial onboarding

- ***Guiding attention:*** Users are more likely to get cognitively overloaded within XR experiences as opposed to web and app experiences, due to its additional dimension and the larger variety of modalities it affords. Where traditional UX is concerns itself with layout and hierarchy to appropriately direct the visual attention of users, influencing attributes like colour, motion, orientation, and size (Wolfe & Horowitz, 2017) need to be managed in spatially for XR. To map and validate spatial relations during the concept sprint, the technique of grey boxing can be used. To appropriately guide attention in an effort to limit cognitive load across modalities, Mayer's (2014) Principles of Multimedia Design could serve as a guide.

Insight #28
Spatial attention

Insight #24
Grayboxing

- ***Affordance:*** For each component that is part of the product, the way in which the user is (un)able to interact with it needs to be determined. What manner of input suits the action best? And how is this kept consistent across the entire product? Where the previously set up interaction design determines which actions the user should be able to take, the system strategy should give insight into which input devices are possible to instigate this action (e.g. clicking a button). To help users understand and take the right actions within the system, both cognitive and physical affordances need to be considered (Hartson, 2003). Where designers for web and app only need to take into account affordances of digital components, UX for XR introduces spatial and potentially physical interactions to the list of considerations. Here the relationship between the physical and digital world may also play an important role. For example, a Quest controller naturally affords pressing buttons. However, turning the digital representation of this controller in VR into a golf club, suddenly makes it affords swinging. As UX designer one of the most important rule to follow when working with affordances is the principle of form follows function: what you see is what it does (Hodent, 2017).

Insight #27
Spatial affordances

- ***Feedback and wayfinding:*** Once the user has taken an action, whether it be right or "wrong", feedback is required. Feedback and wayfinding are key for XR especially, since users have one more dimension to understand and potentially get lost in. In this sense, feedback is a type of cognitive affordance to help understand the environment better. Where the previously set up interaction design determines where feedback is required, the systems strategy should give insight into which output devices are available to provide this feedback. The question then remains which feedback design is most suitable and brings about the desired impact on user behaviour. By evaluating the experience in its spatial context, the most appropriate wayfinding cues and feedback opportunities can be determined.

Insight #30
Spatial wayfinding

Insight #31
Spatial feedback

Surface

The surface layer is encompassed by the final high-level prototype of the experience. Where the skeleton layer is more concerned with functionality, visualising the spatial arrangement of components and way in which they can be navigated, the surface layer is concerned with the final look and feel of the design and thus concerns ***visual design (2D & 3D)***, ***copywriting***, ***spatial design***, and ***audio design***. In this layer of the framework, the role of the UX designer changes. Where they have had the leading role up until now, UX designers likely take on more of an advisory role whilst other experts (sound engineers, UI designers, spatial designers) work to finalise the look and feel of the experience.

6.1.4. Prototyping, testing, and realisation

Prototyping and testing play an important role throughout the UX design process – they are a means to reduce uncertainty in design. Whilst Soda studio normally works closely together with 2D visual designers and copywriters to create prototypes, design for XR adds spatial designers, 3D visual designers and audio engineers to this mix. Moreover, the realisation of a product normally occurs after finished features of the design have been handed off to the development team during refinement sessions. This makes the development team entirely separate from the prototyping and testing process that takes place during traditional UX design. When it comes to XR, the development team (2D and 3D) and installation team responsible for the realisation of physical artefacts are likely to be less isolated from this process. After all, currently no one authoring tool is available for UX designers to prototype and test XR applications start to finish. Some prototypes might need actual coding or physical realisations to test hypotheses during the design process. The design recommendations resultant of these tests can then be shared for review with clients and the other involved disciplines. All in all, when prototyping for XR applications, rather than for web and app, several considerations need to be made:

Insight #20
Reaching a higher fidelity

Challenge #2
A lack of holistic spatial tools and practices

Challenge #1
A lack of guiding principles and patterns
Challenge #2
A lack of holistic spatial tools and practices

- ***More prominent role of testing:*** Where UX designers can rely on existing patterns, principles and practices and their existing expertise for web and app, this knowledge base is not (yet) available in UX for XR at Soda studio. To navigate the uncertainties this introduces in the design process, is likely that prototyping will take on a more prominent role. Where Soda studio now tests a design between the concept and detail sprint to validate the concept design before refining it, prototyping and testing in UX for XR might need to take place in any of the design sprints (from concept foundation to detail design). Such tests might take place internally or with the target audience. For example, when working on the concept foundation, UX designers might create a quick prototype to test internally whether a core interaction they have in mind for the experience is likely to be user-friendly. Over time, the additional testing required in UX for XR is likely to decrease with Soda studio building their own patterns and prototype components that can be re-used in other projects. Aside from more frequent testing during design sprints, a role is reserved for testing after development (and any physical realisation of artefacts) too. The way in which XR technology is coded can impact the user experience greatly. Whilst one can assume that a design in Figma is translated appropriately to web and app, a larger variety of uncertainties and more instability exists when it comes to XR technology. Testing the final experience is thus a crucial step before the product is deemed entirely completed. A more agile approach can be implemented here as well, building the final product in increments through the different prototype iterations used in testing.

Insight #38
The real deal

Insight #36
Incremental prototyping
Insight #38
The real deal

- ***Build goal-oriented prototypes:*** Rather than testing the entire experience at once, it is recommended to split up testing according to what needs to be validated and to build specific prototypes with a specific fidelity to gather the right feedback at the right time. Rather than developing one prototype, specific hypotheses to be tested through the design process need to be set up. Depending on the prototype goal, other disciplines might need then to be involved in its execution. Rather than relying solely only on 2D visual designers and copywriters, parties like 3D visual designers, spatial designers, audio engineers and XR developers might have a role in reaching the desired prototype fidelity.

Insight #36
Incremental prototyping
Insight #19
The right software
Insight #38
The real deal

- ***Prototyping in and across other dimensions:*** To create prototypes, an entire new set of practical skills is required of UX designers. Designers need to prototype across new dimensions: from 3D space to basic audio design and new interaction possibilities. Tooling for such prototypes is still disjointed, but software like Bezi tries to bring these new dimensions together and integrate with known UX tools like Figma. However, even in Figma designers need to adopt new practices. Where canvas sizes within Figma are traditionally bound by website screen sizes, screen sizes in XR might be more unpredictable, altering the known meaning of pixels for designers. Moreover, design across 3D space adds other previously unencountered design variables, such as the user's FOV which influences the way in which components need to be arranged on screen or in space and the different kind of UI canvasses afforded in AR. Even when working on 2D components, 3D space always needs to be taken into consideration. Another challenge when prototyping for AR specifically, is the potential lack of access to the physical environment in which the experience would take place. Recreating this environment in VR, thus testing an AR experience through a VR application, seems like a viable solution direction place. To protect impact/effort, a good rule of thumb is to prototype in 3D where needed and prototype in 2D where possible. During the case study at Rijksmuseum Boerhaave, for example, testing whether users would look down at the segment indicator and would understand its relation to the screen movements, required a 3D representation.

Insight #4
A rapidly changing landscape
Insight #19
The right software

Insight #25
A shifting frame of reference

Challenge #2
A lack of holistic spatial tools and practices
Insight #37
A virtual AR experience
Insight #22
Impact/effort

- ***Test in-person:*** When working on testing certain interactions and user flows, it is likely this testing needs to take place in-person, rather than through the remote set-up Soda studio is currently used to. After all, being able to see physical user movements is an integral part of understanding the usability of an XR system. When working with a VR testing set-up, enabling pass-through mode on the headset can facilitate communication between the researcher and respondents during the user test. A high level "Wizard of Oz" experience can then be created by remotely connecting a keyboard to the VR headset to trigger animations. When it comes to the influence of in-person testing on documentation, the standard way of working can largely be followed.

Insight #33
Test in-person
Insight #34
Pass-through mode
Insight #37
A virtual AR experience
Insight #35
User testing documentation

- ***New means of communication:*** The introduction of UX for XR at Soda studio implies the need for new means of communication. Throughout the design process, other disciplines are to be involved in 1) providing feedback on design possibilities 2) in the creation of prototypes or 3) in final product development. UX designers at Soda studio underscore the need for this type of collaboration within XR as well, indicating that they would feel more secure in their role as designer, if other specialists are involved in the process to discuss possibilities with – especially if their understanding of these other disciplines still lacks. Communicating with newly involved disciplines about design decisions, prototype requirements or final specifications for hand-off, requires UX designers to learn part of their language. When it comes to stakeholder management, the design needs to be presented in an understandable way too. For this audience, concrete visualisations with a high aesthetic fidelity might be required to communicate the design intent well during review moments. The fidelity of a prototype, after all, impacts expectations. This process is likely to take longer for XR applications than it is for web and app. The key question then becomes: are we building prototypes and visualisations for internal communication, external communication or for testing? Which tooling is then most suitable? And how can we maximize impact/effort? Where a

Insight #21
A new language

Insight #32
A recorded demo

video mock-up might be suitable to convince a client of a concept direction, a 3D prototype in Bezi that facilitates communication between team members might be preferred during the design process, and a functioning prototype in Unity might be best suited to test the stability of an AR feature in an app.

6.2. Strategic considerations

Aside from providing insights on a more practical operational level, the project experience at Rijksmuseum Boerhaave also provides a foundation for a more strategic reflection. How should Soda studio deal with XR as part of their company's offering? What competencies should Soda studio's current UX designers develop to take on this new expertise? And is now the right time to commit to this change?

6.2.1. XR as company offering

To effectively integrate UX for XR services into Soda studio's offering, these services must be aligned with company objectives and values. Soda studio is in the business of bringing clients measurable results by applying knowledge and creativity systematically to solve problems. They key to offering UX for XR as a design service at Soda studio, is to view it as a strategic tool in the larger toolbox used to solve digital challenges to meet user and client needs. A technology-first perspective in which XR is deployed for the sake of it should be avoided. Thus, when a potential client approaches Soda studio to design an XR application, the first question should be: "Why?". Soda studio should "rip the design brief" and explore user and client needs before settling on a system and features that would best meet these.

Insight #4
Technology-second, pt. 1

Insight #6
Technology-second, pt.2

Aside from viewing XR as a tool, a key consideration is the formulation of a vision regarding the types of projects Soda studio would like to offer within the XR landscape. To formulate this vision, a project can be viewed from a variety of perspectives. Each of these perspectives has their own practical implications and influences the way in which Soda studio can position themselves in the market.

- ***The XR technologies available in Soda studio's toolbox:*** The range of input/output devices under the XR umbrella is large, forming a variety of experience options: from VR headsets and mobile AR applications to projection-based AR and VR caves. Determining a list of input/output devices available in the solution space will provide both client and UX designers alike with clarity on system and interaction possibilities. Although this definition needs to take place with the client within the first phase of a project, Soda studio can strategically limit system options beforehand themselves. All things considering, the agency's UX designers are at home on the screen. Changing their design practices to include projection-based options might prove to be one step too far, especially at the start of their XR explorations. The broader the range of system options available, the more extensive the technical knowledge UX designers need to have and the larger the variety of prototyping tools they need to master might be. Moreover, having a larger variety of system options available is likely to make the concept foundation sprint more complicated and requires developers and installation technicians to be more versatile too.

Insight #1
Setting the toolbox

- ***The complexity of projects:*** The implementation of XR in a project can vary greatly: from offering complete immersive XR experiences to designing small XR features within existing apps or only making a website user-friendly to view and navigate with a VR headset. Soda studio will need to determine which services fit their (desired) skills and their client's needs best. The way in which the XR market will move in the upcoming years will be an important determining factor, as is finding the right collaboration partners. Currently, no 3D visual designers, Unity developers, audio engineers or spatial designers are housed within the MakerStreet network. Without finding the right partners, possibilities to take on large XR projects from concept to final product dwindle. The more complex the product, the more potential partners UX designers need to be able to communicate with and the longer the entire design process is likely to take.

Challenge #4
A rapidly changing landscape

- ***The role UX designers take on within the project:*** For MakerStreet wide projects, Soda studio currently delivers both a UX lead and a UX designer. Recall that the UX lead is responsible for steering the project in the right direction and aligning all other involved specialisms with one another. This approach would fit projects in which entire XR applications are designed and developed from start to finish. However, on the other end of the spectrum, lies the possibility to place UX designers not in a lead role, but as a supporting actor in existing ongoing projects at clients. In that case, Soda studio's expertise would not be applied in the more abstract layers of the UX for XR framework (strategy, scope, set-up), but designers would take on a more practical advisory role. This would considerably lessen the impact XR would have on Soda studio's global way of working, forgoing expertise in XR product strategy and XR system set-up. A strategic question then remains: if Soda studio is available to define a product strategy for web and app, should a similar service not be available for XR as well? Can Soda studio call themselves experts in the field, without covering all layers of UX (for XR)?
- ***The core value of a project:*** Recall that Soda studio specializes in digital solutions that bring a functional added value, providing real life solution to real-life problems. Therefore, a project at Soda studio is never purely experience-oriented. Translating this quality to UX for XR implies that suitable XR projects must have 1) utility and 2) impact. Therefore, projects in the gaming or entertainment industry do not suit Soda studio's current

business model. Neither would projects in which the investment in XR technology would not justify its costs. At this point in time, that means that products targeted at the consumer market are out of scope, with technology not yet widespread and accessible enough. Commercial projects with very specific applications in which XR provides unique value-added affordances for now seem to fit Soda studio's brand. Take for example an industrial AR guided order picking system, focused on optimizing processes at the client's warehouse. Whilst this perspective on XR projects does not influence the design process itself much, it does dictate which projects to accept or reject. Given the way in which XR more naturally lends itself to experience-based goals when compared to web and app experiences due to its immersive quality, Soda studio should decide on whether they would like to enter the UX for XR market open to more hedonic, rather than only pragmatic, oriented projects too. In other words, Soda studio needs to decide their positioning on Rauschnabel et al.'s (2022) atomistic-holistic VR continuum and assisted reality-mixed reality AR continuum.

Insight #5
Addressing experience-based goals

6.2.2. Developing new competencies

Aside from the strategic need of formulating a concrete vision for the UX for XR offering, Soda studio needs to consider whether their current team is equipped for dealing with the changes this offering would bring. Based on the case study at Rijksmuseum Boerhaave, it becomes clear that a large variety of competencies overlap between the world of UX design for web and app and that of UX design for XR. The basic steps in the layered framework largely correspond and designers are used to working from an abstract to concrete product already. The challenge for Soda studio's current designers is to adapt their current skillset towards one that can deal with an extra dimension. Considering the variety of projects UX designers at Soda studio tackle, it is safe to assume they already possess adaptive rather than routine expertise in the field of UX. This adaptive expertise will help them translate some of their knowledge and skills to the field of UX for XR and enables them to create adaptive expertise there too more easily. The competencies foundational to this expertise, based on the completed case study, can be defined as follows:

- ***Value identification:*** The capability to decide when the use of XR justifies the additional costs and effort. When is the added immersion or connection to the context of significant additional value?
- ***Physical-digital integration:*** The capability to determine an appropriate relation between the physical context and digital context. How does the physical context impact user interactions? Which information from this context needs to become a variable in the system?
- ***XR interaction design:*** The capability to define the right XR system set-up to meet user and business needs, considering the interactions it affords, context restrictions and its impact on cognitive load.
- ***Spatial information design:*** The capability to structure content in 3D space, considering the overall space, core objects/content and their modalities, user flow and potential narrative.
- ***Strategic prototype design (and testing):*** The capability to 1) define design uncertainties and align prototypes with them to test hypotheses and 2) create the right visualisations for (client) communication. Prototype in 3D where necessary and in 2D where possible. Design for onboarding, attention, affordances and feedback and wayfinding are key.
- ***Pattern, principles and practices recognition and development:*** The capability to 1) recognise and use existing 2D UX patterns, principles and practices that are applicable for XR too, 2) recognise and use emerging XR patterns, principles and practices 3) develop and use own patterns, principles and practices based on test results to guide the design process across projects.
- ***New multidisciplinary communication:*** The capability to 1) communicate and present XR concepts clearly to other involved disciplines and clients and 2) facilitate the appropriate hand-off to other involved disciplines at the right time.

It is important to consider that the specific competencies the agency needs to develop depend on their desired strategic vision. For example, if the UX for XR toolbox at Soda is limited to website design for VR headsets, less new multidisciplinary communication is required.

6.2.3. Is the right moment now?

Challenge #4
A rapidly changing landscape

Insight 19
The right software

Insight 20
Reaching a higher fidelity

Having collected the first operational and strategic implications of UX for XR, begs the question whether the right moment to start with UX for XR for Soda studio is now. Based on the completed case study and literature, it becomes clear that the UX for XR landscape is still disjointed and in its infancy. Albeit important developments taking place to make it easier for UX designers to work with this technology in a user-friendly manner (e.g. software like Bezi), no fully-fledged software exists yet in which UX designers can design for/with all other potential disciplines involved in XR application design. Creating XR experiences requires a significant amount of time, a larger variety of design tools and provides less flexibility than UX for web and app does. At Soda studio, delivering high quality designs that lead to measurable results swiftly is key. The inclusion of XR services now could contradict with these values due to the dependency on a wide variety of other disciplines to deliver high fidelity prototypes; disciplines currently not even included in the MakerStreet network. The more the technology matures, the more likely it becomes for software to appear on market that makes authoring of XR applications less dependent on these other disciplines,

Challenge #4
A rapidly changing landscape

Challenge #1
A lack of guiding principles and patterns

Insight #36
Incremental prototyping

bringing the design process for XR applications ever closer to Soda studio's current way of working. Moreover, best practices and conventions are likely to appear over time, providing a knowledge base for Soda studio to lean on during the design process, reducing the need for rapid prototyping across all design sprints to reduce uncertainty.

Considering this temporal perspective, a certain tension surfaces: Soda studio can only start offering UX for XR services if the market is ready, but the market only knows to approach them for such services if they offer them. Moreover, recall that expertise can only be built by doing. Whilst the case study at Rijksmuseum Boerhaave has provided a starting point for UX for XR at Soda studio, it is important to realise that this has just been a single case study. The project concerned a relatively linear experience in a controlled environment. The resultant insights into methods and way of working as defined in this thesis might not, in fact will not, hold up for all XR applications. A starting point and foundation for future development has been laid, but between now and the future lies a long learning path. The question thus becomes: does Soda studio have enough faith in UX for XR now to start building the competencies they need to offer these services when the time has come? Will they actively work to build their own knowledge base or wait for others to do so and potentially miss their opportunity to position themselves as an expert in this field before the market is saturated?

6.3. Chapter round up

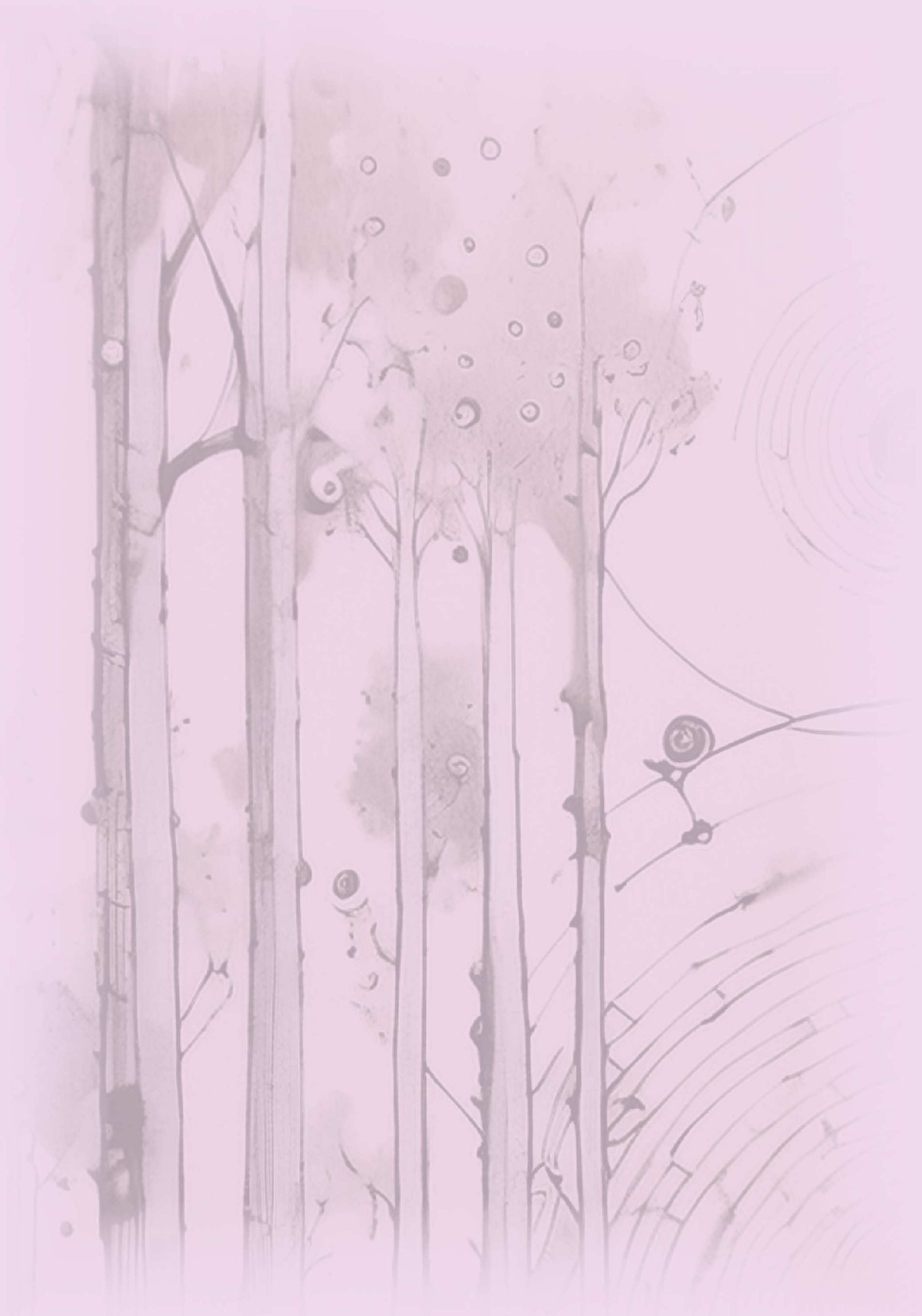
In this chapter the reflective observations from the project experience at Rijksmuseum Boerhaave were consolidated and generalized considering Soda studio's organisational context. Given the practical implications and strategic considerations that could be formulated in this chapter, experiential learning according to Kolb's (2007) learning cycle is deemed valuable in organisational contexts. Although the foundation for future development has been laid, this chapter only manages to communicate explicit knowledge. Soda studio will need to engage continuously in subsequent cycles to be able to build competence and eventually expertise themselves. An upwards learning spiral is needed where each new experience deepens understanding and the formation of tacit knowledge is facilitated (Kolb & Kolb, 2009).

From a practical point of view, Garret's (2011) UX framework has been adapted for UX for XR, forming a foundation around which to formulate a new way of working for Soda studio in this domain. Whilst the global set up this framework and way of working do not differ significantly from traditional UX design at first glance, their interpretation offers important nuances.

- The adapted framework consists of the following layers: strategy, scope, set-up, structure, skeleton, surface.
- The formulated way of working consists of the following sprints: research, concept foundation, concept design, detail design, testing and realisation.
- The main differences between traditional UX and UX for XR can be summarised as: an interconnectedness of the system with the physical environment; the introduction of a new variable (the system); the dependency on new disciplines like audio engineers and spatial designers; the new ways of thinking required to prototype for and test in an additional dimension; and the larger level of uncertainty introduced in the design.

The abstraction of the experience sets the stage for Soda studio to consider whether to pursue an expertise in UX for XR based on:

- The operational adjustments required to execute this new expertise, such as the introduction of a new concept foundation sprint and more prominent and goal-oriented role of prototyping and testing.
- How Soda studio could position themselves in the market when it comes to XR projects. To formulate a UX for XR offering, the available XR technologies, the complexities of projects, the role of UX designers within the design process and the core value of a project need to be considered.
- The competencies UX designers will need to develop to expand their expertise based on the formulated vision. The competencies under consideration include: value identification; physical-digital integration; XR interaction design; spatial information design; strategic prototyping design (and testing); pattern, principle and practices recognition and development; and new multidisciplinary communication.,
- The current state of the landscape, e.g. the state of available software and technological maturity, the time it might take to build expertise and the moment in which they would want to position themselves in the market.



Chapter 7

Leveraging experiential learning as foundation for organisational expertise

This chapter integrates theory with practice by synthesising a concrete vision on how experiential learning can be used as a foundation for the strategic development of organisational expertise. The developed learning strategy is subsequently translated into a practitioner-focused roadmap that provides guidelines and outlines actionable steps. The roadmap is validated at Soda studio on its perceived usefulness and can be used to further guide their exploration into UX for XR.

7.1. Integrating experiential and organisational learning

The goal of this chapter is to formulate how experiential learning and organisational learning can be aligned to strategically broaden expertise to emerging fields of interest, based on insights from theory and practice. The focus therein is on the learning path itself (exploration), not on the systems for exploiting these insights and distributing them across the organisation (exploitation). Under the right conditions, experiential learning can help to identify the implications of expanding expertise on an operational and strategic level, laying the foundation for a subsequent sustained practice for continuous organisational learning.

7.1.1. The first learning cycle

As illustrated by the case study completed for Soda studio, an initial learning cycle can help to gain insight into the operational implications and strategic considerations concerned with broadening expertise to a new field. Based on this information, organisations can assess whether the broadening of expertise is desirable and attainable in the future. A fist exploration in the field can help to:

- Understand key departures from and alignment with the "normal" way of working;
- Understand key competencies that might be involved in broadening expertise to the desired emerging domain;
- Understand the current state of the landscape;
- Give insight into potential strategies and market opportunities related to the technology in question.

Based on the completed case study, a variety of conditions apply to reach such learning outcomes. Firstly, an inherently complex project scenario in the emerging field of interest must be sought. The selected project should push the boundaries of what is normally representative of the organisation's work (e.g. project type and available resources), whilst remaining grounded in realism. Ample room for exploration, innovation and making mistakes is required and no straightforward design solution should be available. Secondly, the project ideally covers all stages in the project lifecycle to holistically understand the similarities and differences between current and potential future processes. Lastly, the project is best executed for a client operating in a market in which the emerging technology already has a use case. Working with stakeholders will add to complexity of the project and provides insights into stakeholder management and decision-making dynamics in this new field. This makes gathered insights directly actionable and based on real-life complexities and encountered challenges. By following these conditions, the potential practical implications and strategic considerations associated with developing expertise in the new domain can be uncovered effectively. Based on these insights, a long-term strategic vision for the broadening of expertise in the field of interest may be formulated. Knowledge workers that have completed and documented the initial experiential learning cycle(s) need to be included when formulating this strategy, as their implicit and tacit knowledge can provide valuable insights in decision making process.

7.1.2. Subsequent learning cycles

Based on the completed case study, experiential learning has proven its value for knowledge creation within organisational contexts, enabling a wide variety of insights. From a theoretical point of view, experiential learning naturally aligns with organisational learning in several valuable ways:

- Experiential learning naturally affords continuous learning required in organisations (Bennet & Bennet, 2009). Knowledge workers can continuously cycle through the experiential learning cycle, learning from and building on their experiences to create an upwards learning spiral (Kolb & Kolb, 2009).
- Experiential learning provides the necessary experience based on which the intuiting process can take place, either subconsciously or consciously through the observation of direct experience (Aponte & Zapata, 2013; Crossan et al., 1999).
- Experiential learning provides a means for knowledge workers to interpret and integrate knowledge (Crossan et al., 1999). They can form shared understanding through joint action and rich means of communication, using the group as a stepping stone towards institutionalised knowledge and contributing to a culture of trust (Crossan et al., 1999; Holste & Fields, 2010; Koskinen & Pihlanto, 2008; Lengel & Daft, 1984; Wiewiora et al., 2019).
- Experiential learning affords knowledge worker's autonomy within exploration, leading to intrinsic motivation that 1) drives deep learning that is a prerequisite for developing expertise and 2) contributes to a culture of motivation needed for knowledge sharing in organisational learning (Biggs & Tang, 2011; Carbonell et al., 2014; Gagné & Deci, 2005; Koskinen & Pihlanto, 2008; North & Kumta, 2018; Pink, 2011).

Despite this natural alignment, a need exists to strategically steer learning efforts within organisations. To exploit experiential learning to build organisational expertise, organisations need to design an intentional learning practice within the larger organisational context, characterised by learning goals, active engagement and systematically reflection after the learning experience (Eraut, 2000). Whilst the experiential learning cycle forms the foundation of this deliberative approach, various factors need to be considered when implementing it in organisational settings.

From competency to learning outcomes

Recall that strategic KM approaches the knowledge ladder top-down: to be developed competencies are identified that are deemed critical to reaching an organisations' strategic goals (North & Kumta, 2018). In the case of expertise expansion, this concerns competencies that form the foundation of the newly desired expertise, which can be extracted from the initial learning cycle. However, such competencies alone might not be too vague to steer learning cycles effectively. Rather, organisations should aim to translate competencies in concrete learning outcomes to be achieved, further clarifying and zooming in on these competencies. Such intended learning outcomes (ILOs) are written from the learner's perspective and describe concretely what learners should be able to achieve at the end of their learning experience (Biggs & Tang, 2011). As such, they provide a clear framework for knowledge workers to value, intuit and interpret their experience (Crossan et al., 1999; Nonaka, 1994). Whilst ILOs are regularly formulated from a third-person perspective ("the student…") in formal education (Biggs & Tang, 2011), organisations may consider framing them from a first-person perspective ("I…") to promote autonomy and personal ownership over the experiential learning path.

Aside from this learner-centred perspective, ILOs require an active verb that reflects what the learner can do at what level (Biggs & Tang, 2011). To that extend a variety of frameworks can be applied, such as the RTTI framework (Drost et al.) or Bloom's taxonomy (Krathwohl, 2002). Independent of the framework applied, the key to formulating learning outcomes for organisational experiential learning is to guide competency development by going through progressively higher forms of cognition, approaching the knowledge ladder bottom-up. In essence, organisations should define what knowledge, skills and behaviours would constitute the desired competency and define knowledge paths on how to develop these. Being aware of such knowledge paths makes it easier for knowledge workers to connect their different experiences and to tailor them towards their current level of expertise, enabling more effective learning (Nonaka, 1994; Persky & Robinson, 2017). Unlike in formal education, emerging fields often lack theoretical knowledge that can inform concrete ILOs. However, broader learning outcomes can still be set to set to provide direction for learning and activities within experiential learning cycles that help organisations develop this knowledge themselves.

Example

In the case of UX for XR the competency ***Pattern, principles and practices recognition and development*** has been identified. One of the knowledge paths related to UX patterns within this competency could look as follows:

1. I can *list* a set of existing 2D UX patterns.
2. I can *apply* existing 2D UX patterns to 2D spatial elements within XR applications.
3. I can *adapt and apply* existing 2D UX patterns to 3D spatial elements within XR applications.
4. I can *analyse* the effectiveness of existing 2D UX patterns when applied in an XR environment and suggest improvements.

Constructive alignment

Once learning outcomes have been defined (what is to be learned), these should be aligned with the learning activity (how should this be learned) and the way in which learning outcomes are evaluated (to what extend has the ILO been achieved?) (Biggs & Tang, 2011). This type of alignment is known in formal education as constructive alignment and ensures a coherent and purposeful learning experience. To achieve alignment, the intended verb (e.g. list, apply, analyse) in the learning outcome is present in both the learning activity and in assessment too (Biggs & Tang, 2011). For example, when the ILO is to safely drive a car, the learning activity consists of driving a car and the assessment concerns how well the student has driven a car. When it comes to experiential learning cycles, constructive alignment can help protect the impact/effort ratio of learning experiences and help to accurately assess how effective the cycle was in reaching intended learning outcomes, working towards competency development (***Figure 20***).

By setting concrete ILOs for organisational learning, learning experiences can be better tailored towards reaching these outcomes. Where one kind of outcome might warrant a project with real-life problems and stakeholders, another might be reached in a more controlled environment that offers short-term learning opportunities, e.g. a fictional one-week project. Moreover, there is no need to reinvent the wheel each time. If one knowledge worker has become competent in an area, they might host a workshop to help other learners reach their goals more quickly, together maybe even reaching new insights. Facilitating such interactions will also contribute to creating the right learning culture. All in all, organisations must ask themselves what complexity of the learning experience is required to fulfil knowledge goals.

Having completed a learning cycle, learners must determine how well they have reached the intended learning outcome, informing them on their progress and desired future experiential learning cycles to reach organisational goals. To assess learning outcomes, learners must question what their performance in the experiential learning experience says about the extent to which the ILO has been achieved (Biggs & Tang, 2011). By reflecting on the entire learning experience, evidence for this assessment can be brought to the surface

(Desjarlais & Smith, 2011). As self-assessment is challenging when one lacks experience with a task, external feedback from others within this process is needed, especially at the start of the learning path (van Loon, 2019). Although assessment primarily focuses on reflecting on the achievement of ILOs, space should be made for recognising desirable but unexpected learning outcomes resultant of the experiential learning process (Biggs & Tang, 2011).

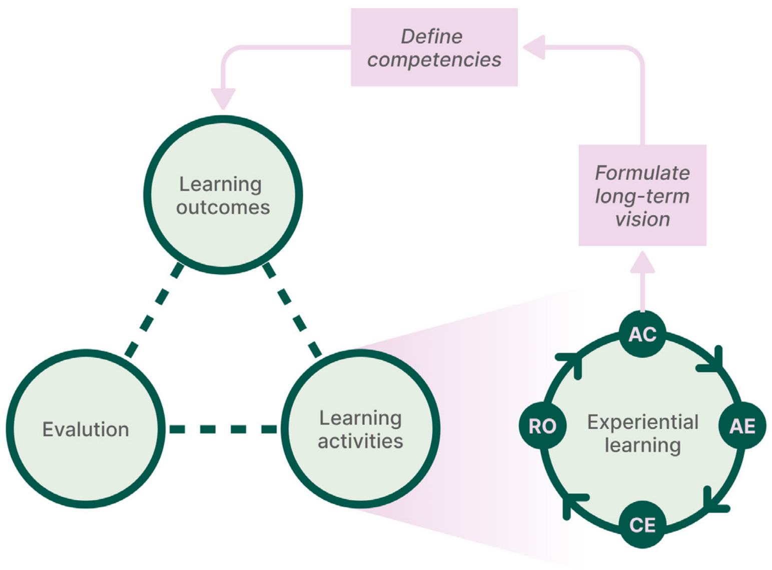


Figure 20
Constructive alignment for organisational experiential learning

Aggregating learning cycles

Reflection should take place not only within, but also across learning cycles. By periodically evaluating the results of aggregated learning cycles, the effectiveness of the learning path can be evaluated. Knowledge, skills, or behaviours that are used throughout experiential learning cycles repeatedly show signs of institutionalisation (Crossan et al., 1999). Based on the knowledge gained during these cycles, learning outcomes might need to be adapted. Regular time- based evaluations can provide a baseline for reflection and track competency speed development over time.

Change management

To implement experiential learning as a sustained continuous practice, change management processes need to take place. According to Kotter (2012), management must effectively communicate why change is necessary and provide a vision for this change. Buy-in from stakeholders is required to support the change initiative and for it to be shared across the organisation. Through a change management readiness assessment, obstacles to change can be identified and subsequently removed. By celebrating early successes and ongoing reflection and adaption, the change is made sustainable. Thus, reflection needs to take place not only on a content level across learning cycles, but on a facilitating level too. Over time, the structures and processes in place to support the learning path should be adjusted where necessary. A pilot project may be executed before scaling up learning efforts to get feedback on whether the envisioned set-up is right and to showcase the value of the learning path for the organisation. Subsequent event-based evaluations ensure the learning path can adequately be adapted to environmental changes, such as a change in resources.

7.2. A practical roadmap

To aid practitioners in leveraging experiential learning in strategic KM, a roadmap is developed that translates the discussed integration of experiential learning in organisational learning to a concrete OLS. This roadmap is designed for project-based organisations navigating the dynamic technological landscape that want to strategically broaden their expertise to an emerging field of interest. It is tailored specifically towards practitioners that are responsible for steering learning within their organisation. It aims to support these practitioners in setting long-term strategic goals in the emerging field of interest, as well as offering a means to design a subsequent practice of continuous learning to reach these objectives.

7.2.1. Roadmap requirements

For the development of the roadmap several requirements can be identified. At its core, actionable and understandable steps should be provided to practitioners that enable them to strategically steer learning though the application of experiential learning cycles. A clear distinction should be made between the way in which experiential learning can help set long-term strategic goals in the emerging field of interest, as well as how it can be used as a subsequent practice of continuous learning to reach these objectives. To ensure the steps involved in executing the OLS are actionable, appropriate guidance should be given. By offering practitioners guiding questions to address in each step, rather than prescribing specific methods with which these need to be answered, organisations are given the freedom to select approaches that align best with their culture and resources. However, to ensure the steps do in fact contribute to the strategic broadening of expertise, optimally exploiting the opportunities experiential learning affords, concrete guidelines/ recommendations for step execution are needed. In addition, to ensure steps are actionable, actors that play a role in the OLS need to be identified. This ensures organisations understand who needs to be involved in which steps and what new organisational roles might need to be created. Lastly, the question of making the roadmap understandable remains. This can be achieved by providing practitioners with a language surrounding the learning strategy. Language, after all, can shape and negotiate meaning (Whittle et al., 2023). In summary, the requirements for the roadmap are as follows:

The roadmap should…

1. *Provide practitioners with the steps involved in executing the OLS, making a clear distinction between the two ways in which experiential learning can inform organisational learning.*
2. *Provide practitioners with concise guidelines/recommendations under which these steps contribute to the strategic broadening of expertise based on the explored theory and practice.*
3. *Provide practitioners with guiding questions to address at each step.*
4. *Provide practitioners with the different actor roles involved in executing the OLS and explain their responsibilities.*
5. *Provide practitioners with a shared language to better communicate and understand the actions taken within the OLS.*

7.2.2. Roadmap design

Req #5

Req #1, #2, #3, #5

The final roadmap consists of two components: a global visual representation and step guides. The visual representation presents the steps involved in executing the OLS in a ***visual metaphor***, providing a shared language across the organisation to discuss and understand the learning strategy. It consists of ***two phases***: discovery and commitment. The ***step guides*** subsequently provide more insight to practitioners for each step, including guiding questions, guidelines and actors involved in step completion. The complete roadmap can be found in ***Appendix D***.

The metaphor

They key metaphor used in the roadmap is one of exploration, aptly suited to the strategic exploration side of knowledge management that this roadmap supports. In a way, this metaphor immediately communicates the explorative mindset required to make the OLS a success. The elements of the metaphor include:

- The ***sun:*** the vision of the organisation, the overall goal they are trying to achieve by executing the learning path.
- The ***wind:*** the dynamic nature of the landscape in the emerging field of interest. This landscape changes over time.
- The ***forest:*** the unknowns in the emerging field of interest. Little theoretical knowledge and practical tools are yet available for organisations to harness within this field. An organisation needs to rely on explorations within this landscape to formulate these for themselves. As time progresses, the forest might start clearing.
- The ***circular learning path:*** the experiential learning cycle. The path in the forest is obstructed from view, as the exact steps taken in this landscape will differ each learning cycle. Over time, well-trodden paths will take shape in the landscape – paths that are taken often throughout the learning cycles. These represent the know-what and know how that is becoming institutionalised.
- The ***canyon:*** the obstacles that are in the organisation's way in realising their vision through the learning path.
- The ***camp:*** the centre of learning within the organisation. It represents the space in which and time when knowledge workers can come together to interpret and integrate their knowledge and work towards its institutionalisation.

Phases

The visual framework is divided into two phases: discovery and commitment. Where the first phase is aimed at gaining insight into whether the broadening of expertise in question is in fact desirable and attainable, the second phase represents the actions taken to realise continuous learning. Between the first and second phase thus lies a crucial decision: is the organisation ready to commit to starting the learning path at this point in time? To answer this question, the discovery phase consists of the following steps:

1. ***Understanding the landscape*** through an initial experiential learning cycle. Within this cycle, the strategic opportunities and operational impact that the broadening of expertise to the emerging field of interest might have, are explored (i.e. the case study from this thesis).
2. ***Formulating a vision***, on a strategic, normative, and operative level. In terms of the metaphor, a sun is envisioned on the horizon and a camp is envisioned in the centre of the learning path. Amongst others, key competencies needed to realise the long-term vision of the organisation are identified based on the initial learning cycle.
3. ***Defining the obstacles*** impeding the organisation from achieving its vision, considering the organisation's current and desired state and the envisioned learning trajectory between. In other words, a change readiness assessment is conducted.

If the broadening of expertise is deemed desirable and attainable based on these steps, the organisation can progress towards the second phase in the roadmap framework. If not, conditions need to be set under which a new exploration, if any, might take place. Which obstacles would need to be removed for the organisation to reconsider this broadening of expertise?

The commitment phase of the framework is action oriented, applying experiential learning as a sustained practice to broaden organisational expertise. At this stage, the organisation has committed to the learning path and can execute the OLS according to the following steps:

4. ***Setting up camp*** through communicating the vision for change and removing the obstacles in the way of its realisation. Change management processes are applied that turn vision into reality and concrete learning outcomes are formulated based on desired competency development to guide explorations.
5. ***Continuous expeditions*** into the emerging field of interest in groups, the stepping stones of organisational change. Each learning cycle consists of three stages: 1) preparation, 2) going on expedition and 3) assessment. These stages reflect the identification of desired learning outcomes, the execution of an experiential learning cycle and the learning assessment, all of which need to be aligned constructively. Throughout these expeditions, knowledge workers might meet in camp to collaboratively reflect and conceptualise their experience.
6. ***Continuous reflection*** on the learning path and camp set-up. The result of the aggregated learning cycles and way in which these are facilitated are reflected upon and analysed periodically. Based on this reflection, the set vision and corresponding competencies and ILOs and/or the structure and systems that facilitate the learning path might be adapted. This ongoing reflection and adaption process makes the change sustainable and enables continuous learning both on a content and facilitation level.

Step guides

For each of the steps incorporated in the visual roadmap, step guides have been developed that contain key guidelines, guiding questions and involved actors (***Appendix D***). The guidelines and key questions have been distilled from chapter ***7.1. Integrating experiential and organisational learning*** and enablers of learning as discussed in chapter ***3.1. A learning approach for developing expertise*** and chapter ***3.2. A framework for organisational learning***. The ***actors*** involved in executing the design strategy have been formulated in light of the overarching ***metaphor*** and can be summarised as follows:

Req #4

Req #5

- ***Expedition leaders:*** Management responsible for the formulation of a vision and for the facilitation of its execution. Expedition leaders set the right culture of trust and motivation and create time and space for learning to take place. They are responsible for determining which learning path direction to pursue and set up desired competencies along this path.
- ***Scouts:*** The knowledge worker(s) send ahead to explore the landscape of an emerging field of interest. They are responsible for gathering information that can help formulate a vision and the obstacles that might be encountered in realising this vision.
- ***Navigators:*** Employees responsible for the practical execution of sustained learning cycles. Navigators translate competencies to concrete learning outcomes for explorers. They steer the learning path and set up different expedition teams based on their past experiences, current competencies, and the ILOs defined. Furthermore, they facilitate continuous reflection with knowledge workers to determine if the learning path and camp set-up are still right. If not, navigators instigate a meeting with expedition leaders to initiate change. In other words, the navigator serves as a type of middle management, translating between the overall vision and practical learnings of explorers.
- ***Explorers:*** The knowledge workers that partake in continuous expeditions. Explorers are part of an expedition team that picks specific learning outcomes with the navigator (preparation). Based on the chosen outcome, an appropriate experience is formulated and executed (learning cycle). The intended and unintended outcomes of this cycle are assessed with the navigator (assessment).
- ***Guides:*** Experienced explorers in a particular subject that want to share their findings with other expedition teams, either through providing short, guided expeditions (e.g. hosting a workshop) or through providing input before/during expedition cycles. The most well-rounded guides become the experts of the organisation.
- ***Campsite crew:*** Employees that provide coaching and supervision to help explorers reflect during and after their completed expeditions.

7.2.3. Roadmap evaluation

The final roadmap, as presented in ***Appendix D***, was evaluated with the two managing partners of Soda studio that are responsible for the strategic positioning of the agency. Through a semi-structured interview, the roadmap was evaluated in light of its understandability, actionability and the general appeal of the OLS it outlines. All in all, the overall structure, trajectory, and goal of the roadmap was understood well. However, at times, the roadmap felt more like an academic frame than a practical guide. It could benefit from the inclusion of specific methods and more manageable chunks of information. Aid was especially desired in more clearly envisioning the way in which continuous expeditions could be supported.

Understandability

The global structure and outlined trajectory were generally understood and deemed suitable for setting up an experiential learning path within organisations. The metaphor-based visual representation was identified as the main contributor to this understanding. When asked to explain the structure of the roadmap in their own terms, stakeholders recognised it as being "an initial exploration with minimal investments, which is subsequently scaled up in a structured manner to support the learning process of individuals or teams within a certain domain". Albeit understandable, stakeholders indicated that the addition of a general timeframe at each step in the process could help practitioners to estimate the effort involved in each better. Where step 3. Obstacle definition might take place in a single afternoon, step 5. Continuous expeditions could take months.

To further improve the understandability of the roadmap, stakeholders desired it to be easier to comprehend at a quick glance. For example, the responsibilities of the learning team and the guidelines of each step might be easier to understand if these were represented as a "do's" and "don't" list. On the other hand, some guidelines could have benefitted from more explanation or examples. The way in which the ILO, experience and assessment can be made to constructively align, for example, remained unclear until further elaboration was given verbally.

Lastly, throughout the evaluation, it became clear stakeholders expressed most interest and saw most value in the fifth step of the roadmap, continuous expeditions. It seems that the way in which all other steps are in fact in service of executing these guided explorations within organisational contexts effectively was not conveyed well enough.

Actionability

Whilst some guidelines were seen as being directly actionable and valuable, such as "Value group explorations over individual explorations" and "Formulate learning outcomes in the "I" form", many remained too theoretical in the eyes of the stakeholders. According to them, especially the fifth step of the roadmap, continuous expeditions, required more practical guidelines. Whilst stakeholders understood this step as the core of the learning strategy where actual learning takes place, they had difficulty to imagine what this learning path might look like for them in practice. For example, how can a variety of experiences be ensured? And what would a good, guided exploration look like? In other words, the roadmap currently does not provide enough practical guidance to formulate a vision for the learning path in step 2.

This perceived partial lack of actionability likely stems from the fact that the guidelines in the roadmap often focus on a "what" instead of a "how". The roadmap is, after all, meant as a tool for practitioners to shape their own organisational learning path based on the OLS. The specific "how" for each organisation might differ, whilst the overall principles and guiding questions stay the same (e.g. the need to strive for a personalisation strategy or to evaluate the learning path as a process, output, and outcome). The way in which an organisation translates such guidelines to practice, can depend on factors such as their culture and resources. However, this does not take away from the fact that practitioners that steer organisational learning might need more concrete methods or outside council to help them properly implement the roadmap.

Appeal

In general, stakeholders showed enthusiasm for the proposed OLS. They recognised its theoretical foundation and showed willingness to implement the roadmap in the future, starting with a pilot project, when their need for learning is high. They identified the use of artificial intelligence in their way of working as a current topic of interest and are in fact exploring the way in which the roadmap might inform the design and implementation of a learning path in this field.

For stakeholders, the biggest advantage of the proposed OLS is the way in which it structures learning. This makes it easier to organise, monitor and upkeep organisational learning and can help make learning processes more transparent for its employees.

The biggest risk associated with the proposed OLS is the significant number of resources that would need to be spent to formulate a vision for and execute the learning path properly. This risk might especially be high at Soda studio, as they currently do not have any explicit learning path/innovation track in place. Often, their designers learn in practice based on their client needs, relying on their current adaptive expertise to be able to complete the task at hand. The way this roadmap deviates from their current vision on learning complicates implementation for them: rather than adapting their current learning path, an entirely new one would need to be set up. To achieve this, Soda studio would need to shift their KM mindset, supplementing their currently mostly operative approach with a strategic approach and find the balance between.

7.3. Chapter round-up

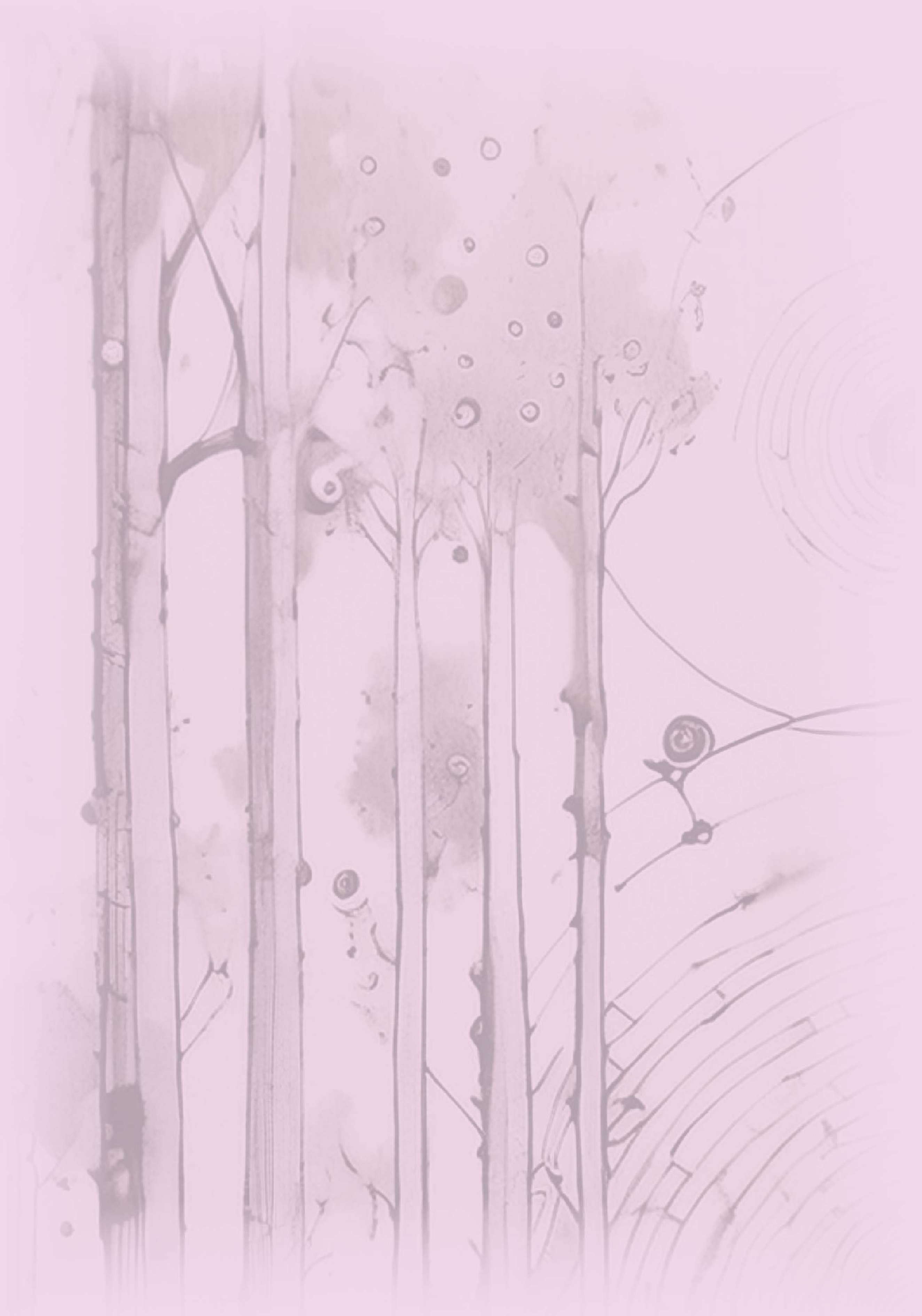
In this chapter, the theoretical and practical contributions of previous chapters have been combined to form a concrete vision on how experiential learning principles can be leveraged within organisational learning. The proposed OLS formulated within a practitioner-focused roadmap to help bring it to practice. Whilst the roadmap was validated with practitioners, only the first step in this roadmap (1. Understand the landscape) has shown its practical value in this thesis through the conducted UX for XR case study. Further practical insights are needed to validate and refine the subsequent more theoretically informed steps.

Under the right conditions, experiential learning can help to identify the practical implications and strategic considerations involved in expanding expertise, laying the foundation for subsequent continuous experiential organisational learning.

- Experiential learning naturally aligns with organisational learning across a variety of levels, such as providing a natural method for continuous learning through its cyclical nature and providing a means for knowledge workers to interpret and integrate knowledge based on joined action and reflection.
- Experiential learning can serve as an initial foundation for organisational learning by providing insight into whether the broadening of expertise is desirable and attainable in the future.
- To effectively steer experiential learning processes within organisations, desired learning outcomes need to be identified (based on desired competencies identified in the initial learning cycle) and constructively aligned with the experiences at the centre of the experiential learning cycle and their assessment. Reflection should not only take place within, but also across learning cycles on both content and facilitating factors.
- Change management processes are at the core of implementing and sustaining the new OLS.

A practical roadmap is developed as a guide for practitioners to shape and implement their own organisational learning path based on experiential learning cycles.

- The roadmap consists of two components: a global visual representation and step guides. The visual framework presents the steps involved in executing the OLS in a visual metaphor, providing a shared language across the organisation to discuss and understand it. The step guides provide more insight to practitioners each step, including guiding questions, guidelines and actors involved in step completion.
- The roadmap consists of two subsequent phases: discovery and commitment. These phases outline the steps involved to utilize experiential learning as a means to determine whether the broadening of expertise is desirable and attainable and as a subsequent continuous practice respectively.
- Initial validation of the roadmap at Soda studio shows the general appeal of the developed OLS. Although the overall structure, trajectory and goal of the roadmap are clear, practitioners are likely to need more specific methods to guide them through the design and implementation process.



Chapter 8

Discussion and conclusion

In this thesis, the groundwork has been laid to formulate how project-based companies in dynamic technological landscapes can leverage experiential learning principles as foundation for the strategic broadening of organisational expertise. This chapter concludes and reflects upon the findings of this thesis and offers recommendations on how the proposed learning strategy can be solidified further.

8.1. Discussion

Due to the fast-paced and ever quickly changing landscape of technological innovation, the competitiveness of organisations operating in this landscape relies on its ability to adapt and learn (Edmondson & Moingeon, 1998; Garvin et al., 2008). This especially holds true for project-based companies that continuously need to adapt to changing market and client needs due to the temporary nature of their projects (Koskinen & Pihlanto, 2008). In answer to the learning needs of these companies, this thesis set out to explore the way in which experiential learning can be used to strategically broaden expertise on an organisational level. To facilitate this exploration, both a theoretical and practical perspective was adopted.

Based on the explored theory in ***Chapter 2 and 3***, the way in which experiential learning can provide value in broadening organisational expertise becomes clear. For one, the creation of adaptive expertise, the kind of expertise applied in project-based companies, relies on the development of deep tacit knowledge through continuous learning and reflection (Bennet & Bennet, 2009; Carbonell et al., 2014; Herling, 2000; Persky & Robinson, 2017). This knowledge is characterised by a comprehensive level of understanding and housed in the unconscious mind, shaping intuition (Bennet & Bennet, 2008, 2009). To strategically steer its development to reach long-term organisational objectives, a continuous, intentional experiential practice is required (North & Kumta, 2018; Persky & Robinson, 2017). This thesis recognises Kolb's (2007) experiential learning cycle to offer the foundations of such a structured learning approach: based on experience, learners reflect, conceptualise and experiment. In addressing how the individually created expertise in this cycle can be transferred to an organisational level, an autopoietic epistemology is adopted (von Krogh and Roos, 1995, as cited in Koskinen & Pihlanto, 2008). This perspective views knowledge as a dynamic entity that is created and applied by individuals and cannot simply be transferred like a static object. Thus, group interactions in which knowledge is interpreted and integrated, are pivotal in extending learning beyond individuals (Crossan et al., 1999). To facilitate this process, shared experiences are key (Koskinen & Pihlanto, 2008; Leonard & Sensiper, 1998). Experiential learning may form the foundation of this process.

From a practical point of view, an experiential learning case study was completed at the project-based digital agency Soda studio, to gain insight into the implications of UX for XR on their organisation (***Chapter 4, 5 and 6***). Throughout this case study process, the practical, rather than theoretical, value of experiential learning within organisational contexts could be assessed. The project completed for this case study took place in Rijksmuseum Boerhaave and afforded the exploration of the UX for XR domain holistically. Through the experience, a total of 38 concrete reflective observations were made which were subsequently generalized and abstracted in light of Soda's organisational setting. Aside from gaining practical experience with UX for XR, the case study helped to delineate a new way of working for Soda within this new domain. Moreover, the experience enabled the formulation of the strategic considerations Soda would need to make to position themselves in this new field. A key understanding of the competencies UX designers would need to develop to expand their expertise was created, and general insight into the current landscape was formed. Based on this information, the case study sets the stage for Soda to determine whether to pursue an expertise in this field or not.

Combining both theoretical and practical insights, a concrete organisational learning strategy was formulated in ***Chapter 7***. At its core, this strategy proposes that, under the right conditions, experiential learning can help to identify the practical implications and strategic considerations involved in expanding expertise, laying the foundation for a subsequent sustained practice for continuous organisational learning. To effectively steer experiential learning processes within organisations, concrete learning outcomes need to be identified and constructively aligned with the experiences at the centre of the experiential learning cycle and their assessment (Biggs & Tang, 2011). Where a first holistic experiential learning cycle can help to define the competencies based on which these learning outcomes can be formulated, subsequent cycles can zoom in on these competencies through the intended learning outcomes to deepen understanding and develop expertise. Reflection should not only take place within, but also across learning cycles on both content and facilitating factors. The formulated OLS was presented in a practical roadmap that serves as guide for practitioners to shape and implement a learning path to broaden expertise within their own organisational context. As such, this OLS address the current lack of learning structures in the organisational learning field (Garad & Gold, 2019). It enables practitioners of project-based companies to bring experience-based organisational learning into practice in an understandable and structured manner that is founded in theory. In this way, organisations are enabled to broaden expertise strategically to navigate today's dynamic landscape.

Although an initial validation of the roadmap at Soda studio shows the potential of the proposed OLS, it became clear that setting up an experiential learning path within organisations would require significant resources to be spent. Realistically speaking, organisations might not be willing to make such an investment if the execution of the OLS based on the designed roadmap has not proven itself in practice. Currently, only the first step of this roadmap (I. Understand the landscape) is the direct result of practical experience, experience that was gained during the UX for XR case study. Whilst this learning cycle clearly proved its value for Soda studio, further practical research is needed to determine the value and completeness of the subsequent steps in the roadmap. Such research could then also be used to workshop concrete methods for each step that help organisations answer the guiding questions and adhere to the proposed guidelines. After all, the validation of the roadmap revealed that it occasionally still feels like an academic frame, lacking additional practical guidance to fully mitigate the current highly conceptual nature of organisational learning (Basten & Haamann, 2018). Moreover, the experiential learning cycle executed in this case study was completed individually. Future research should explore the way such learning cycles fit the needs of a variety of learners and assess whether the execution of group cycles indeed provides a means to interpret and integrate knowledge.

Another limitation of the proposed OLS is its focus on the internal learning path. Whilst such a path makes sense in emerging domains due to a lack of foundational theoretical knowledge from outside sources, this knowledge will be created over time. Currently, it remains unclear how the learning path should be adapted to match the development of the landscape. Whilst experiential learning will always remain key to develop expertise, having access to valuable knowledge outside the organisation is likely to cut back on the explorations needed to define new knowledge. In fact, employees might possess enough adaptive expertise to overcome the learning hurdle in their day-to-day client work.

This also begs the question: when has an organisation completed sufficient learning to be able to position themselves in the market and take on client projects? After all, the case study also showed that value can already be provided for clients throughout the learning process in new domains. The project approach, however, shows no signs yet of optimal efficiency of effectiveness. One potential direction would be to take on client projects (at a discount) when a certain level of competency has already been created, but exploration is still of the essence. In this way, the investments required in executing the OLS could be limited too. Eventually, however, there comes a time when operational KM rather than strategic KM is required to successfully apply the learned knowledge in day-to-day operations (North & Kumta, 2018). Where in small agencies, like Soda studio, the knowledge that was institutionalised during exploration might relatively naturally disseminate across the organisation through personal interactions, this becomes a different story entirely for large corporations. The changes made to the shared knowledge system during the learning path are then not readily accessible for all people. Rather than placing people and their tacit knowledge at the heart of the KM process (personalisation strategy), explicit knowledge starts to play a more important role to collect, store and disseminate information across the organisation (codification) (Greiner et al., 2007). Even if employees did not participate in the experiential learning trajectory, the explicit knowledge gained there might still need to be used by them. Whilst experience will always be required to turn employees into experts, this tension between exploration and exploitation surrounding the OLS warrants further research.

Lastly, the proposed OLS was tailored specifically towards project-based organisations where adaptive expertise is key. Experiential learning is specifically suited for such organisations, as it enables employees to use their current expertise in new scenarios to develop new insights. The proposed OLS is less suited for organisations that sell products rather than services. In this field, innovation not so much has to do with the broadening of competencies of employees in new fields, adapting the way of working, but rather requires entirely new products or product lines to be developed.

8.2. Conclusion

To address the needs of project-based organisations that seek to broaden their expertise into new domains, exemplified by Soda studio's interest in UX for XR, this thesis set out to answer the question:

"How can project-based companies in dynamic technological landscapes leverage experiential learning principles as foundation for the strategic broadening of organisational expertise?"

In answer to this question, this thesis proposes the application of Kolb's (2007) experiential learning cycle within organisational contexts. This approach is particularly valuable in dynamic technological landscapes where emerging fields lack a sound theoretical basis, necessitating experiential insights for organisations to effectively and strategically learn and adapt. Moreover, Kolb's (2007) cycle offers a structured and deliberate approach to learning that is needed to refine competencies and build expertise, enhancing organisational learning processes by naturally affording many of its enabling factors.

The findings of this thesis demonstrate that, under the right conditions, experiential learning can help uncover the practical implications and strategic considerations involved in expanding organisational expertise, laying the foundation for continuous experiential organisational learning. An initial holistic experiential learning cycle can be used to inform a long-term vision and define the competencies that can drive an organisation's future competitiveness. Subsequent cycles can then be used to achieve this vision by zooming in on these competencies, deepening understanding to strategically develop expertise in the emerging field of interest. In the case of Soda studio, initial suggestions for such competencies, along with various other strategic considerations, were proposed based on the completed UX for XR project at Rijksmuseum Boerhaave. Additionally, a UX for XR framework and workflow were developed that provide a structured overview to explore the components and design processes associated with XR technology, aptly contextualising the defined competencies. To effectively steer the sustained organisational learning process, these competencies then need to be translated to concrete ILOs and be constructively aligned with the learning experience and their assessment. Continuous reflection and adaption within and across learning cycles, on both content and facilitating factors, is key to keep the policy surrounding the knowledge creation process up to date. As such, the new experiences and knowledge gained throughout the experiential learning cycles are incorporated in the organisation's approach to learning, preventing competency or failure traps.

In formulating this vision on experiential learning within organisations, this thesis addresses the current lack of concrete and holistic learning structures in the theoretical field of organisational learning. To make the defined OLS actionable in practice, a roadmap was developed. This roadmap guides practitioners in shaping their own experiential learning path, providing concrete steps and guidelines to strategically leverage experiential learning principles. Whilst the first step of the roadmap (1. Understand the landscape) has shown its value through the completed UX for XR case study, initial validation of the roadmap revealed it still lacks the practical guidance required to fully mitigate the current highly conceptual nature of organisational learning. To validate and refine the steps the OLS proposes, further practical research is needed, preferably in a variety of organisational contexts to strengthen its validity and find its limitations. Such research is crucial for the application of the OLS in practice, as significant investments may be associated with its execution. Without a proper substantiation of its effectiveness, organisations are not likely to adopt the approach.

One promising future research direction lies in improving the actionability of the roadmap, e.g. by developing concrete methods for each step that help organisations answer the guiding questions and adhere to the proposed guidelines. Moreover, given that the experiential learning cycle executed in this case study was completed individually, future research should explore how such cycles fit the needs of various learners and assess whether the execution of group cycles indeed provide an effective means to interpret and integrate knowledge in practice. Lastly, the current research was executed in the context of a small project-based company and limited to the exploration process. Further research is needed to assess how the implementation of the learning strategy may vary within larger corporations, particularly concerning the instutitionalisation and future disseminiation of knowledge for exploitation amongst large groups.

Ultimately, although much work remains to be done, the systemic application of Kolb's (2007) experiential learning cycle shows promise to facilitate the strategic broadening of organisational expertise to drive competitiveness in dynamic technological landscapes, both from a theoretical and practical perspective.

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AI disclaimer

Throughout this thesis, the AI ***ChatGPT*** *was used to improve the quality of writing of original content provided by the author. The author critically reviewed and adapted all AI-improved content before use in this thesis. The AI* ***Adobe Firefly*** *was used to generate the visual for the front cover and chapter pages of this thesis.*

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The Strategic Broadening of Organisational Expertise through Experiential Learning

A UX for XR Case Study

Appendices

The Strategic Broadening of Organisational Expertise through Experiential Learning: A UX for XR Case Study

Appendices

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Appendix A

Case study elaborations

In this appendix, additional elaborations are provided that offer more background information on some of the process steps as outlined in the UX for XR case study, facilitating their potential future execution by Soda studio. Topics covered include Mindsets, questions to abstract an experience in terms of space, the OOUX process and the different types of UI that can play a role in XR experiences.

A1. Mindsets

Mindsets are a UX tool proposed by Lino and Bazoli (2020) that provide an alternative to personas. They are a means to converge user research into profiles that capture the range of attitudes and emotional responses people have to certain experiences. They can support the design process by highlighting a variety of people who fit within a certain Mindset (pushing people on the team to not become fixated on a single demographic that introduces bias) and by identifying their key attributes and needs. A key characteristic of Mindsets is that they are fluid rather than fixed: individuals don't forever belong to a single Mindset. The key features that make up a Mindset include:

- A memorable ***name*** that captures the essence of the Mindset.
- A concise ***description*** of the Mindset.
- Its position along a ***spectrum of key attributes***, illustrating its relation to other Mindsets in this respect.
- A short ***description*** of a variety of people that might embody this Mindset
- The specific ***relationship and support*** the Mindset requires from the product or service they engage with.
- Direct ***quotes*** from the interviewed target audience.
- Short and long-term ***projections*** of how this Mindset might evolve in the future.

Mindsets in practice

When working with Mindsets for the project at Rijksmuseum Boerhaave, the following reflections were made:

- Given Mindsets' inherent focus on attitudes and emotional responses, they are likely to be of most value for user journeys where such elements play a key role the user experience. This may range from fun museum experiences to more sensitive topics like mental health aid.
- Not all aspects of a Mindset might be of value for each and every project. In the case of Rijksmuseum Boerhaave, the short and long-term projections of how the Mindset might evolve were placed out of scope, as a museum is not something people often have a long-standing relationship with.
- Whilst the short interviews conducted at Rijksmuseum Boerhaave provided valuable insights, in-depth interviews are likely to create a more well-rounded image. One of the most informing questions to quickly uncover visitor's attitudes at the museum, was: *"When has your museum visit truly been a success?"*.

- Mindsets can only be applied when having sufficient access to a wide variety of interviewees that represent the target audience.
- Mindsets may effectively be incorporated in product vision workshops by using different coloured post-its. By keeping track of whether chosen product features align with the needs of different Mindsets, a product can be created.
- Using different coloured post-its to represent different Mindsets during a product vision workshop facilitates visually assessment of how well selected product features with diverse user needs. To do so, each product feature is assigned to a post-it, or sets of post-its, that match to the colour of the Mindset to which it caters. For example, in the project at Rijksmuseum Boerhaave, the proposed feature "conversation/reflection starters" could meet the needs of Explorers (green) by providing them with food-for-thought, Enrichment seekers (orange) by providing them with a means to share their knowledge with others, and Facilitators (blue) by supporting them in having discussions.

A2. The lens of space: Guiding questions

To abstract an experience in terms of space, Schell (2008) proposes a variety of questions. Answering these questions may help UX designers define the world of experience and the (spatial) spaces within:

- ***Is the space discrete or continuous?***

  Example: a VR museum environment where users can explore freely (continuous space) vs. a VR museum environment in which users can select specific exhibits to teleport to (discrete).

- ***How many dimensions does the space have?*** More simply put, are we designing this space in a 2D or 3D manner?

  Example: an AR feature in an app to digitally preview furniture in your own living room vs. the log-in screen in this app.

- ***Are there any spaces within spaces?*** How are nested spaces connected to one another?

  Example: an educational AR application to learn about the human body (main space), where users can zoom in on different internal body parts (nested spaces).

- ***What are the boundaries of the space?*** In other words, when do we move from space to the next?

  Example: walking through a doorway in a VR environment.

A3. The lens of the object: The OOUX process

According to Hillmann (2021) the design philosophy OOUX by Sophia V. Prater, in which core content is addressed as objects before considering procedural actions, is a valuable means to design digital products for spatial computing. During the project at Rijksmuseum Boerhaave, OOUX showed its value by aiding in the exploration of different modalities and distinguishable states of objects within the AR experience. Moreover, it facilitated consistency by providing a means to recognise and define instances of the same object. Broadly speaking, the OOUX process consists of the following steps that enable UX designers to identify the key objects for the experience they are designing:

1. ***Object extraction:*** Core content is extracted from completed research. To identify objects, nouns are highlighted. These nouns should have structure (certain attributes), instances (different examples) and a purpose. Objects can also be inferred from actions, e.g. "commenting" suggests the need for "comment" as an object.
2. ***Define relationships:*** Next, the relationship between objects is determined. How are objects related to or nested into one another? What are their dependencies?
3. ***Calls-to-action:*** Once objects and their relations a defined, calls to action for each object can be determined. What do users do with these objects? Does that differ per object?
4. ***Define attributes:*** To explicitly define an object, the components it is made of are determined (e.g. name, profile picture). Core content (text and images) can be separated from metadata (any data the user might sort and filter on).
5. ***Ranking:*** Lastly, relationships, attributes and calls-to-action can be ranked from most to least important per object. What are must haves and nice-to-haves? Which elements are most important to the user?

A4. Spatial canvasses

To map interface elements within XR experiences, UX designers might consider the use of different spatial canvasses. According to Fagerholt and Lorentzon (2009), a distinction can be made between the following:

- ***Diegetic UI:*** a highly immersive form of UI that signifies the integration of interface elements within the (fictional) world of the experience. They are a natural part of the environment.

  Example: a 3D map that users can navigate with.

- ***Non-diegetic UI:*** interface elements that are overlayed over the user's view of the (fictional) world. They are not part of the environment.
  Example: a 2D ring menu.

- ***Spatial UI:*** interface elements that are positioned within the (fictional) world but are not a natural part of it.
  Example: navigational arrows on the ground.

- ***Meta UI:*** interface elements that are not positioned within the (fictional) world but are a natural extension of the story being told.
  Example: a 2D text message pop-up from a telephone that goes off.

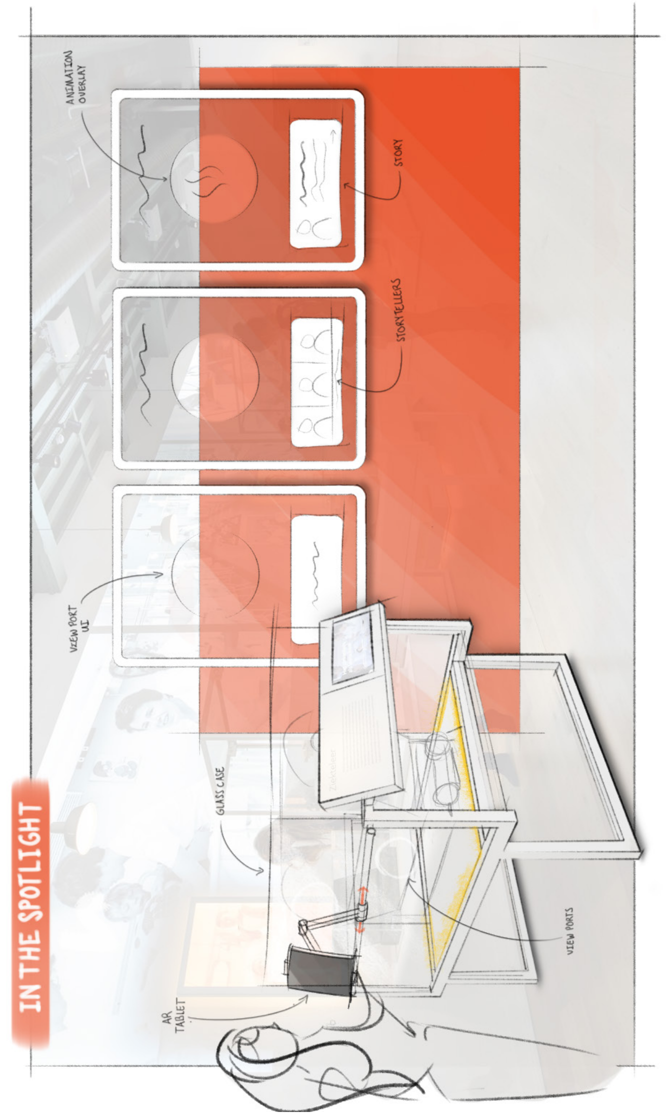
Working with these spatial canvasses in the project for Rijksmuseum Boerhaave made clear that each has their own unique affordances that can contribute to the experience. For example, where the flow of blood in the artificial kidney was visualised in the AR experience on a diegetic level, forming a natural extension of the physical artefact to bring it to life, navigational elements were deliberately placed on a non-diegetic layer to highlight their separation from the virtual environment presented by AR.

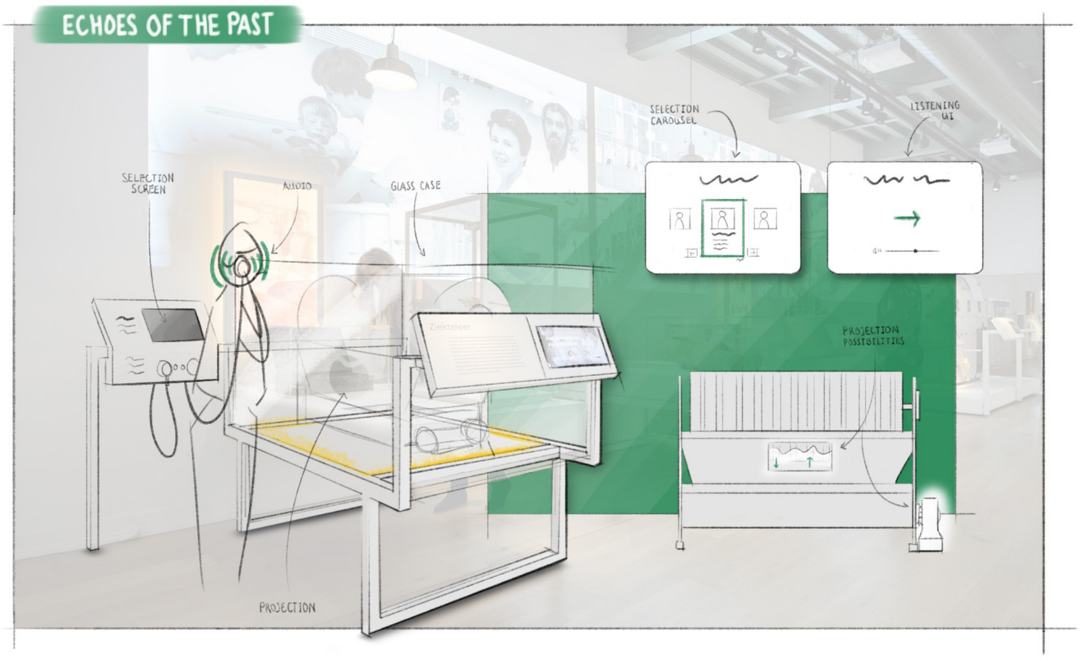
Appendix B
Exhibit design directions

In this appendix, the initial concept design directions that were presented to the stakeholders at Rijksmuseum Boerhaave are elaborated. Each was designed around a different approach to how visitors could interact with the content surrounding the artificial kidney: artefact first, people first or interest first. All sketches were drawn over the original image by Rijksmuseum Boerhaave (n.d.).

In the spotlight (artefact first)

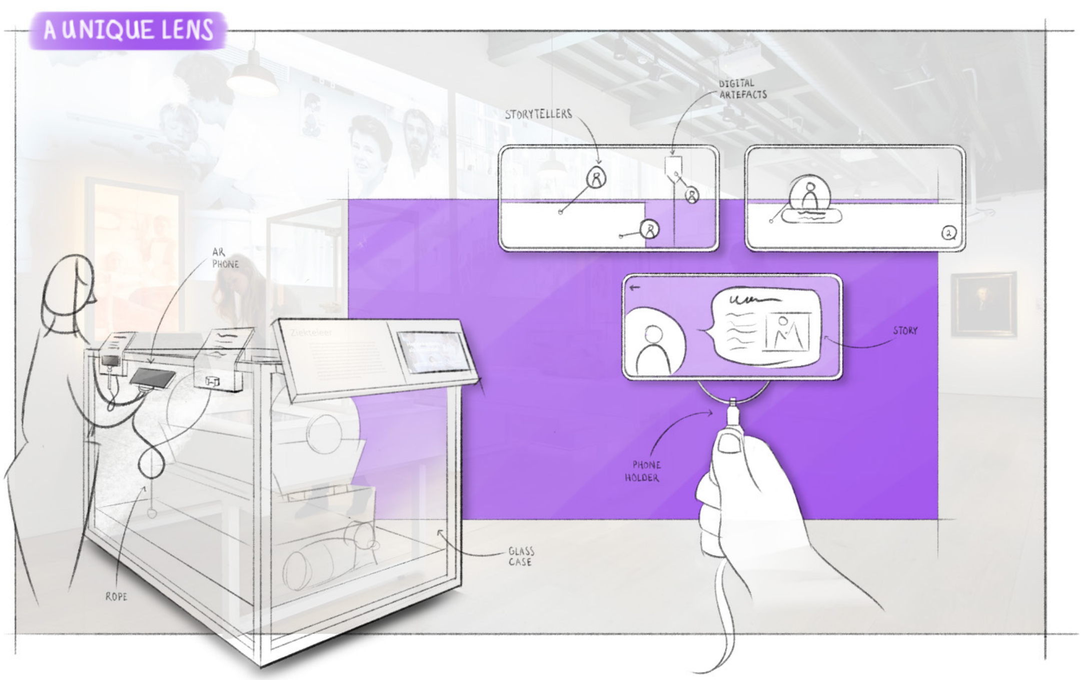
This concept was primarily focused on providing interactive visual attention for the artificial kidney. A tablet on a rail enables visitors to zoom in on specific parts of the artefact by aligning it with view ports on the glass case that protects it. For each artefact component, different contributors can share their unique story. AR is used to overlay contextual virtual information that brings this story to life.





Echoes from the past (people first)

This concept was primarily focused on providing exciting in-depth stories. A small touchscreen to the side of the exhibit enables visitors to pick one of the artificial kidney contributors to listen to their audio story. This story is complemented by a projection on the side of the artefact. The audio set-up was purposefully placed to the side, as the process of sketching in 3D made clear that any other position would visually obstruct the artefact.



A unique lens (interest first)

This concept was primarily focused on providing fresh perspectives and capitalizes on the idea that presenting different perspectives to different visitors affords social learning processes (Dunleavy & Dede, 2014). A set of mobile devices with handles each represent a topic that can be explored based on the visitors own interest, e.g. the material origins of the artefact or the challenges faced during its design. By viewing the artefact through these lenses, several contributors can be discovered and selected. They present the visitor with a short story that is related to a component of the kidney and is in line with the chosen perspective.

Appendix C
Kolff exhibit design

In this appendix, the design document detailing the key findings related to the design of the artificial kidney exhibit is presented. Information on the assignment and target audience is presented first, followed by a general description and further detailing of the exhibit design. To validate the final concept design, a user test was conducted and its set-up, limitations and results are thoroughly discussed. The document concludes with insights and recommendations based on the user test results as well as a general reflection on how well the concept design meets the set product vision and restrictions. The design document was written in Dutch at the request of the involved stakeholders.

Welkom!

Introductie

Rijksmuseum Boerhaave streeft ernaar een zo breed mogelijk publiek te interesseren en te enthousiasmeren voor de wetenschap. Hierbij staan persoonlijke verhalen centraal. In de zaal Ziekte & Gezondheid, die het ontstaan van de moderne geneeskunde omschrijft, wordt plaats gemaakt voor een van de pronkstukken van het museum: de eerste kunstnier. Maar welk verhaal zou dit artefact moeten vertellen? Op welke manier kan dit het beste? En hoe sluit deze exhibit aan bij de andere exhibits in de zaal?

Dit document omschrijft het ontwerp van een nieuw tentoonstellingsonderdeel omtrent de eerste kunstnier voor Rijksmuseum Boerhaave. Met input van Desiree Hagens, Ilse van Zeeland, Annelore Scholten, Mieneke te Hennepe en Daan van de Weijer is een nieuw ontwerp tot stand gekomen: een ontwerp wat het verhaal van de ontwikkeling en werking van de eerste kunstnier tot leven brengt. In dit document worden de de belangrijkste beslissingen in en resultaten van dit ontwerpproces besproken. Eerst wordt de achtergrondinformatie uiteengezet, gevolgd door een globale omschrijving en detaillering van het ontwerp. Dit ontwerp is nadien geverifieerd middels een gebruikstest. Het document sluit af met inzichten en adviezen op basis van de testresultaten en een algemene reflectie.

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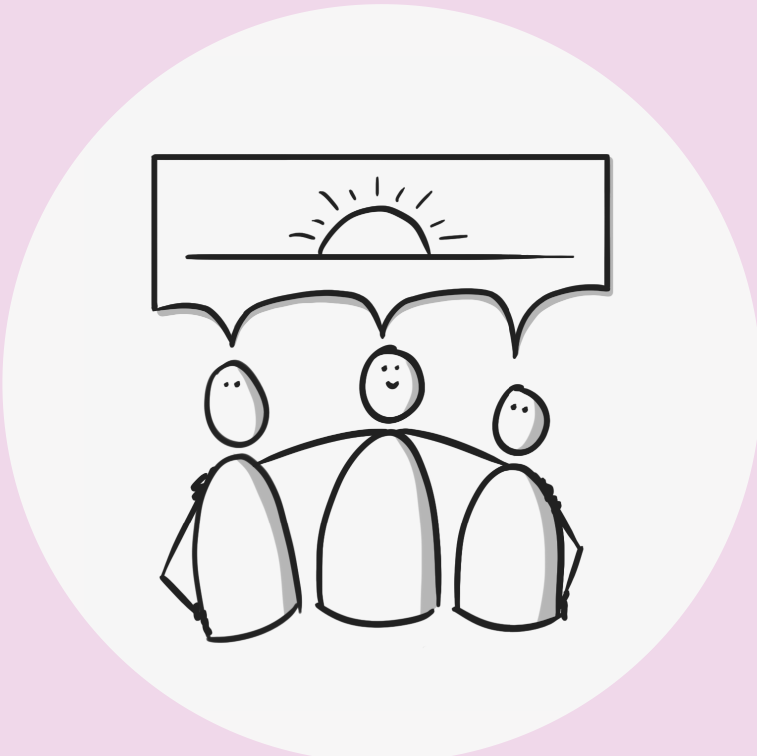
“Een succesvolle tentoonstelling laat een bezoeker gezien en gehoord voelen.”



Hoofdstuk 1

De achtergrond

Een effectieve exhibit is afgesteld op de behoeftes van de doelgroep en die van het museum zelf. Om meer inzicht te krijgen in deze behoeftes, zijn er interviews afgenomen met zowel bezoekers als medewerkers. Op basis van deze informatie is gezamenlijk een visie gevormd voor de exhibit van de kunstnier. Welk verhaal moet de exhibit vertellen? Welke elementen staan daarbij centraal? En welke limitaties spelen hierin een rol?

Bezoekersanalyse

Een goede museumervaring is toegankelijk voor en afgesteld op de behoeftes van de doelgroep. Om meer inzicht te verkrijgen in het soort bezoekers van Rijksmuseum Boerhaave, zijn er gedurende twee dagen 20 korte interviews afgenomen. In totaal is er gesproken met 28 personen. Het doel van deze interviews was om de mindset te achterhalen waarmee deze personen het museum bezoeken. In andere woorden: wat zijn de houdingen, gedragingen en reacties die verschillende mensen hebben in hun museumbezoek? Door het begrijpen van deze mindsets kunnen toekoemstige tentoonstellingen beter worden toegespitst op de behoeften van bezoekers. Zo ook voor het exhibit rondom de eerste kunstnier.

Aan de hand van de interviewresultaten en bestaande theorie over bezoekersgedragingen binnen musea (Falk, 2006; Sookhanaphibarn & Thawonmas, 2009), zijn er in totaal vier verschillende mindsets opgesteld (met nadruk op de zaal Ziekte & Gezondheid): de verrijking-zoeker, de ontdekker, de begeleider en de vermaak-zoeker. Hierbij is het belangrijk om te benadrukken dat een enkel persoon niet is gebonden aan een enkele mindset. Op basis van huidige omstandigheden (bijvoorbeeld het onderwerp van de zaal waarin men zich bevindt, het vermoeidheidsniveau, of de groepsdynamiek) kan een mindset veranderen.

Voor elke mindset is het volgende gedefinieerd:

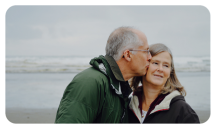
- Een korte samenvatting;
- Voorbeelden van personen die binnen deze mindset zouden kunnen vallen (gebaseerd op de interviewresultaten);
- Op een spectrum geplaatste eigenschappen die deze mindset vertoont en onderscheidt van andere mindsets;
- De relatie die het museum heeft met deze mindset. In andere woorden: welke rol speelt het museum voor een bezoeker van deze mindset?;
- Korte tips voor tentoonstellingen die houvast bieden om aan de behoeften van deze mindset te voldoen.

“Ik volg de interesses van mijn kinderen”

Verrijking-zoeker

Bewonderen en delen

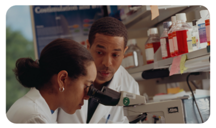
Frequente museumbezoekers, veelal met een wetenschappelijke achtergrond of expertise. Verrijking-zoekers zijn op zoek naar nieuwe perspectieven op objecten/onderwerpen die ze herkennen en richten zich op het grotere verhaal. Ze delen graag hun kennis en herinneringen met anderen in hun groep en kunnen wetenschapscommunicatie waarderen. Ze zijn volwassen, kalm en ontvankelijk en brengen gemiddeld 2-3 uur door in het museum.



Hugh & Petra, 65

Hugh and Petra zijn net met pensioen gegaan. Ze hebben jaren in het ziekenhuis gewerkt. Het stel was op vakantie in de buurt en besloot spontaan het museum te bezoeken. Ze houden ervan om herinneringen op te halen en hun verwondering met elkaar te delen.

Dit chirurgische mes uit circa 1700 lijkt heel erg op wat ik zelf in het ziekenhuis gebruikte!



Lucas & Annie, 30

Twee vrienden die net zijn gepromoveerd in de natuurkunde en microbiologie. Ze bezoeken het museum specifiek voor één tentoonstelling en waardeerden de wetenschapscommunicatie ervan enorm. Ze vinden het leuk om te vanuit hun eigen expertise kennis te delen op basis van wat ze zien in het museum.

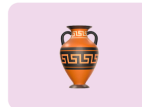
Het is zo mooi om te zien hoe al deze kennis toegankelijk wordt gemaakt voor het grote publiek. De ode aan de wetenschap maakt mij trots om wetenschapper te zijn.

Tom, 47

Tom is wiskundeleraar en is aan het kijken of hij met school het museum wil bezoeken. Hij heeft een algemene belangstelling voor de wetenschap en verwondert zich graag over de geschiedenis ervan. Zijn technische achtergrond zorgt ervoor dat sommige artefacten nog meer tot leven komen.

Het is zo gek om je te bedenken dat de dingen die we tegenwoordig normaal vinden, nog niet zo lang geleden baanbrekende uitvindingen waren.

Tentoonstelling tips



Artefacten en beelden

Zorg voor artefacten en afbeeldingen die herkenning en herinneringen teweegbrengen.

Een nieuwe kijk

Omring artefacten met interessante en verrassende historische feiten of indrukwekkende persoonlijke verhalen.

Een duidelijk verhaal

Geef het grotere geheel weer met een duidelijk verhaal (en route). Creëer onmiddellijke begrijpelijkheid.

Slimme wetenschaps-communicatie

Gebruik verschillende soorten media om inhoud op een creatieve manier aan het 'grote' publiek weer te geven in simpele termen.

Eigenschappen

Interesseniveau

Oppervlakkig | Algemeen | Gedetailleerd

Strategie

Impulsief | Selectief | Methodisch

Keuzevrijheid

Eigen | Gedeeld | Gedirigeerd

Relatie// Muze (Nostalgisch)

Het museum is een (nostalgische) muze. Het biedt mogelijkheden voor verrijking-zoekers om herinneringen op te halen en te delen. Het bevordert een nieuwe kijk op herkenbare onderwerpen en zorgt zo voor verwondering.

Ontdekker

Ontdekken, leren en reflecteren

Frequente museumbezoekers, vaak met een algemene interesse in de wetenschap. Ontdekkers willen alles ervaren wat het museum te bieden heeft en alle mogelijke kennis opdoen. Ze zijn nieuwsgierig, leergierig en reflecterend. Ontdekkers willen op hun eigen tempo onderzoeken en waarderen structuur. Ze zijn cognitief actief en kunnen een hele dag in het museum verblijven.

Gabriella, 45
Gabriella heeft interesse in de wetenschap en gezondheidszorg. Ze probeert de inhoud van een tentoonstelling altijd grondig te begrijpen en legt graag verbanden tussen tentoonstellingen. Haar voorkennis komt hierbij goed van pas.

Mijn museumdag is een succes als ik iets nieuws heb geleerd. Een museum is niet de plek om met vrienden af te spreken. Daar heb je een café voor.

Anaya & Anouk, 25
Anaya en Anouk vinden echt alles in het museum interessant. Voor hen is leren leuk. Tijdens het bezoek dagen ze elkaar uit door hun kennis van en reflecties op de tentoonstellingsinhoud te delen.

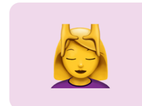
Wij willen graag terugkomen naar het museum om er zeker van te zijn dat we niets gemist hebben en echt nieuwe kennis hebben opgedaan.

Frank, 56
Frank is op bezoek met zijn dochter (19). Zij wil geneeskunde gaan studeren. Beiden volgen hun eigen pad in het museum. Hoewel Frank een beroep heeft in de medische wereld, wil hij nieuwe kennis tot in detail in zich opnemen en tot nadenken worden gezet.

Wij zijn op eigen gelegenheid op onderzoek uit. Onze gedachten delen over de tentoonstelling? Dat doen we in de auto op weg naar huis.

Tentoonstelling tips

Stof tot nadenken
Zorg voor verrassende inhoud die persoonlijke reflectie en intellectuele discussies stimuleert.



Minimale prikkels
Beperk de prikkels in een ruimte tot een minimum. De inhoud van een tentoonstelling mag niet afleiden van de leerervaring.

Een duidelijke route
Zorg voor een duidelijke route die ontdekkers structuur geeft en het idee dat ze niets missen.

Afwisselde wetenschaps-communicatie
Zorg afwisselende media om te verkennen. Zo worden ontdekkers minder snel moe.

Eigenschappen

Interesseniveau

Oppervlakkig — Algemeen — **Gedetailleerd**

Strategie

Impulsief — Selectief — **Methodisch**

Keuzevrijheid

Eigen — Gedeeld — Gedirigeerd

Relationship// Intellectuele gids

Het museum is een intellectuele gids. Het ondersteunt de ontdekker op zijn ontdekkingsreis en stelt hem in staat dieper na te denken en zinvolle vragen te stellen.

Begeleider

Rondleiden & ondersteunen

Bezoekers die het museum niet voor zichzelf bezoeken, maar meegaan voor anderen. Begeleiders laten zich primair leiden door de behoeften van anderen en ervaren de museuminhoud slechts oppervlakkig. Hun belangrijkste doel is om anderen een leuke tijd te bezorgen door hen actief te begeleiden (aanwijzen van informatie) of te ondersteunen (op de achtergrond blijven om vragen te beantwoorden). Ze zijn informatief en onzelfzuchtig.

Karel, 27
Karel bezoekt het museum met zijn zusje Luna (6). Hij heeft een hele dag gepland. Hij doet zijn best om zijn zusje op interessante feiten te wijzen en helpt haar de interactieve media te bedienen.

Luna, wist je dat artsen bij het uitvoeren van operaties meestal twee van deze tangen tegelijkertijd gebruiken?

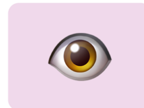
Gabriella, 45
Gabriella bezoekt het museum met haar twee kinderen (12 en 14). Ze laat hen de museumervaring dicteren. Omdat zij bekend is met de getoonde onderwerpen, kan zij hun vragen beantwoorden.

Als ik de interesses van mijn kinderen volg, steken ze meer op. Ze bepalen zelf waar ze geïnteresseerd in zijn en wat ze willen ontdekken.

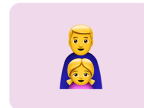
Lucinda, 70
Lucinda bezoekt het museum met een groep van twee Amerikaanse vrienden die op bezoek zijn. Zij is verantwoordelijk voor de organisatie van de dag en zorgt ervoor dat alles soepel verloopt.

Ze hebben het zo naar hun zin. We zijn iets te lang in de eerste tentoonstellingsruimte gebleven, dus we moeten nu echt opschieten!

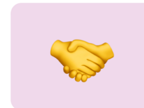
Tentoonstelling tips



Duidelijk overzicht
Ondersteun de begeleider bij het vinden van interessante onderwerpen en zorg voor een duidelijk overzicht over de tentoon-stellingsruimte.



Samen beleven
Bied interactieve inhoud aan die samen kan worden ervaren. Zo wordt ook de begeleider actief betrokken in het museum-bezoek.



Een helpende hand
Ondersteun de begeleider bij het voeren van discussies of het beantwoorden van vragen. Dit zorgt ervoor dat ze hun rol goed kunnen vervullen.

Veel lezen? Nee bedankt.
Begeleiders hebben weinig tijd om nieuwe kennis in zich op te nemen. Bied hapklare feitjes aan om hun museumervaring te ondersteunen.

Eigenschappen

Interesseniveau

Oppervlakkig — Algemeen — Gedetailleerd

Strategie

Impulsief — Selectief — Methodisch

Keuzevrijheid

Eigen — Gedeeld — Gedirigeerd

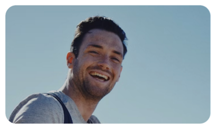
Relatie// Bondgenoot

Het museum is een bondgenoot. Het staat de begeleider bij in zijn begeleidende en ondersteunende rol. Samen met het museum kan de begeleider een onvergetelijke en leerzame ervaring creëren.

Vermaak-zoeker

Verbinden & plezier

Ongedwongen bezoekers wiens primaire motivatie een leuk dagje uit is. Ze bezoeken het museum niet om inhoudelijk iets te leren, maar om verbinding te maken met anderen en/of plezier te hebben. Ze zijn actief, sociaal, experimenteel en hebben over het algemeen een lage aandachtsspanne. Ze zijn op zoek naar spanning en hebben de neiging om te kiezen voor extremen: dingen die óf heel herkenbaar zijn, óf echt absurd. Gemiddeld besteden ze 2-3 uur in het museum.

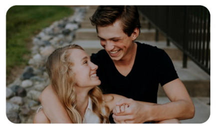


Robert, 32
Robert bezoekt het museum met zijn vrouw, een meer methodische ontdekker. Robert houdt van de stimulerende interactieve ervaringen in het museum en probeert zijn vrouw ervan te overtuigen om deze samen te verkennen.

Hoe vreemder hoe beter! De installatie met de projectie op de arm was geweldig. Ik kon het mes bijna voelen.

Marjan & Rosanne, 55
Marjan en Rosanne zijn oude vriendinnen. Ze hebben elkaar ruim een jaar niet meer gezien. Ze zijn daarom vooral bezig met bijkletsen. Vreemde of spannende tentoonstellingen trekken wel hun aandacht. Dan hebben ze het daar even over.

Marjan, kom eens kijken! Blijkbaar zitten er echte menselijke resten in deze pop?!

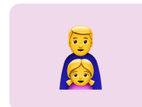


Thomas & Irene, 18
Thomans en Irene zijn voor hun date naar het museum gekomen. Ze hebben vooral oog voor elkaar en willen niet te lang in één zaal blijven hangen. Het samen ervaren en bespreken van de tentoonstellingen brengt hen dichter bij elkaar.

We vinden het erg leuk om samen de games in het museum te spelen.

Tentoonstelling tips

Prikkel met extremen
Trek de aandacht van vermaak-zoekers met extremen: iets heel herkenbaars of echt absurds.



Samen beleven
Bied interactieve inhoud aan die samen kan worden ervaren. Zo kunnen vermaak-zoekers verbinden met elkaar.

Multimedia is koning
Vermaak-zoekers willen geprikkeld worden. Ze zijn minder geïnteresseerd in traditionele media. Plaats artefacten in de juiste context om deze interessant te maken.

Veel lezen? Nee bedankt.
Vermaak-zoekers hebben een lage aandachtsspanne. Maak tekstuele informatie kort en krachtig.

Eigenschappen

Interesseniveau

Oppervlakkig | Algemeen | Gedetailleerd

Strategie

Impulsief | Selectief | Methodisch

Keuzevrijheid

Eigen | Gedeeld | Gedirigeerd

Relatie// Partner in crime

Het museum is een partner in crime. Het richt zich op het creëren van gedenkwaardige ervaringen voor vermaak-zoekers. Momenten van plezier en verbinding kunnen worden gecreëerd door middel van zeer herkenbare of absurde (interactieve) content.

Hoodstuk 1

Visie en voorwaarden

Een effectieve exhibit vindt niet alleen aansluiting bij de doelgroep, maar ook bij het museum zelf. Een exhibit is immers deel van het grotere verhaal wat het museum vertelt. Om beter inzicht te krijgen in de probleemstelling en wensen omtrent de kunstnier exhibit, zijn er er diepte-interviews afgenomen met Ilse, Desiree, Annelore en Mieneke. De resultaten hiervan, in combinatie met die van de bezoekersanalyse, vormden de basis van een product vision workshop (rechts afgebeeld). Het doel? Het creëren van een gezamenlijke visie voor de exhibit die past bij de behoeften van de doelgroep en de wensen van het museum. Er is gekozen om de exhibit te ontwerpen met oog op voornamelijk de verrijking-zoekers en ontdekkers. De gevormde visie heeft gedurende het ontwerpproces als rode draad gefunctioneerd en luidt:

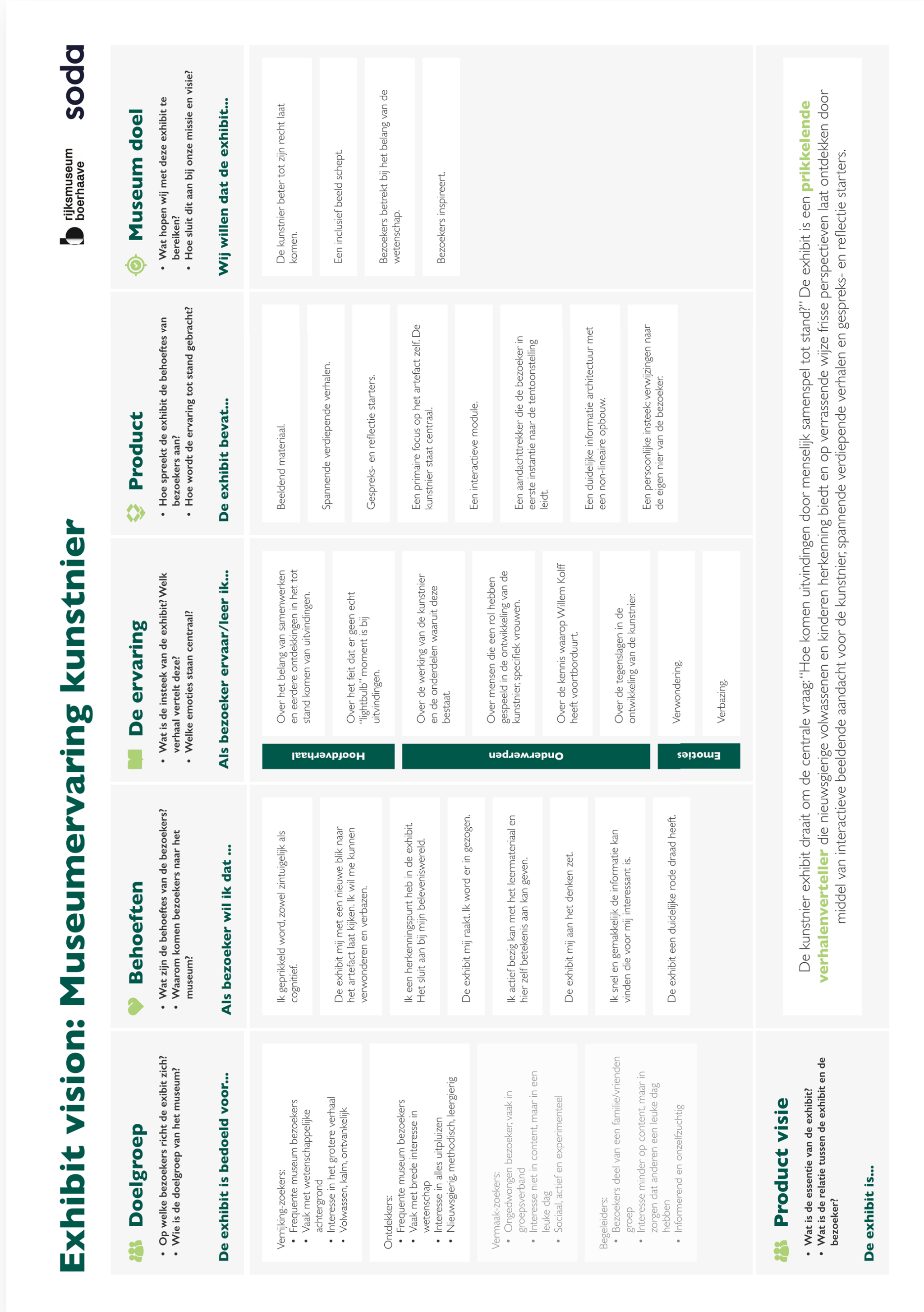
> De kunstnier exhibit draait om de centrale vraag: "Hoe komen uitvindingen door menselijk samenspel tot stand?" De exhibit is een **prikkelende verhalenverteller** die nieuwsgierige volwassenen en kinderen herkenning biedt en op verrassende wijze frisse perspectieven laat ontdekken door middel van interactieve beeldende aandacht voor de kunstnier, spannende verdiepende verhalen en gespreks- en reflectie starters.

De potentie van XR in musea

In de gekozen product visie staat "interactieve beeldende aandacht voor de kunstnier" centraal, met doel om bezoekers te betrekken bij de ervaring en om de kunstnier tot leven te laten komen. Het gebruik van Extended Reality (XR), een verzamelnaam voor een aantal immersieve technologieën, is daarom aangewezen als geschikt uitgangspunt voor de exhibit. Bekende technologieën die vallen onder XR zijn Virtual Reality (VR) en Augmented Reality (AR). Waar gebruikers in VR compleet worden ondergedompeld in een virtuele wereld, vult AR de werkelijkheid enkel aan (Milgram & Kishino, 1994). Het toevoegen van virtuele informatie aan de werkelijk dient om de waarneming van en interactie met de werkelijkheid te verbeteren (Bekele et al., 2018).

Uit meerdere literatuuronderzoeken blijkt dat het gebruik van XR in (museum)onderwijs een positief effect kan hebben op de leerervaring (Akçayır & Akçayır, 2017; Goff et al., 2018; Zhou et al., 2022). Het gebruikt van XR ondersteunt het leerproces door het bieden van verrijkende en meeslepende leeromgevingen (Zhou et al., 2022). Deze omgevingen bieden voornamelijk kansen binnen het (museum)onderwijs door (1) het bieden van interactiemogelijkheden met de leerstof en (2) het in context plaatsen van informatie (Zhou et al., 2022). Effectief leren is namelijk actief en is gesitueerd (Pritchard, 2017). Interactieve installaties bieden bezoekers de mogelijkheid actieve "consumenten" van de leerstof te zijn, in plaats van passieve "ontvangers" (Spadoni et al., 2022). Diepgaande en betekenisvolle ervaringen kunnen worden gecreëerd door

18



bezoekers een vorm van controle te geven (Geroimenko, 2021). Naast interactiviteit, is een betekenisvolle context die aansluit bij de beleveniswereld van de leerling van belang (Pritchard, 2017). Bij het gebruik van XR in musea is met name een vorm van gesitueerd leren die trouw blijft aan de authenticiteit van een artefact populair (Zhou et al., 2022). Door het toevoegen van een digitale informatie-laag over het artefact via AR, wordt het onzichtbare zichtbaar gemaakt (bijvoorbeeld een scheikundig principe). Zo wordt een betekenisvolle context gecreëerd en komt het artefact echt tot leven. Naast interactiviteit en context, spelen ook sociale aspecten een belangrijke rol in het leerproces (Pritchard, 2017). Hoewel XR hier inherent minder aan voldoet, kunnen exhibits wel dusdanig worden vormgegeven dat er ruimte is voor sociale interacties. Een eerder uitgevoerd veldwerk in de zaal "Ziekte & Gezondheid" toont de potentie hiervan al aan: digitale media in deze tentoonstellingsruimte worden vaker samen ervaren dan individueel (Hogeschool van Amsterdam, 2018).

Ondanks dat XR in (museum)onderwijs vele voordelen biedt, draait Rijksmuseum Boerhaave om meer dan enkel "leren". De missie van het museum is om een zo breed mogelijk publiek te inspireren en enthousiasmeren voor de wetenschap. Diverse onderzoeken wijzen uit dat ook hier het gebruik van XR een positieve bijdrage kan leveren: percepties zoals plezier, betrokkenheid, motivatie en interesse kunnen door het gebruik van deze technologie worden versterkt (Akçayır & Akçayır, 2017; Dunleavy & Dede, 2014; Goff et al., 2018; Zhou et al., 2022).

Restricties

Waar de visie de wens vastlegt voor de exhibit, moet aan deze visie binnen bepaalde randvoorwaarden worden voldaan. Vanuit de afgenomen diepte-interviews met medewerkers zijn een aantal belangrijke restricties naar voren gekomen, rekening houdende met de insteek om gebruik te maken van XR technologie in de exhibit. Tabel 1 geeft deze beperkingen weer.

Tabel 1: Restricties aan het ontwerp

Systeem restricties Restricties aan de interactie, technologie en uiterlijke onderdelen van de exhibit.	
1: Integratie in de operationele ruimte	
1.	De exhibit zal voorkomen dat bezoekers de kunstnier aan kunnen aanraken.
2.	De exhibit zal geen gebruik maken van directe, harde belichting op (het lichtgevoelige cellofaan van) de kunstnier.
3.	De exhibit zal de kunstnier toegankelijk houden voor (routine) onderhoudswerkzaamheden.
4.	De exhibit zal een stand-alone ervaring bieden. Bezoekers zullen niet actief te hoeven worden begeleid door personeel om de ervaring te doorlopen.
5.	De exhibit zal de mogelijkheid bieden voor een groep (max. 15 personen) om het artefact te bekijken tijdens museumrondleidingen.
2: Integratie in de fysieke ruimte	
6.	De exhibit zal passen in de sfeer van de zaal en opgaan in het lichte, frisse en ruimtelijk ontwerp hiervan.
7.	De exhibit zal spelen met de metafoor van een ziekenhuiszaal die in de grotere zaal wordt weerspiegeld.
8.	De exhibit zal een digimagazine bevatten die voldoet aan de ontwerprichtlijnen die gelden voor alle digimagazines in de zaal.
9.	De exhibit zal een grondoppervlak van maximaal 2200 mm x 1550 mm beslaan.
10.	De exhibit zal staand worden gebruikt door bezoekers, maar wel toegankelijk blijven voor rolstoelgebruikers
11.	De exhibit zal geen gebruik maken van audio die bezoekers van andere exhibits in de zaal stoort.
12.	De exhibit zal bestand zijn tegen onvoorzichtigheid en ruw gebruik van bezoekers.
3: Integratie in de educatieve ruimte	
13.	De exhibit zal gebruik maken van technologie die in dienst staat van de leerervaring. De focus van de bezoeker ligt op de leerinhoud, niet op de technologie zelf.
14.	De exhibit zal gebruik maken van technologie die in dienst staat van het artefact. De focus van de bezoeker ligt op het artefact, niet op de technologie zelf.

15.	De exhibit zal geen geïsoleerde leerervaringen promoten en biedt bezoekers de mogelijkheid om de exhibit samen te ervaren (met minimaal 2 personen).
16.	De exhibit zal geen gebruik maken van persoonlijke mobiele apparaten die de museumervaring verstoren.
17.	De exhibit zal comfortabel en intuïtief gebruikt kunnen worden door bezoekers. Benodigde cognitieve inspanningen zullen waarde toevoegen aan de (leer)ervaring.
Inhoudelijke restricties Restricties aan de inhoudelijke onderdelen van de exhibit.	
1: Integratie in de fysieke ruimte	
18.	De inhoud van de exhibit zal, gemiddeld gezien, binnen twee minuten door bezoekers kunnen worden opgenomen. Aanvullende inhoud zou mogelijk aan ontdekkers kunnen worden verstrekt.
2: Integratie in de educatieve ruimte	
19.	De inhoud van de exhibit zal geschreven zijn op het niveau van een 12- tot 15-jarige.
20.	De inhoud van de exhibit zal in het Nederlands en Engels worden verstrekt.

Hoofdstuk 2

Het ontwerp

Na het vormen van de exhibit visie en de daarbij behorende randvoorwaarden, zijn deze vertaald naar een concreet voorstel. In de ontworpen exhibit worden bezoekers meegenomen naar 1945. Daar zijn ze deel van een historische gebeurtenis en maken ze kennis met het team achter, en de werking van, de kunstnier via augmented reality (AR). In dit hoofdstuk wordt het volledige ontwerp behandeld: van de inhoudelijke tot ruimtelijke en digitale aspecten. Hoe wordt het verhaal omtrent de kunstnier tot leven gebracht?

Inhoudelijk concept

Op basis van de exhibit visie is er, met inspraak van Ilse en Mieneke, een inhoudelijk concept geformuleerd. Dit concept heeft als leidraad gefunctioneerd om het ontwerp van de exhibit te sturen. Het heeft hierin een belangrijke rol vervuld in het scherpstellen van het verhaal en de rol van XR-technologie hierin. In dit proces is er kritisch gekeken welke informatievoorziening op basis van het concept kon plaatsvinden en of dit aansloot bij de informatie die de conservator, Mieneke, wilde overbrengen. Op deze manier is de relatief algemene exhibit visie omgezet naar een duidelijke concept richting die in dienst staat van de inhoud. De uiteindelijke vorm van de exhibit is enkel een middel om dit doel te bereiken.

Inhoudelijk concept: Een letterlijke rode draad
Het bloed vormt de letterlijke rode draad van de ervaring: het verhaal van de exhibit ontvouwt zich terwijl bezoekers het bloed van links naar rechts door de kunstnier volgen. Tijdens het verkennen van de werking van de kunstnier, maakt de bezoeker kennis met het team erachter. Zo wordt er antwoord gegeven op de vraag "Hoe komen uitvindingen door menselijk samenspel tot stand?" en komt de kunstnier tot leven.

Exhibit-structuur

De globale opzet van de exhibit is hieronder omschreven aan de hand van de onderdelen die een rol spelen in de gebruikerservaring.

Exhibit titel	Samenspel
Content	Belangrijke innovaties, zoals de eerste kunstnier, komen tot stand door meer mensen dan enkel "de" uitvinder.
Centrale boodschap	Een heel team was betrokken bij het mogelijk maken van de eerste succesvolle hemodialyse met de eerste kunstnier in Stadsziekenhuis Kampen. De kunstnier spoelt het bloed schoon.

Leeftijd	**Aantal gebruikers**	**Tijdsduur**	**Soort interactie**	**Hoofd interactie**
8+	1-4	2 min	Hands-on	Bewegen AR scherm

Een verhaal in AR

Om de gewenste boodschap over te brengen, neemt de ontworpen exhibit de bezoeker mee op reis naar 1945. Hier wordt de bezoeker deel gemaakt van een historische gebeurtenis: de dialyse van Sofia Schafstadt (patiënt nummer 17), wat de eerste succesvolle menselijke hemodialyse in de medische geschiedenis markeerde. Bovendien draagt verhaal bij aan het scheppen van een inclusiever beeld in het museum: een vrouw staat centraal. Het is haar bloed wat de rode draad van het verhaal vormt.

Om dit verhaal te kunnen vertellen, is de kunstnier in een vitrine op een plateau geplaatst met aan de lange zijde een scherm met AR functionaliteit (zie pagina 30). Via dit scherm kunnen bezoekers het bloed van Sofia door vier verschillende stappen/segmenten volgen. Digitale artefacten, animaties en geluidseffecten brengen de kunstnier tot leven. Via een overkoepelend audioverhaal vertellen Willem Kolff (uitvinder) en Maria ter Welle (hoofdzuster in Stadsziekenhuis Kampen waar de kunstnier is ontwikkeld) de bezoeker over het functioneren van de kunstnier en hun team. Een gevoel van samenwerking wordt gewekt in het verhaal door verwijzingen naar andere teamleden en hun bijdragen te maken. Om bezoekers te betrekken in het verhaal, eindigt elk audio segment met een kleine cliffhanger die inspeelt op hun nieuwsgierigheid. Aan het eind van het AR-verhaal wordt de bezoeker gestimuleerd het scherm weer terug naar het begin te verplaatsen door middel van het ontdekken van gespreks- en reflectiestarters.

Technische vereisten

- Motion sensor
  Detecteert wanneer de bezoeker in het actieve gebied is.
- Lokale audio
  Bezoekers houden zo hun handen vrij om het scherm te kunnen bewegen, terwijl de ervaring van andere exhibits in de zaal niet wordt gestoord.
- Live video feed (of opname van de kunstnier om kosten te besparen)
  Deze onderliggende laag wordt gebruikt om informatie overheen te leggen in het AR-verhaal.
- Positioneringssysteem
  Het systeem moet weten in welke positie het scherm zich bevindt en waar het artefact zich bevindt ten opzichte van het scherm.
- Schuifmechanisme
  Een mechanisme waarmee het AR scherm zonder te veel kracht kan worden bewogen langs de kunstnier.

Audiovisuele elementen
Schermen

- Standby scherm
- Startscherm
- AR scherm
- Instructie scherm (om te beginnen/om verder te gaan)
- Stof tot nadenken (met gespreks- en reflectiestarters)

Audio

- 3x stemacteur (NL/EN) voor: Willem Kolff, Maria ter Welle en Willy Eskens
- Geluidseffecten
  - I. Algemeen omgevingsgeluid ziekenhuis
  - II. Draaiende kunstnier
  - III. Voetstappen

Animaties

- 3D onderdelen
  - I. Rubberen slang; *Geplaatst over draaikoppeling*
  - II. Trommel; *Horizontaal draaiend*
  - III. Cellofaan buis; *Horizontaal draaiend met trommel*
  - IV. Bloed; *Vloeit door cellofaanbuis, wordt schoner*
  - V. Spoelvloeistof; *Golvend in spoelbak*
- Dialyse animatie
  - I. X-Ray; *Doorkijkje spoelbak*
  - II. Ureum; *Bewegend van bloed naar spoelvloeistof*
  - III. Mineralen en glucose; *Bewegend van spoelvloeistof naar bloed*
- Tijdsprong (van dag naar nacht naar dag)

Interactie mogelijkheden

- Start AR-verhaal
- Verander taal (NL/EN)
- Ondertiteling (aan/uit)
- Kies segment via bewegen AR scherm

Digimagazine & overige onderdelen

Naast het AR-scherm dat centraal staat in de exhibit, is het digimagazine een bron van interactie. Dit magazine volgt het stramien dat is vastgesteld in de rest van de zaal. Hoewel de inhoud van dit magazine niet volledig is uitgewerkt, zouden de volgende verhalen een rol kunnen spelen:

- ***Voorbij de uitvinder – Rollen in innovatie (introductieverhaal)***
  Veel mensen komen te pas aan het doen van innovaties: schoonmakers, scheikundigen, werktuigbouwkundigen, etc. In de ontwikkeling van de kunstnier, hebben vrouwen specifiek een belangrijke rol gespeeld. Kolff nodigden hen uit op zijn proefschriftdiner.
- ***Niet zo makkelijk als het lijkt – Materialen in de oorlog (object verdieping)***
  De kunstnier is gebouwd in tijden van oorlog en maakt gebruik van bijvoorbeeld het cellofaan van een worstenvel en aluminium van een Duitse bommenwerper. Een duidelijke link kan gemaakt worden naar de menselijke hulp in het vervaardigen van deze materialen.
- ***Een patiënt van nu vertelt - Leven met en door dialyse (persoonlijk verhaal)***
  Een patiënt van nu vertelt over het leven met en door dialyse.

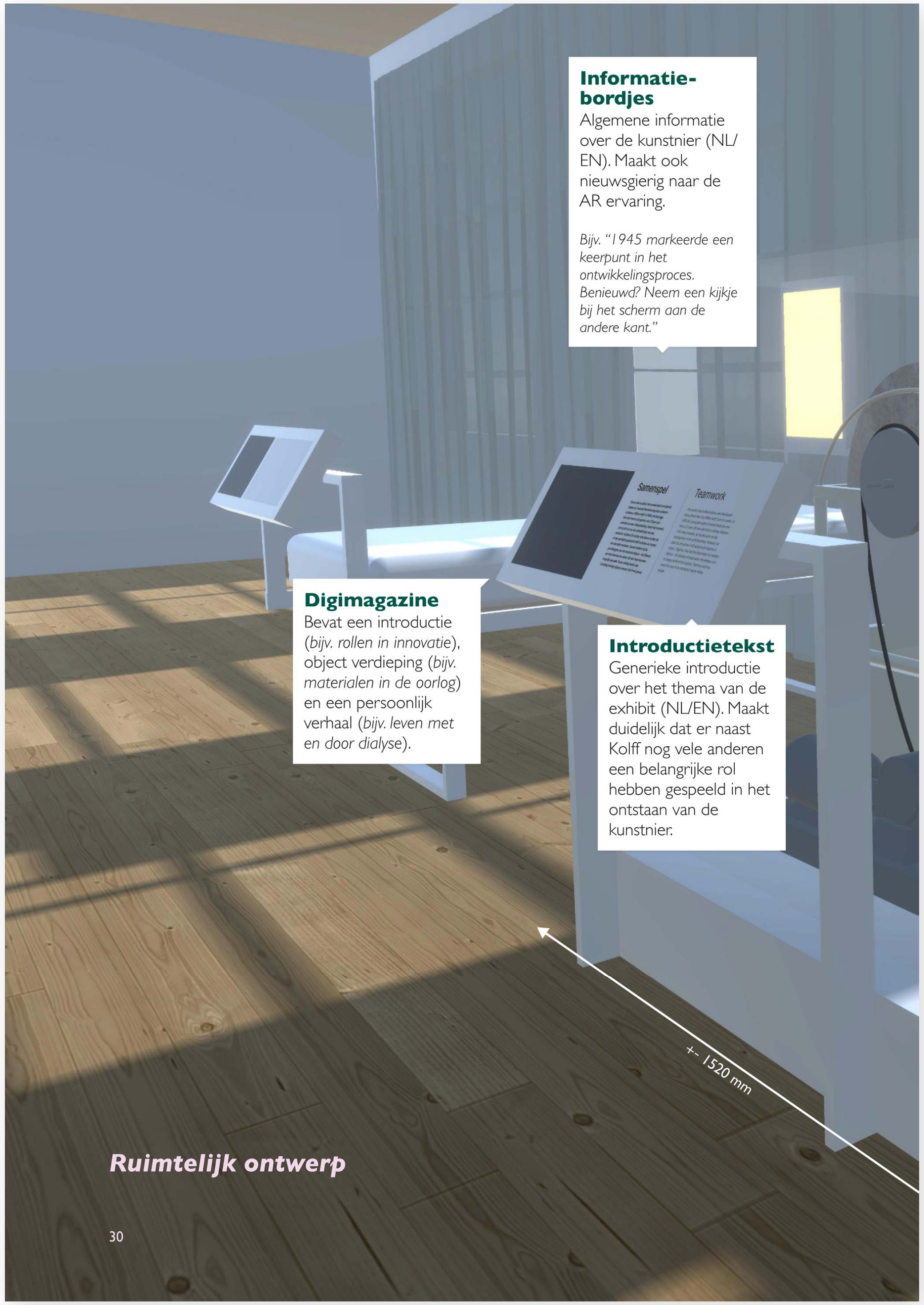
Naast het digimagazine is er, het stramien volgende, ruimte voor de exhibit titel en introductietekst. Informatiebordjes met algemene informatie over het artefact, geplaatst op de lege zijde van de vitrine, maken de exhibit compleet.

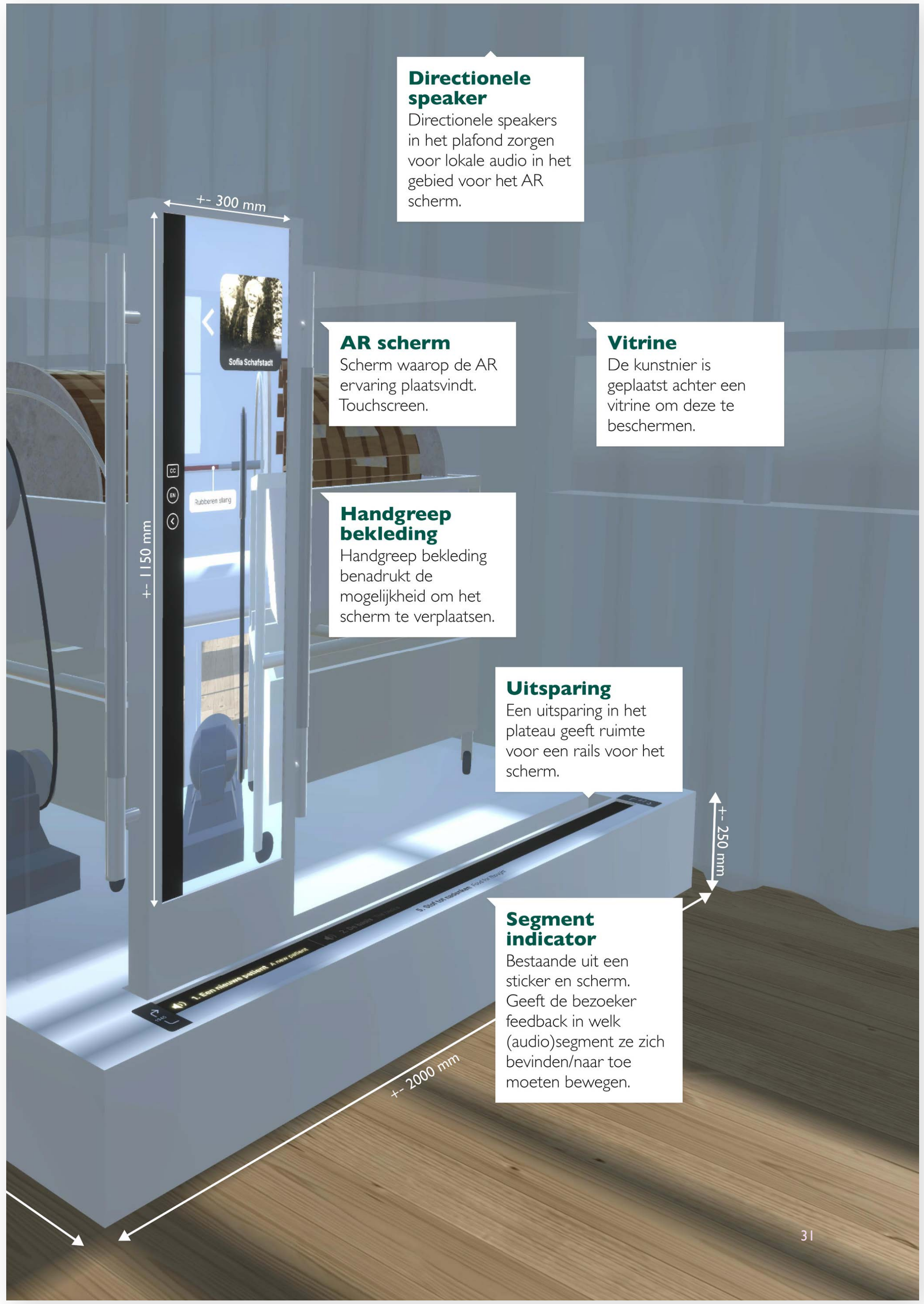
Overige elementen

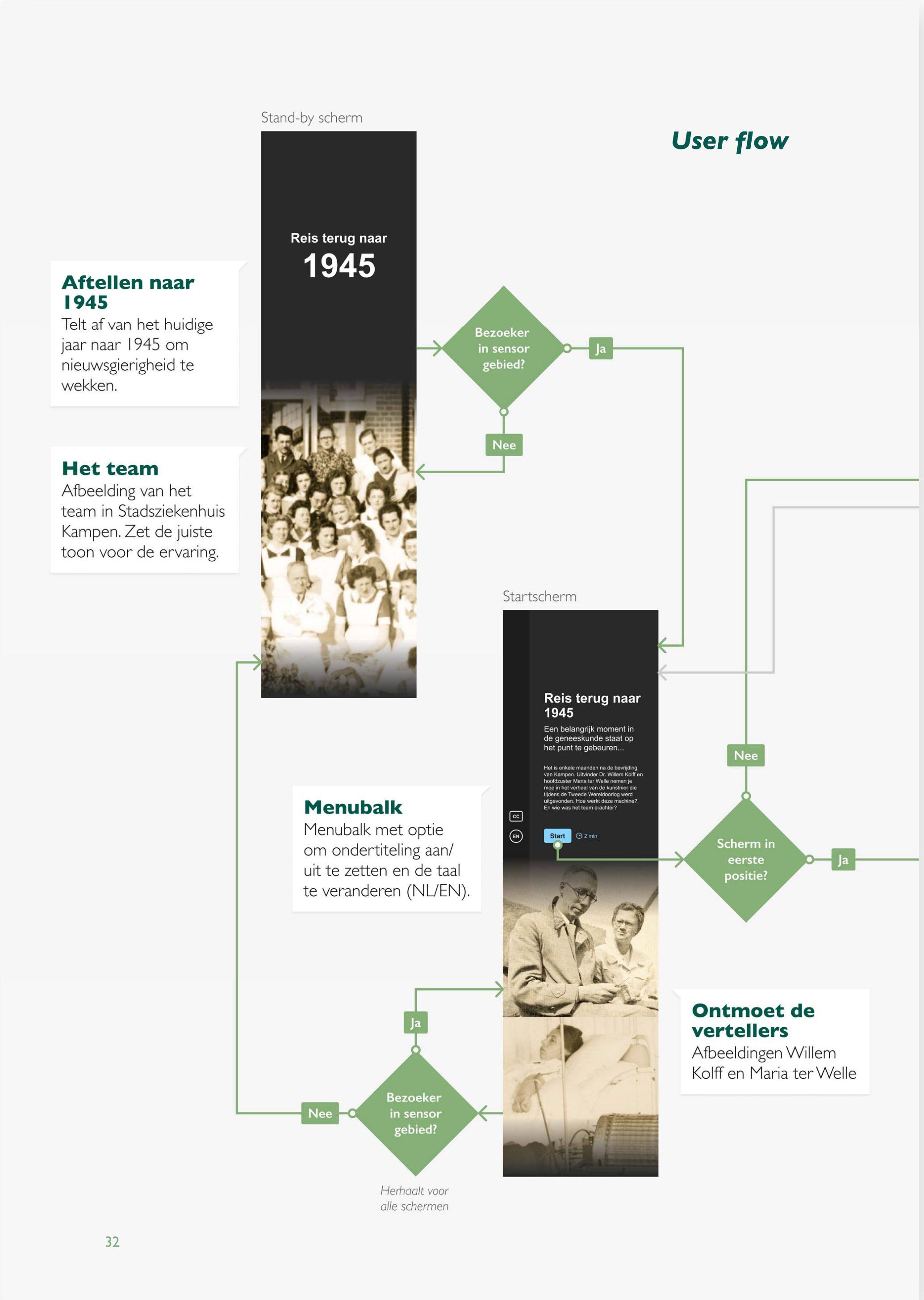
- Digimagazine (inclusief 3x digimagazine verhaal)
- Exhibit titel
- Introductietekst
- Informatiebordjes (algemene informatie over het artefact)

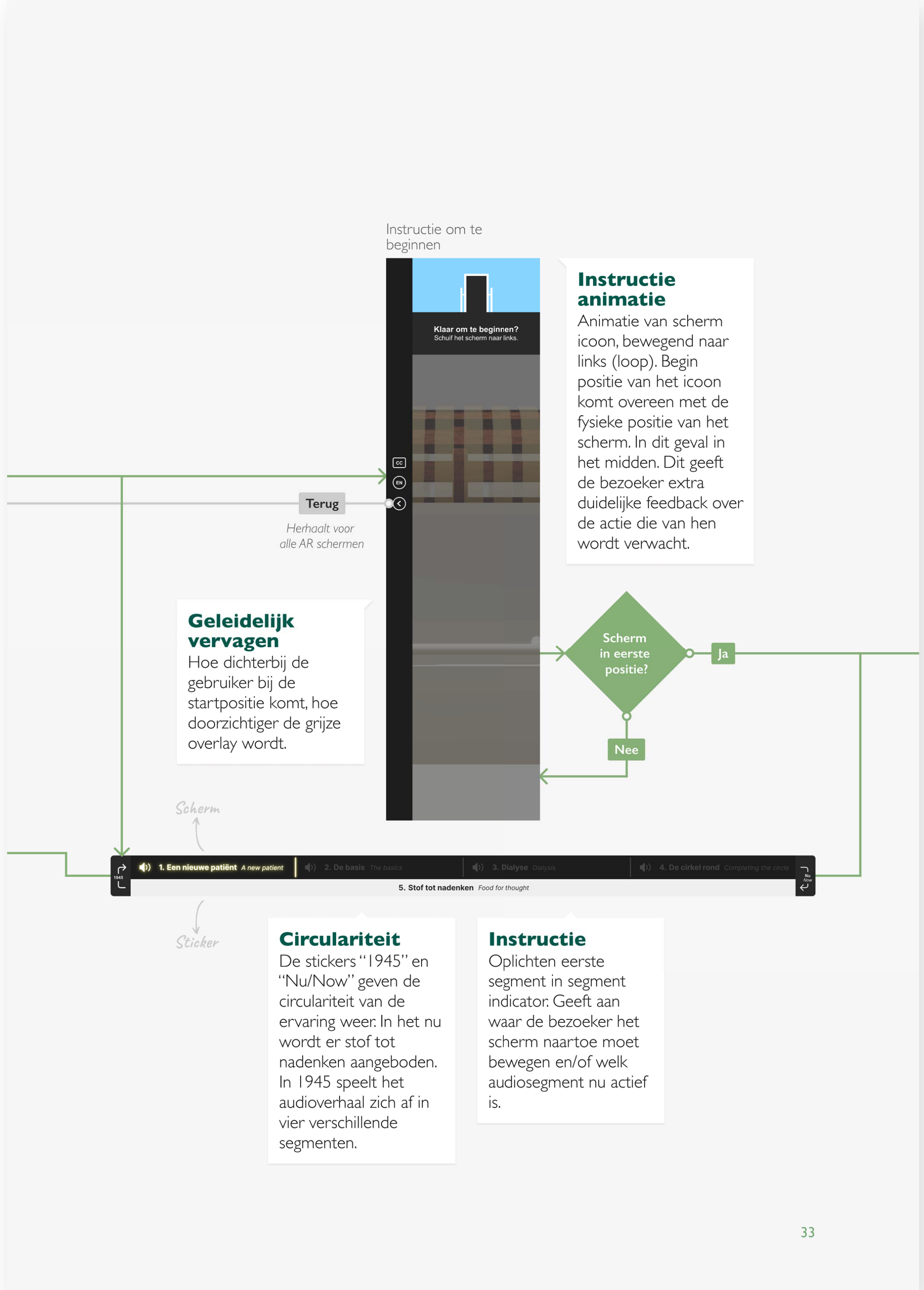
Detaillering

Verdere detaillering van het ontwerp is op de hieropvolgende pagina's samengevat. Eerst wordt het ruimtelijk ontwerp met zijn fysieke onderdelen toegelicht, gevolgd door een user flow die zowel het ontwerp van de schermen als de afhankelijkheden daartussen verduidelijkt. In het ontwerp van deze schermen heeft de field-of-view (FOV) van gebruikers een belangrijke rol gespeeld om de juiste plaatsing van onderdelen te bepalen. Voor vergrote varianten van de schermen kan worden gekeken in *Hoofdstuk 3. Verificatie.*

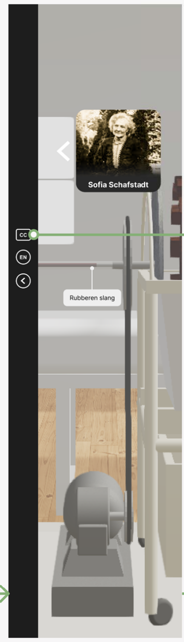

Informatie-bordjes
Algemene informatie over de kunstnier (NL/EN). Maakt ook nieuwsgierig naar de AR ervaring.
Bijv. "1945 markeerde een keerpunt in het ontwikkelingsproces. Benieuwd? Neem een kijkje bij het scherm aan de andere kant."
Digimagazine
Bevat een introductie (*bijv. rollen in innovatie*), object verdieping (*bijv. materialen in de oorlog*) en een persoonlijk verhaal (*bijv. leven met en door dialyse*).
Introductietekst
Generieke introductie over het thema van de exhibit (NL/EN). Maakt duidelijk dat er naast Kolff nog vele anderen een belangrijke rol hebben gespeeld in het ontstaan van de kunstnier.
+- 1520 mm
Ruimtelijk ontwerp
30


Directionele speaker
Directionele speakers in het plafond zorgen voor lokale audio in het gebied voor het AR scherm.
+- 300 mm
+- 1150 mm
AR scherm
Scherm waarop de AR ervaring plaatsvindt. Touchscreen.
Vitrine
De kunstnier is geplaatst achter een vitrine om deze te beschermen.
Handgreep bekleding
Handgreep bekleding benadrukt de mogelijkheid om het scherm te verplaatsen.
Uitsparing
Een uitsparing in het plateau geeft ruimte voor een rails voor het scherm.
+- 250 mm
Segment indicator
Bestaande uit een sticker en scherm. Geeft de bezoeker feedback in welk (audio)segment ze zich bevinden/naar toe moeten bewegen.
+- 2000 mm
31


User flow
Stand-by scherm
Reis terug naar
1945
Aftellen naar 1945
Telt af van het huidige jaar naar 1945 om nieuwsgierigheid te wekken.
Het team
Afbeelding van het team in Stadsziekenhuis Kampen. Zet de juiste toon voor de ervaring.
Bezoeker in sensor gebied?
Ja
Nee
Startscherm
Reis terug naar 1945
Een belangrijk moment in de geneeskunde staat op het punt te gebeuren...
Start
Menubalk
Menubalk met optie om ondertiteling aan/uit te zetten en de taal te veranderen (NL/EN).
Scherm in eerste positie?
Nee
Ja
Ontmoet de vertellers
Afbeeldingen Willem Kolff en Maria ter Welle
Bezoeker in sensor gebied?
Ja
Nee
Herhaalt voor alle schermen
32


Instructie om te beginnen
Klaar om te beginnen?
Instructie animatie
Animatie van scherm icoon, bewegend naar links (loop). Begin positie van het icoon komt overeen met de fysieke positie van het scherm. In dit geval in het midden. Dit geeft de bezoeker extra duidelijke feedback over de actie die van hen wordt verwacht.
Terug
Herhaalt voor alle AR schermen
Geleidelijk vervagen
Hoe dichterbij de gebruiker bij de startpositie komt, hoe doorzichtiger de grijze overlay wordt.
Scherm in eerste positie?
Ja
Nee
Scherm
1. Een nieuwe patiënt A new patient
2. De basis
3. Dialyse
4. De cirkel rond
5. Stof tot nadenken Food for thought
Sticker
Circulariteit
De stickers "1945" en "Nu/Now" geven de circulariteit van de ervaring weer. In het nu wordt er stof tot nadenken aangeboden. In 1945 speelt het audioverhaal zich af in vier verschillende segmenten.
Instructie
Oplichten eerste segment in segment indicator. Geeft aan waar de bezoeker het scherm naartoe moet bewegen en/of welk audiosegment nu actief is.
33

AR-verhaal
Een nieuwe patiënt



Patiëntkaart
Een foto van Sofia Schafstadt geeft een gezicht aan nierfalen zonder het eng te maken voor jonge bezoekers. De pijl duidt aan waar Sofia is ten opzicht van de kunstnier.

Onderdeellabels
Onderdeellabels geven bezoekers een duidelijk beeld waar de onderdelen benoemd in het audioverhaal zich bevinden.

Rubberen slang
Een 3D model van de rubberen slang verrijkt het fysieke artefact.

Einde audio verhaal

Audioverhaal

Team **//Geluidseffect** *Cliffhanger*

Maria:
//Start algemeen omgevingsgeluid ziekenhuis "Welkom in het Stadsziekenhuis Kampen, ik ben **Maria, hoofdzuster**."

Kolff:
"En ik ben **Dr. Kolff, uitvinder**."

Maria:
"Een nieuwe patiënt is net binnengekomen. Sofia, een 67-jarige vrouw met acute nierfalen. Haar nieren filteren haar bloed niet meer. Hierdoor heeft ze teveel gifstoffen. Levensgevaarlijk! Daarom gaan we nu haar bloed proberen te reinigen. Kunstmatig: met deze machine!"

Kolff:
"De machine heet de kunstnier. **Ons teamlid Bob** sluit de kunstnier met de rubberen slang aan op patiënt Sofia. Mooi, nu kunnen we starten met het reinigen van haar bloed." **//Start geluid kunstnier**

Kolff:
"Tot nu toe loopt het op rolletjes. *Hopelijk gaat het anders dan bij de 16 patiënten hiervoor.*"

34

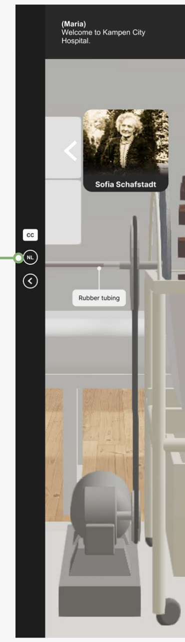
Ondertiteling

Herhaalt voor alle AR schermen

Ondertiteling
De ondertiteling is bovenaan het scherm geplaatst voor de beste leesbaarheid. Maak duidelijk voor de bezoeker wie er aan het woord is en welke geluidseffecten afspelen.

Einde audio verhaal

Engels



Herhaalt voor alle AR schermen

Een andere taal
Een taalverandering vindt plaats, zowel op het scherm, als in het audioverhaal.

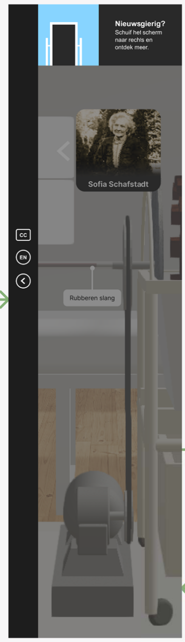
Einde audio verhaal

35

Geleidelijk vervagen
Hoe dichterbij de gebruiker bij de volgende juiste positie komt, hoe doorzichtiger de grijze overlay wordt.

Doorzichtige overlay
Door de doorzichtige grijze overlay blijft de bezoeker in contact met de AR wereld, terwijl er voldoende afstand wordt gecreëerd om een actie in de echte wereld uit te voeren.

Instructie om te verder te gaan

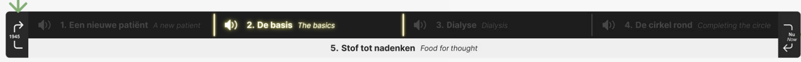


Instructie animatie
Animatie van scherm icoon, bewegend naar rechts (loop). Kleiner dan instructie om te beginnen, zodat UI elementen uit het verhaal zichtbaar blijven. Bovendien is het bewegen van het scherm altijd dezelfde stap naar rechts.

Scherm in tweede positie?

Ja

Nee

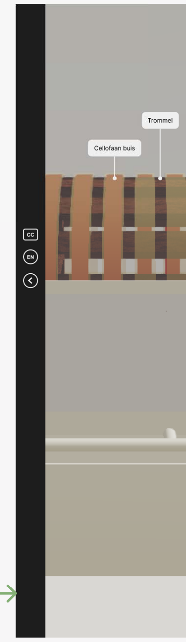


Instructie
Oplichten tweede segment in segment indicator. Geeft aan waar de bezoeker het scherm naartoe moet bewegen en/of welk audiosegment nu actief is.

36

AR-verhaal
De basis

Stroming van het bloed
Tijdens het eerste audiosegment begint het bloed te stromen. Dit bloed blijft altijd centraal in beeld staan. Tijdens het verschuiven van het scherm tussen de audiosegmenten in, stroomt het bloed mee in het tempo van beweging. Zo krijgt de bezoeker een gevoel van controle in het verhaal.



Cellofaan buis
Een 3D model van het cellofaan verrijkt het fysieke artefact. Zorg ervoor dat dit cellofaan goed uitlijnt met het cellofaan wat zich nog op het fysieke artefact bevindt.

Een draaiende trommel
3D model van de trommel draait om zijn as. Zo komt de kunstnier echt tot leven.

Einde audio verhaal

Audioverhaal

Team **//Geluidseffect** *Cliffhanger*

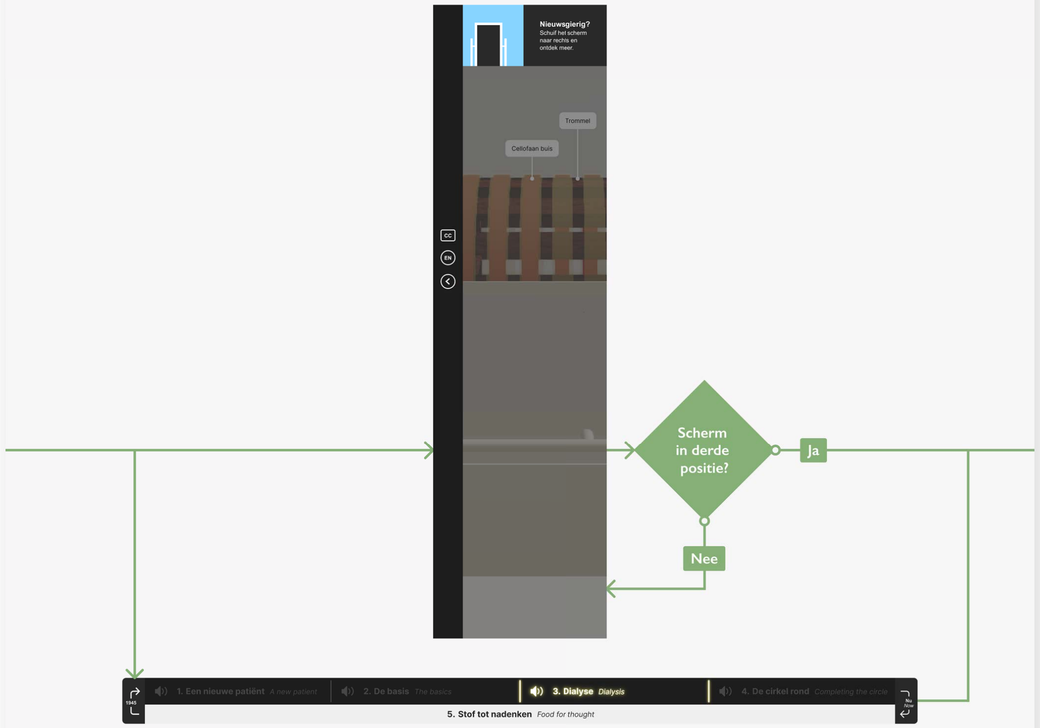
Maria:
"Nadat het bloed met gifstoffen door de rubberen slag is gegaan, komt het in de cellofaanbuis. En dat is nogal een opmerkelijk ding. Het is namelijk gemaakt van een worstenvel van **de lokale slager**. Door de oorlog hebben we weinig andere opties."

Kolff:
"Dit worstenvel zit om een draaiende trommel. De **werktuigbouwkundige uit ons team** heeft 'm horizontaal gelegd, zodat we maximaal gebruikmaken van de zwaartekracht."

Maria:
"Benieuwd hoe dit helpt bij het reinigen van Sofia's bloed?"

37

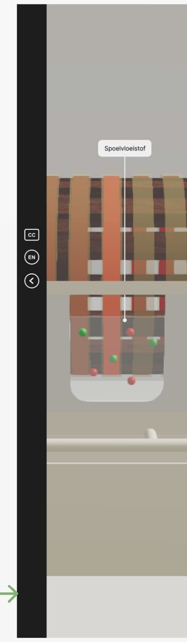
Instructie om te verder te gaan



Instructie
Oplichten derde segment in segment indicator. Geeft aan waar de bezoeker het scherm naartoe moet bewegen en/of welk audiosegment nu actief is.

AR-verhaal
Dialyse

Schoner bloed
Door de uitwisseling van stoffen in dialyse wordt het bloed steeds een stukje schoner. Maak dit proces expliciet voor de bezoeker (bijvoorbeeld door het bloed helderder rood te maken).



XR-ray
Een kijkje door de spoelvloeistofbak geeft de bezoeker zicht op de bewegende spoelvloeistof en de uitwisseling van stoffen in dialyse.

Einde audio verhaal

Audioverhaal

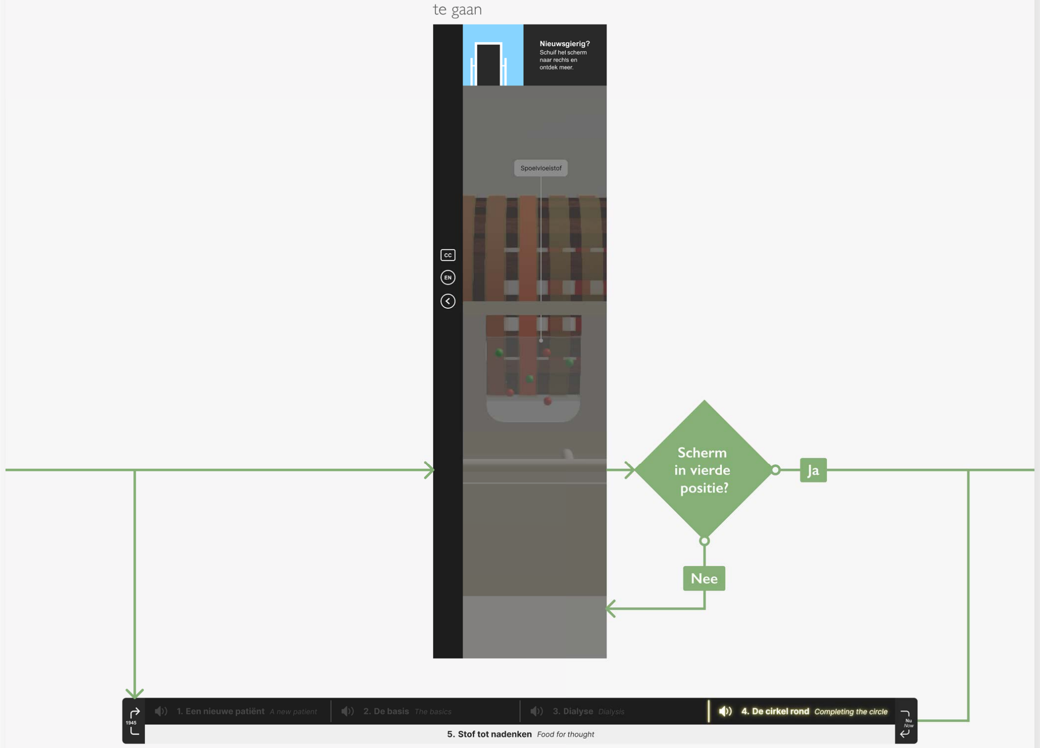
Team **//Geluidseffect** *Cliffhanger*

Kolff:
"Kijk, zoals je hier ziet steekt de onderste helft van de trommel in een grote bak. Deze is gevuld met 100 liter spoelvloeistof. Hier gaat de dialyse van start."

Maria:
"Tijdens de dialyse verlaten giftige stoffen het bloed. Dat gaat via de wand van het worstenvel. Tegelijkertijd gaan de gezonde mineralen en glucose, die in de spoelvloeistof zitten, naar het bloed. Zo wordt Sofia's bloed steeds schoner."

Kolff:
"Door het draaien van de trommel, gaat de uitwisseling van giftige en gezonde stoffen extra snel. *Maar is het snel genoeg om Sofia's leven te redden?*"

Instructie om te verder te gaan



Instructie
Oplichten vierde segment in segment indicator. Geeft aan waar de bezoeker het scherm naartoe moet bewegen en/of welk audiosegment nu actief is.

AR-verhaal
De cirkel rond

Tijdsprong
In een tijdsprong wordt het in de AR wereld nacht en weer dag. Zo begrijpen bezoekers dat dialyse uren lang duurt.

De cirkel rond
De patiëntkaart met pijl communiceert dat Sofia's bloed via een rubberen slang weer naar haar terugstroomt.

Stop de machine
Aan het eind van de dialyse wordt de kunstnier stilgezet. De kunstnier stopt met draaien en raakt leeg.

Audioverhaal

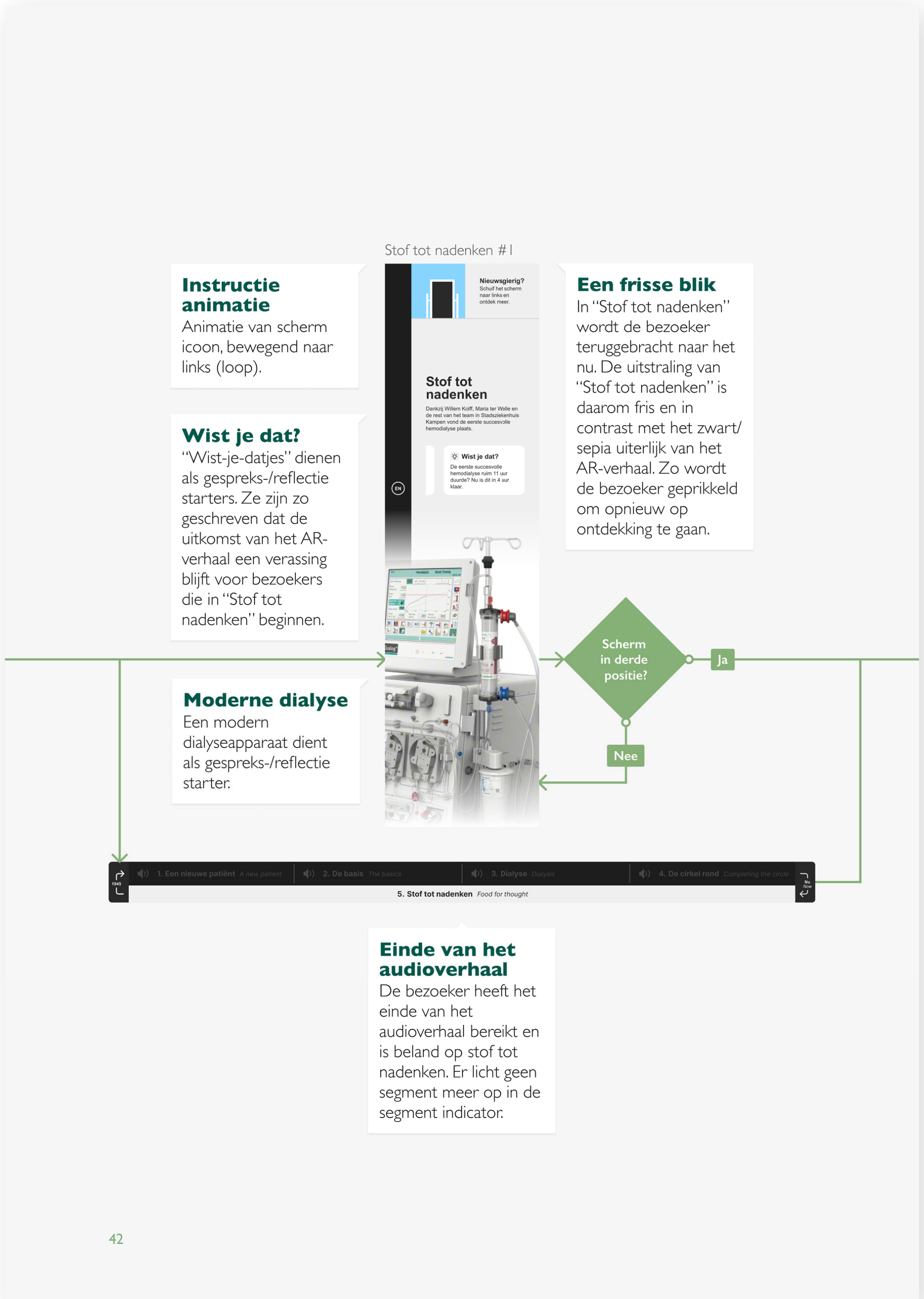
Team **//Geluidseffect** *Cliffhanger*

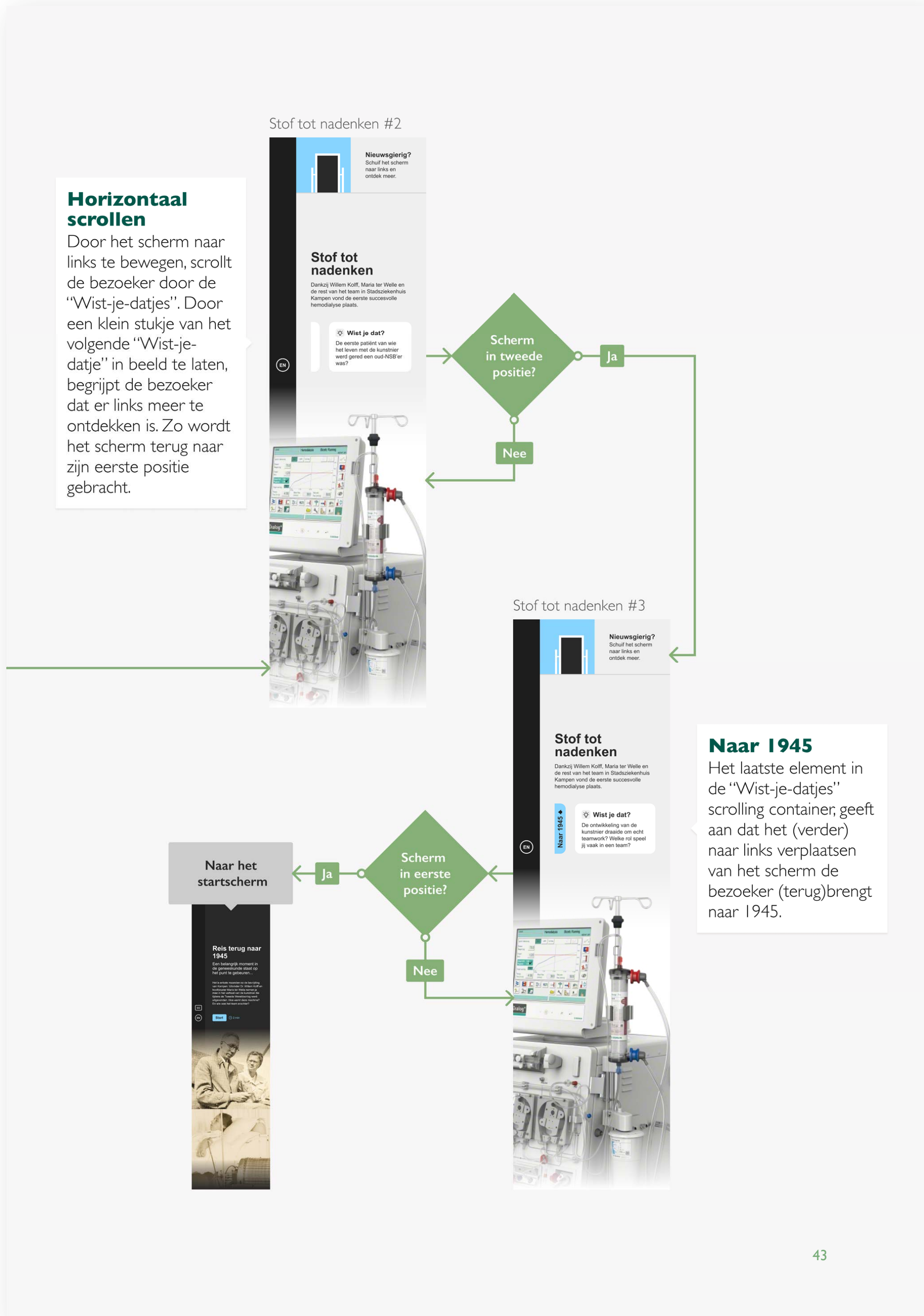
Kolff:
"Nu is het wachten geblazen. Het bloed stroomt via een rubberen slang terug naar Sofia. Haar bloed blijft de komende uren in een cirkel door de kunstnier lopen. Onze medische analisten Willy en Mieneke houden de hele nacht bij of de giftige stoffen in het bloed dalen. Als dat zo is, kleurt het bloed helder rood."

//Voetstappen

Maria:
"Daar zal je Willy hebben."

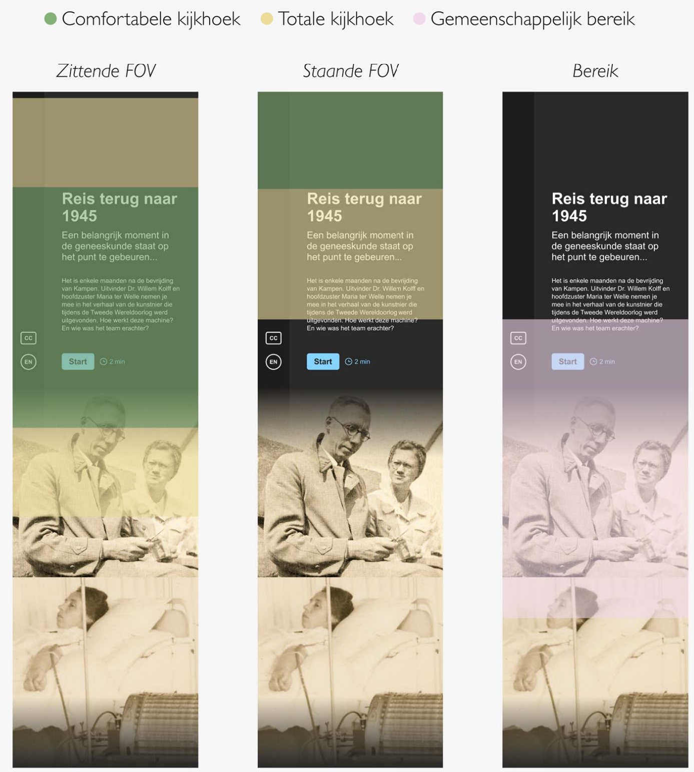
Kolff:
"We hebben wel 60 gram giftige stoffen verwijderd. We zetten de kunstnier uit. Sofia's leven is gered!"
//Stop geluid kunstnier //Stop algemeen omgevingsgeluid ziekenhuis


Stof tot nadenken #1
Instructie animatie
Animatie van scherm icoon, bewegend naar links (loop).
Wist je dat?
"Wist-je-datjes" dienen als gespreks-/reflectie starters. Ze zijn zo geschreven dat de uitkomst van het AR-verhaal een verassing blijft voor bezoekers die in "Stof tot nadenken" beginnen.
Moderne dialyse
Een modern dialyseapparaat dient als gespreks-/reflectie starter.
Nieuwsgierig?
Stof tot nadenken
Wist je dat?
Een frisse blik
In "Stof tot nadenken" wordt de bezoeker teruggebracht naar het nu. De uitstraling van "Stof tot nadenken" is daarom fris en in contrast met het zwart/sepia uiterlijk van het AR-verhaal. Zo wordt de bezoeker geprikkeld om opnieuw op ontdekking te gaan.
Scherm in derde positie?
Ja
Nee
5. Stof tot nadenken Food for thought
Einde van het audioverhaal
De bezoeker heeft het einde van het audioverhaal bereikt en is beland op stof tot nadenken. Er licht geen segment meer op in de segment indicator.
42


Stof tot nadenken #2
Horizontaal scrollen
Door het scherm naar links te bewegen, scrollt de bezoeker door de "Wist-je-datjes". Door een klein stukje van het volgende "Wist-je-datje" in beeld te laten, begrijpt de bezoeker dat er links meer te ontdekken is. Zo wordt het scherm terug naar zijn eerste positie gebracht.
Nieuwsgierig?
Stof tot nadenken
Wist je dat?
Scherm in tweede positie?
Ja
Nee
Stof tot nadenken #3
Naar 1945
Het laatste element in de "Wist-je-datjes" scrolling container, geeft aan dat het (verder) naar links verplaatsen van het scherm de bezoeker (terug)brengt naar 1945.
Naar het startscherm
Ja
Scherm in eerste positie?
Nee
Reis terug naar 1945
43

FOV

Voor het plaatsen van de UX-elementen op het AR scherm is er rekening gehouden met de field-of-view (FOV) van gebruikers. Deze analyse is uitgegaan van een in een rolstoel zittende (gemiddelde ooghoogte 1220 mm) en staande (gemiddelde ooghoogte 1550 mm) volwassenen op een afstand van 750 mm van het scherm met een *comfortabele kijkhoek* van 30° en 20° respectievelijk (Giannasca, 2014). De maatvoering gepresenteerd door Giannasca (2014) wordt bevestigd door Haak and Leever-Van der Burgh (1980) die stelt dat de ooghoogte van de gemiddelde man ligt op 161 cm en die van de gemiddelde vrouw op 150 cm. Er verder vanuit gaande dat maximale oogrotatie ongeveer 25° is, is een *totale kijkhoek* van 50° gebruikt voor beide scenario's. Interactieve elementen, zoals knoppen, zijn geplaatst in het gebied van gemeenschappelijk bereik zoals geïdentificeerd door Giannasca (2014).



Hoofdstuk 3

De verificatie

Dit hoofdstuk omschrijft de verificatie van het ontwerp. Een gebruikerstest is uitgevoerd met drie respondenten om de gebruiksvriendelijkheid van de exhibit en de betrokkenheid van bezoekers in de ervaring te evalueren. Vanwege het beperkte aantal respondenten, gebrek aan verscheidenheid binnen de respondenten en de kunstmatige testcontext, is dit onderzoek gelimiteerd. Desondanks, laat de gebruikerstest zien dat het ontwerp erg positief wordt ontvangen. Gemiddeld scoort de exhibit bij respondenten een 7.8. De grootste obstakels in het huidige ontwerp liggen in de navigatie (te danken aan UI elementen die onjuiste verwachtingen wekken) en het overbrengen van de juiste boodschap. Hoewel gebruikers na het bekijken van de exhibit een basis begrip hebben ontwikkeld voor het proces van dialyse, lijkt het overbrengen van een gevoel van samenwerking/teamverband achter te blijven.

Testopzet

Doelstelling

Het doel van dit onderzoek is om te bepalen in hoeverre de ontworpen exhibit begrijpbaar is voor de bezoeker, zowel in gebruik als in overdracht van de beoogde centrale boodschap. De focus hierbij ligt op de gebruiksvriendelijkheid van de exhibit en de betrokkenheid van de bezoeker binnen de ervaring.

Opstelling

Tijdens de gebruikerstest zijn de respondenten door verschillende scenario's geleidt. Er is hierbij opzettelijk gekozen voor scenario's die potentieel de meeste negatieve impact op de gebruikerservaring kunnen hebben.

Scenario #1: Stof tot nadenken
Het eerste scenario schetst een situatie waarin een vorige bezoeker net is weggelopen bij de kunstnier exhibit. Het scherm is hierbij achtergelaten halverwege "Stof tot nadenken". "Stof tot nadenken" is het eerste scherm wat de respondent ziet. Dit scenario eindigt als de respondent het startscherm heeft bereikt.

Scenario #2: Een reis naar 1945
Het tweede scenario schetst een situatie waarin een vorige bezoeker het scherm halverwege heeft achtergelaten. Het scherm is op stand-by gesprongen. Dit scherm is het eerste scherm wat de respondent ziet. Het scherm staat dan nog niet op de juiste startpositie. Dit scenario eindigt als de respondent door het volledige AR-verhaal is gelopen, eindigende bij het scherm "Stof tot nadenken".

Om respondenten een zo goed mogelijk gevoel te geven van de ervaring, is er gebruik gemaakt van een Virtual Reality (VR) prototype. Door middel van een VR headset konden respondenten het 3D model van de exhibit, geplaatst in de testruimte, bekijken. Om de acties van de respondenten te contextualiseren, werd het beeld van de headset tijdens de test gestreamd naar een laptop. Zo konden de onderzoekers meekijken met de respondenten.

Naast het fysieke ontwerp, speelt audio een belangrijke rol in de beoogde ervaring. De audio behorende bij de exhibit werd tijdens de test gesimuleerd door het afspelen van een opname van een telefoon. Om de opname zo getrouw mogelijk aan het ontwerp te houden, zijn enkele geluidseffecten toegevoegd: het geluid van de draaiende kunstnier en de voetstappen van Willy. Op basis van de gedragingen van de respondenten, werden de juiste animaties in het 3D model geactiveerd en de juiste audiofragmenten afgespeeld.

Onderzoeksvragen

De onderstaande onderzoeksvragen zijn als leidraad gebruikt tijdens de gebruikerstest om relevante inzichten te verzamelen.

1. In hoeverre wordt de navigatie als gebruiksvriendelijk ervaren?
2. In welke mate is de beoogde centrale boodschap helder met betrekking tot:
    a. De werking van de kunstnier
    b. Het gevoel van samenwerking/teamverband
3. In hoeverre prikkelt de exhibit de nieuwsgierigheid? Voelen bezoekers zich betrokken (in het AR-verhaal)?
4. In hoeverre worden van tevoren de juiste verwachtingen bij bezoekers gewekt over wat de ervaring te bieden heeft? Hoe verschilt dit voor de verschillende scenario's?

Respondenten

In totaal namen drie respondenten deel aan het onderzoek. De respondenten zijn alle mannenlijk en tussen de 25 en 35 jaar oud, hebben enige ervaring met VR en zijn onbekend met Rijksmuseum Boerhaave. Wel bezoeken ze ieder wel eens een (wetenschappelijk) museum. Twee respondenten waren totaal onbekend met het principe van dialyse voorgaand het onderzoek.

Limitaties

Vanwege het beperkte aantal respondenten en gebrek aan verscheidenheid binnen de groep, is dit onderzoek gelimiteerd. Meer onderzoek is vereist om te achterhalen hoe een jongere of veel oudere doelgroep om zou gaan met de hoge mate aan interactiviteit en AR functionaliteit binnen de ontworpen exhibit. Een andere belangrijke limitatie is dat de context van de test (een afgesloten kantoorruimte) niet overeenkomt met de daadwerkelijke gebruikerscontext van het museum. Hierdoor werden respondenten minimaal geconfronteerd met afleidende prikkels, zoals tijdsdruk of omgevingsgeluid. Ook werd de invloed van de rest van de tentoonstelling (en overige zalen in het museum) hiermee buitengesloten. Bepaalde verwachtingen en gedragingen die normaal gesproken in deze museumcontext zouden ontstaan, en daarmee van invloed zijn op de ervaring, zijn niet meegenomen in het onderzoek.

Ondanks deze limitaties geven de bevindingen een eerste inzicht in de voordelen en potentiele obstakels van het ontwerp met betrekking tot gebruiksvriendelijkheid en betrokkenheid van bezoekers binnen de ervaring.

Testresultaten

Op de volgende pagina's zijn de resultaten van het onderzoek uitgelicht. Voor elk onderdeel wordt er door middel van kleurcodes betekenis aan het resultaat gegeven. Als een respondent of onderzoeker op basis van een bepaald resultaat tijdens de test tot een aanbeveling kwam, wordt deze opvolgend aan het resultaat gegeven in *italics*. Tot slot worden op basis van alle individuele inzichten de onderzoeksvragen beantwoord en aanbeveligingen gedaan voor een volgende iteratie van het ontwerp.

1. Heeft een negatieve impact op de gebruiksvriendelijkheid. De gewenste ervaring wordt niet bereikt. De gebruiker ondervindt hinder.
2. De impact op de gebruiksvriendelijkheid is matig. De gewenste ervaring wordt niet bereikt, maar de impact is minder erg. De gebruiker kan hieromheen werken.
3. Draagt bij aan een positieve, gebruiksvriendelijke ervaring. De gewenste ervaring wordt bereikt.
4. Een neutrale opmerking.

Exhibit

Algemeen

1. De kijkhoek wordt door gebruikers als prettig ervaren.
2. Gebruikers zijn betrokken in het gebruik van de exhibit. De combinatie van doen, kijken en luisteren wordt hiervoor als reden gegeven; de kunstnier komt echt tot leven. Vooral de interactiviteit door middel van het bewegen van het scherm draagt bij aan een positieve ervaring.
3. Het gevoel van samenwerking of het horen van meerdere teamleden in het AR-verhaal is door geen enkele respondent expliciet genoemd. De exhibit titel "Samenspel" wordt wel gelezen, maar niet meegenomen in de reflectie op de ervaring.
4. Gebruikers die niet bekend waren met het proces van dialyse voor het bekijken van de exhibit, konden de basiswerking van dit proces in eigen woorden naderhand uitleggen. Deze inhoudelijke overdracht lijkt voldoende plaats te vinden.
5. Door middel van het tekstbordje aan de achterzijde van de vitrine werd een gebruiker succesvol geleid naar het grote scherm om meer te ontdekken.

   Deze instructie zou wel meer op mogen vallen.
6. Informatie met een bepaalde "shock-value" blijft bij gebruikers het beste hangen. (bijvoorbeeld het worstenvel van de lokale slager en Sofia als NSB'er). Een respondent gaf aan dat dit soort leuke feitjes hetgene zou zijn wat hij vervolgens met anderen zou delen.

“Ik wil weten of Sofia het overleeft”

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Scherm

Stof tot nadenken #1

1. De instructie bovenaan het scherm trekt de aandacht. Respondenten maken vaak direct een beweging om het scherm te verschuiven. De link tussen het icoon en het scherm wordt goed gelegd.

2. Als gebruikers beginnen bij dit scherm, is de doelstelling van de tentoonstelling niet gelijk duidelijk. Een gebruiker gaf wel aan te denken dat het over een bloedfiltersysteem zou gaan. Het is voor gebruikers moeilijk in te schatten wat er zou gebeuren als ze het scherm naar links zouden bewegen.

3. Gebruikers geven aan dat ze het scherm zouden lezen (of doen dit daadwerkelijk), omdat de tekst kort en overzichtelijk is.

4. Meerdere gebruikers proberen te swipen over het “Wist-je-dat” gebied. De link tussen het bewegen van het scherm en het horizontaal scrollen door deze feitjes wordt niet goed gelegd.

5. Sommige, maar niet alle, gebruikers leggen de link dat deze afbeelding de moderne variant van de kunstnier weergeeft.

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Scherm
Stof tot nadenken #2

1. "Stof tot nadenken" is zo geschreven dat de afloop van het AR-verhaal spannend zou blijven (overleeft Sofia het?) als de gebruiker hier begint. Hierdoor kan echter ook verwarring ontstaan. De gebruiker kan over het hoofd zien dat eerste patiënt van wie het leven werd gered, gaat over Sofia uit het AR-verhaal.

2. Zodra gebruikers het scherm bewegen en zien dat de "Wist-je-datjes" daarmee verschuiven, komt dit wel overeen met hun verwachting dat er iets aan de content zou veranderen.

Scherm
Stof tot nadenken #3

1. Geen enkele gebruiker zei iets over het label "Naar 1945" die de transitie naar het AR-verhaal aangeeft. Het is nog onbekend of deze overgang als duidelijk wordt ervaren. Respondenten gaven bij de overgang naar het startscherm echter geen verwarde indruk.

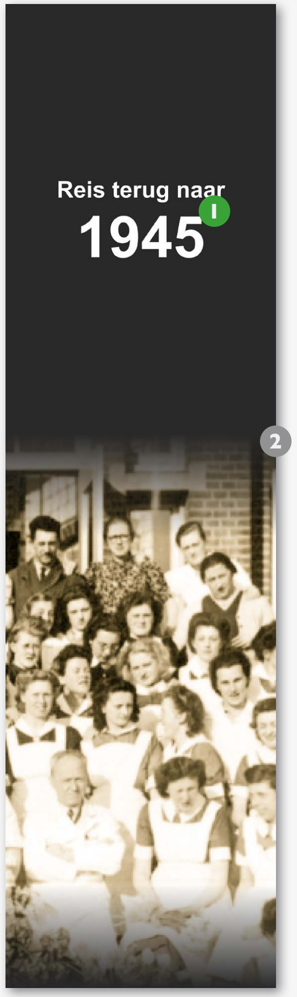
2. Voor sommige gebruikers kan de reflecterende vraag over het "echte leven" hen uit de museumwereld halen.

   Een dilemma die aansluit bij het AR-verhaal zou een minder abrupte trigger kunnen zijn voor een discussie.

Scherm

Stand-by scherm

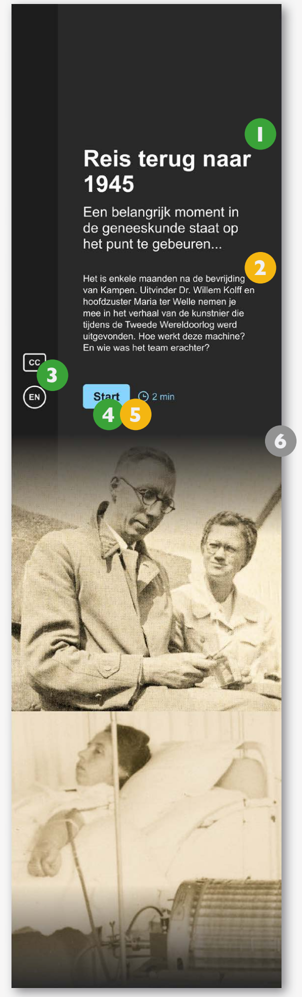
1. De titel valt goed op en wekt interesse bij gebruikers.
2. De afbeelding wordt herkent als een groep. Niet elke gebruiker snapt dat dit gaat om het team.



Scherm

Startscherm

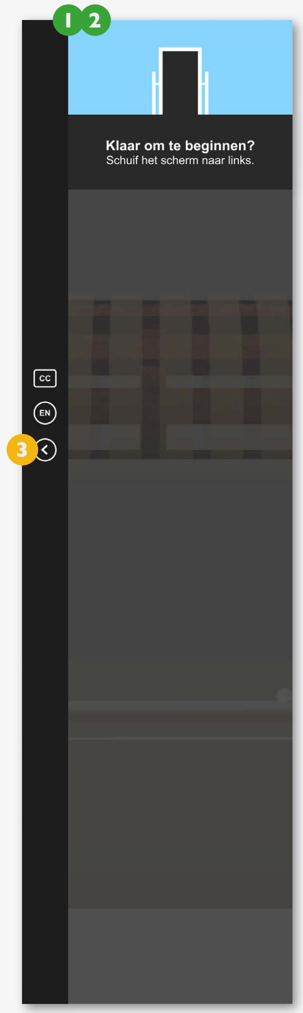
1. Wordt duidelijk herkend als een startscherm met introductie.
2. Gebruikers lijken de intruductie niet echt te lezen of scannen.
3. De ondertitel en taal knop worden makkelijk herkend en begrepen.
4. De startknop is uitnodigend om op te drukken en de tijdsindicator wordt begrepen.
5. Het is niet voor alle gebruikers duidelijk wat er gaat gebeuren als ze op de "Start" knop drukken. De AR funcionaliteit komt als een (blijde) verrassing,
6. Geen enkele gebruiker benoemde de afbeeldingen expliciet.



Scherm

Instructie om te beginnen

1. De instructie heeft het gewenste resultaat. Gebruikers willen het scherm vaak gelijk naar links verschuiven.
2. Gebruikers begrijpen goed waarom deze instructie op het scherm komt te staan: het scherm staat nog niet helemaal links op de juiste beginpositie.
3. De terug-knop kan bij gebruikers de verkeerde impressie wekken. Een gebruiker gaf aan eerst te denken dat het scherm met deze knop naar links zou kunnen worden bewogen.



Feedback

Segment indicator

1. De segment indicator wordt door gebruikers juist geïdentificeerd als een tijdlijn. Ook het idee dat elk segment een nieuwe bron van informatie representeert is duidelijk.
2. De oplichtende segment delen worden gezien door gebruikers op de juiste momenten en dienen tijdens het AR-verhaal goed hun doel. Gebruikers snappen dat de oplichtende delen een indicatie geven tot waar ze het scherm moeten bewegen aan het einde van een audio verhaal.
3. Op het moment dat gebruikers starten bij "Stof tot nadenken" wekt de segment indicator niet de juiste verwachtingen. De sticker met "5. Stof tot nadenken" veroorzaakt verwarring en wordt gezien als de overkoepelende titel van de 4 segmenten daarboven. Gebruikers verwachten dat de informatie op het scherm binnen "Stof tot nadenken" zal veranderen op basis van de deze segmenten.

   Deze sticker zou vervangen kunnen worden met een een eigen oplichtend segment.
4. De stickers "1945" en "Nu/now" zijn door een enkele gebruiker benoemd. Het lijkt dat deze onvoldoende bijdragen aan het communiceren van de circulairiteit van de ervaring en het wekken van de juiste verwachtingen daarin.
5. Het audio icoon is door geen enkele gebruiker expliciet benoemd. Het is onzeker of het voor gebruikers duidelijk is dat de exhibit audioverhalen bevat. Respondenten maakte echter geen verwarde indruk bij de start van deze audioverhalen.

“Ik had geen idee wat ik moest verwachten, dus het was positief dat ik iets door het scherm heen zag.”

AR-verhaal

AR (algemeen)

1. De AR functionaliteit, in combinatie met de handvatten, wekt de juiste verwachting bij gebruikers. Ze verwachten meer te kunnen zien in AR als ze het scherm naar rechts zouden bewegen.

2. Gebruikers willen het scherm kunnen bewegen tijdens het audioverhaal. Dat deze dan door zou blijven spelen, komt overeen met de verwachtingen.

   Het wordt als logisch ervaren dat het camerabeeld langzaam een steeds zwartere overlay zou krijgen, als deze een ongewenste kant op wordt bewogen.

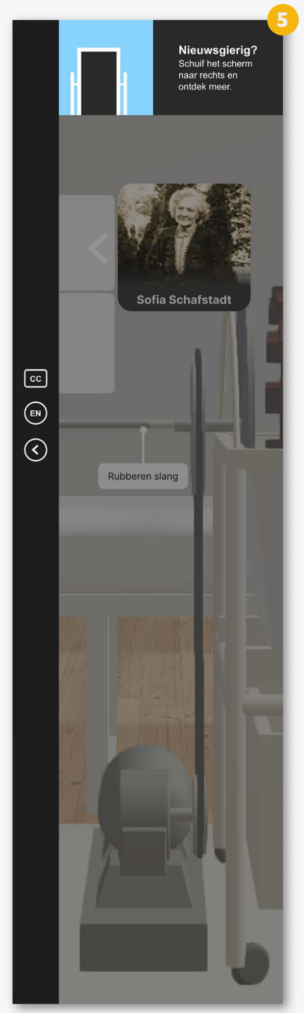
3. Gebruikers willen audioverhalen opnieuw te kunnen afspelen (bijvoorbeeld om iets met een medebezoeker te kunnen delen) en verwachten dat dit kan. Deze functie is op dit moment nog niet in het ontwerp opgenomen.

4. De jonge en moderne audio (van het prototype) haalt de gebruiker uit de beleveniswereld van 1945.

   Vertellen van het audioverhaal in een “oude” sfeer (denk aan oude radio), kan het gevoel van de reis naar 1945 versterken en gebruikers beter meenemen in de belevenis.

5. Een respondent vond de audioverhalen niet altijd even “klaar” voelen.

   Een duidelijkere instructie om naar de volgende stap te gaan wordt verwacht.

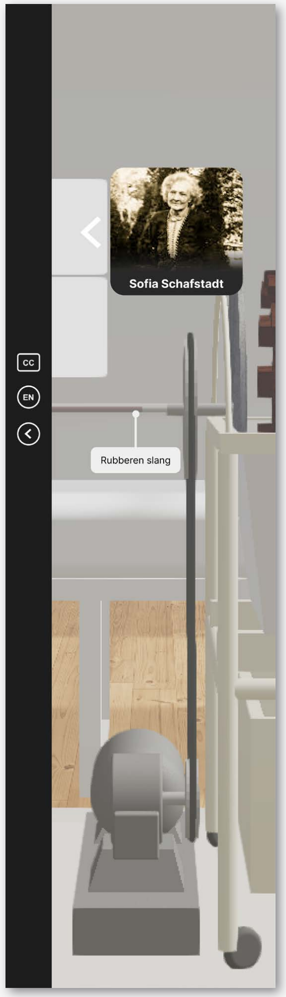


AR-verhaal
Een nieuwe patiënt

1. Het audioverhaal zet de juiste toon dat de bezoeker mee zal worden genomen in het dialyse proces door Maria ter Welle en Willem Kolff.

2. Geen enkele gebruiker maakte een opmerking over de zestien patienten die Sofia voorgingen, maar het dialyse proces niet overleefde.

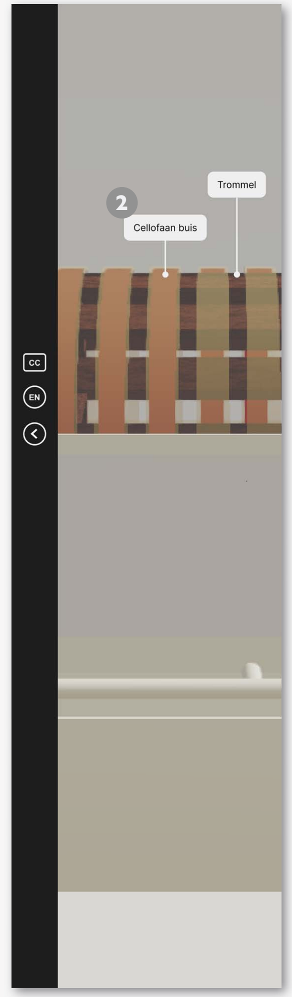
   Het feit dat Sofia patiënt #17 is, zou meer in de spotlight mogen worden geplaatst.



AR-verhaal
De basis

1. Voor gebruikers kan het aanvoelen alsof dit audioverhaal abrupt eindigt. Zowel de lengte van het verhaal, die significant korter is dan het eerste verhaal, als de vraag die op het eind wordt gesteld, zouden hier aan kunnen bijdragen.

2. Van dit verhaal onthoudt de gebruiker voornamelijk dat de cellofaan buis van dierlijk materiaal gemaakt is.



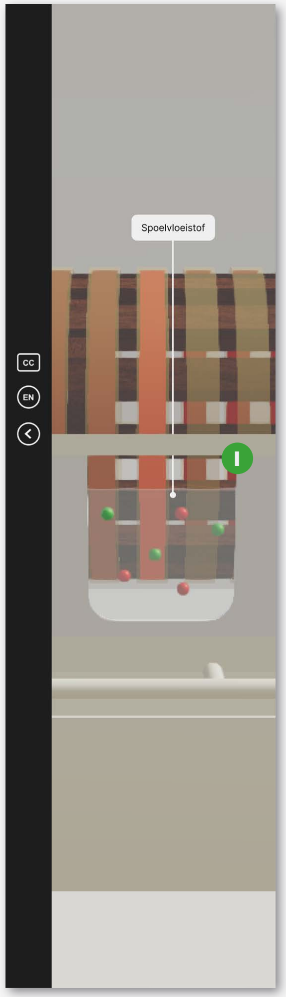
AR-verhaal

Dialyse

1. Gebruikers geven aan dat de "X-Ray" door de spoelvloeistofbak positief bijdraagt aan de ervaring.

2. Gebruikers vormen succesvol een basis begrip van het dialyse proces. Echter, niet elke gebruiker begrijpt hoe de kunstnier dat precies doet.

3. De cliffhanger aan het einde van het audioverhaal wordt opgemerkt door gebruikers en stimuleert om het verhaal af te willen kijken/luisteren.



"Dit vind ik wel een spannende hook met die cliffhanger"

AR verhaal

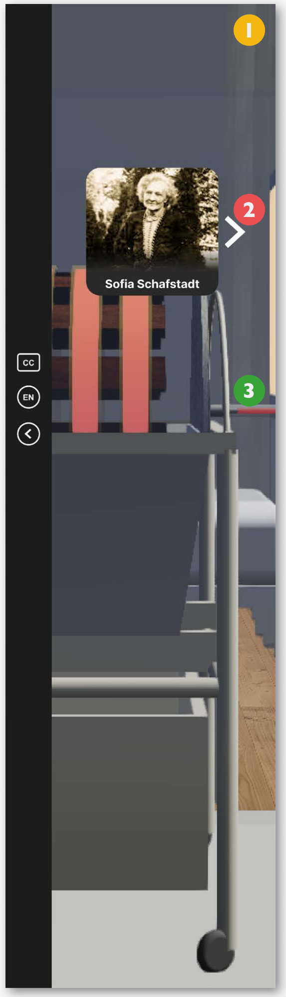
De cirkel rond

1. De tijdsprong, gevisualiseerd door het worden van nacht en dag, wordt door geen enkele gebruiker expliciet benoemd. Het is onzeker of het concept van verstrijken van tijd nu duidelijk wordt overgebracht.

2. De pijl die aangeeft dat het bloed weer terug stroomt naar Sofia, kan voor sommige gebruikers verwarring veroorzaken. Dit component kan het idee wekken van een UX component waarmee andere patiënten bekeken kunnen worden door op de pijl te drukken.

3. Gebruikers begrijpen dat het bloed wat rechts uit de kunstnier stroomt, weer terug wordt gevoerd naar Sofia.

4. Voor sommige gebruikers voelt het audioverhaal niet af. Er blijven vragen over, zoals "Hoeveel liter bloed is er gereinigd?" en "Wat doet het met Sofia als haar bloed door de kunstnier loopt?".



Conclusies en aanbevelingen

In hoeverre wordt de navigatie als gebruiksvriendelijk ervaren?

Over het algemeen wordt de navigatie als gebruiksvriendelijk bevonden. Het schuiven van het scherm draagt bij aan een positieve gebruikerservaring en geeft de gebruiker een gevoel van controle. In (aanloop naar) het AR-verhaal gaat dit schuiven gebruikers natuurlijk af. De oplichtende segment delen en instructie schermen ondersteunen dit proces. De navigatie op het scherm zelf wordt verder ook goed herkend (met name de startknop en knoppen om de taal en ondertiteling te kunnen veranderen). De grootste uitdaging in de huidige navigatie is te danken aan UI elementen die onjuiste verwachtingen wekken.

1. In (aanloop naar) het AR-verhaal kunnen de terug-knop en pijl in "De cirkel rond" valse impressies wekken.
2. De instructie aan het eind van een audiosegment kan voor sommige gebruikers onvoldoende expliciet zijn, waardoor deze nog niet "klaar" voelt.
3. Het gevoel van controle over het scherm wekt de impressie dat audioverhalen opnieuw afgespeeld kunnen. Op dit moment is deze functionaliteit nog niet in het ontwerp opgenomen.
4. In "Stof tot nadenken" verwachten gebruikers door de wist-je-datjes heen te kunnen swipen via het touchscreen.
5. De segment indicator wekt verwarring als de bezoekerservaring begint bij "Stof tot nadenken". Gebruikers verwachten dat de informatie op het scherm binnen "Stof tot nadenken" zal veranderen op basis van de segmenten die in werkelijkheid behoren tot het AR-verhaal.

Aanbeveling #1: Bied betere begeleiding
Bied gebruikers betere begeleiding door middel van expliciete verduidelijkende instructies of visuele aanwijzingen.

Aanbeveling #2: Verbeterde hiërarchie
Zorg voor een meer gelijkwaardige hiërarchie in de 5 stappen van de segment indicator.

Aanbeveling #3: Nog een keer!
Verwerk de mogelijkheid om audioverhalen opnieuw af te spelen.

In welke mate is de beoogde centrale boodschap helder?
De nadruk in de informatieoverdracht ligt in het huidige ontwerp meer op de werking van de kunstnier dan op het team erachter. De basis werking van de kunstnier en het proces van dialyse komt goed over op gebruikers (ook al geven sommigen aan behoefte te hebben aan meer details). Respondenten verbaasten zich over "hoe een ogenschijnlijk eenvoudige taak zo'n complexe machine vereiste." Het gevoel van samenwerking/teamverband werd echter door geen enkele respondent expliciet benoemd, zelfs wanneer ze wel de exhibit-titel "Samenspel" hadden gelezen. Deze overdracht lijkt nog onvoldoende (of enkel impliciet) plaats te vinden.

Aanbeveling #4: Wees expliciet
Verwerk een duidelijke verwijzing naar het teamverband dat nodig was om de kunstnier te ontwikkelen.

In hoeverre prikkelt de exhibit de nieuwsgierigheid? Voelen gebruikers zich betrokken (bij het AR-verhaal)?
De exhibit prikkelt en betrekt gebruikers voldoende. De prikkelende titel ("Reis teurg naar 1945"), cliffhanger(s) in het audioverhaal, feitjes met een bepaalde "shock-value" en het bewegen van het scherm dragen hieraan bij. Een van de respondenten gaf expliciet aan dat AR hierin echt toegevoegde waarde leverde: de animaties, het verhaal en de interactiviteit vond hij indrukwekkend. Over het algemeen houdt de combinatie van doen, kijken en luisteren de aandacht van gebruikers dus goed vast. Desondanks dragen een aantal elementen dragen negatief bij aan de betrokkenheid van gebruikers:

1. Het voor het gevoel abrupt eindigen van een audioverhaal (bijvoorbeeld omdat deze veel korter is dan de voorgaande) haalt gebruikers uit de flow.
2. De reflecterende vraag bij "Stof tot nadenken" kan gebruikers uit de museumbeleving halen door te moeten reflecteren op het "echte leven".

Naast deze obstakels gaven respondenten aan dat het toevoegen van meer geluid (en misschien zelfs geur) uit die tijd, de ervaring nog completer zou kunnen maken. Een voorbeeld? Stemgeluid dat meer getrouw is aan de tijd van 1945.

Aanbeveling #5: In the flow
Maakt de overgang tussen de verschillende delen in het audioverhaal minder abrupt.

Aanbeveling #6: Houdt het in het museum
Laat de reflectie-starter(s) beter aansluiten bij het AR-verhaal of de beleveniswereld van het museum in het algemeen.

Aanbeveling #7: Een wereld van geluid
Zorg ervoor dat geluidseffecten de visuele ervaring in het AR-verhaal ondersteunen. Hoe kan geluid worden ingezet om het gevoel van 1945 nog beter te versterken?

In hoeverre worden van tevoren de juiste verwachtingen bij bezoekers gewekt over wat de ervaring te bieden heeft?
De verwachtingen over wat de exhibit te bieden heeft zijn veelal niet compleet duidelijk.

Als gebruikers beginnen bij het stand-by scherm, lijkt de juiste verwachting van terug gaan in de tijd gewekt te worden. Wat de ervaring precies inhoud (AR + audioverhaal) komt voor sommige gebruikers als een (positieve) verassing. De introductie op het startscherm die de toon hiervoor zou moeten zetten, lijkt niet echt gelezen te worden.

Gebruikers die beginnen bij "Stof tot nadenken", weten niet goed wat ze moeten verwachten als ze het scherm naar links verplaatsen. Hoewel te instructie om het scherm te verplaatsen genoeg prikkelt om op ontdekking te gaan, is het onduidelijk waar de reis naar toe gaat.

Aanbeveling #8: Duidelijke verwachtingen
Verduidelijk de AR-functionaliteit in de exhibit.

Aanbeveling #9: Geen kaart nodig
Verduidelijk het gevoel van circulariteit en de overgang tussen het AR-verhaal en "Stof tot nadenken". Zorg dat de gebruiker weet waar de reis op welk moment naar toe gaat.

Hoofdstuk 4

De reflectie

In dit hoofdstuk wordt er afgesloten met een algemene reflectie op het ontwerp. Op welke manier is de exhibit visie vervuld, rekening houdende met alle restricties? Welke onderdelen in het ontwerp zijn cruciaal, en wat zou er verbeterd kunnen worden? De aanbevelingen van de gebruikerstest worden aangevuld op basis van deze reflectie, zodat het team bij Rijksmuseum Boerhaave de stap naar verdere ontwikkeling en uitwerking van het concept kan zetten.

Invulling van visie

Het ontwerpproces begon met het opstellen van een gezamenlijke visie voor de exhibit. Maar hoe uit deze visie zich in het uiteindelijke ontwerp?

De kunstnier exhibit draait om de vraag: "Hoe komen uitvindingen door menselijk samenspel tot stand?" In het ontwerp komt het antwoord op deze vraag naar voren in de centrale boodschap: belangrijke innovaties, zoals de eerste kunstnier, komen tot stand door meer mensen dan enkel "de" uitvinder. Op basis van het inhoudelijk concept is ervoor gekozen om de focus voornamelijk te leggen op het team wat met Willem Kolff de kunstnier heeft getest in Stadsziekenhuis Kampen – dit team staat immers het meest dichtbij het dialyse proces. Via het audioverhaal maken bezoekers kennis met Willem Kolff en Maria ter Welle die verwijzingen maken naar de andere teamleden Bob, Willy en Mieneke. Verschillende soorten bijdragen aan innovaties als deze, worden extra benadrukt door ook mensen buiten het directe ziekenhuis team kort aan te halen, zoals de lokale slager en de werktuigbouwkundige.

Aldus de visie, zou het ontwerp een prikkelende verhalenverteller moeten zijn - eentje die nieuwsgierige volwassen en kinderen herkenning biedt en op verrassende wijze frisse perspectieven laat ontdekken door middel van interactieve beeldende aandacht voor de kunstnier, spannende verdiepende verhalen en gespreks- en reflectie starters. Het uiteindelijke ontwerp geeft hieraan invulling door de bezoeker mee te nemen in een spannend historisch moment: de eerste succesvolle hemodialyse van patiënt nummer 17. Aansluiting bij de beleveniswereld van de bezoeker wordt gezocht door een digitale informatie laag over het fysieke artefact te leggen. Via het bewegen van het scherm wordt zo interactieve beeldende aandacht voor het artefact gecreëerd. Bovendien zijn de teksten in de tentoonstelling zonder jargon geschreven en zouden deze dus niet vervreemdend voor bezoekers moeten zijn. Tot slot worden de gespreks- en reflectie na het AR-verhaal ingezet om de bezoeker te stimuleren zelf betekenis te geven aan dat wat ze net hebben ervaren. Op deze manier krijgen bezoekers een nieuwe kijk op het anders stilstaande artefact.

Invulling binnen restricties

Hoewel er theoretisch aan de verschillende aspecten van de visie wordt voldaan, is het ook van belang om te reflecteren op de invulling hiervan binnen de gestelde restricties aan het ontwerp. Voldoet het uiteindelijk ontwerp hieraan? En waar liggen de kansen voor verbetering? Om beter inzicht te krijgen in de manier waarop er rekening is gehouden met de restricties, zijn deze met kleur gemarkeerd. Tabel 2 geeft deze reflectie weer.

- 🔴 Er is onvoldoende rekening gehouden met de restrictie, waardoor verdere ontwikkeling en evaluatie nodig is.

- 🟡 Er is gedeeltelijk rekening gehouden met de restrictie. Verdere ontwikkeling en/of evaluatie is vereist voor realisatie van het ontwerp.
- 🟢 Er is voldoende rekening gehouden met de restrictie. Het is aannemelijk dat weinig tot geen verdere ontwikkeling en/of evaluatie is vereist.

Tabel 2: Reflectie op de toepassing van restricties in het ontwerp

Systeem restricties Restricties aan de interactie, technologie en uiterlijke onderdelen van de exhibit.	
1: Integratie in de operationele ruimte	
🟡 1. De exhibit zal voorkomen dat bezoekers de kunstnier aan kunnen aanraken.	*Het ontwerp plaatst de kunstnier in een afgesloten vitrine. Het uiteindelijke ontwerp van deze vitrine zal verder moeten worden gedefinieerd.*
🟢 2. De exhibit zal geen gebruik maken van directe, harde belichting op (het lichtgevoelige cellofaan van) de kunstnier.	*Het ontwerp maakt geen gebruik van directe, harde belichting op de kunstnier. Er is met opzet niet gekozen voor AR middels projecties.*
🟡 3. De exhibit zal de kunstnier toegankelijk houden voor (routine) onderhoudswerkzaamheden.	*Het ontwerp houdt een zijde van de vitrine volledig vrij, waar toegang mogelijk kan worden gemaakt voor onderhoudswerkzaamheden. Het uiteindelijke mechanisme hiervoor zal verder moeten worden gedefinieerd.*
🟢 4. De exhibit zal een stand-alone ervaring bieden. Bezoekers zullen niet actief te hoeven worden begeleid door personeel om de ervaring te doorlopen.	*Het ontwerp kan zonder toezicht van personeel door bezoekers worden ervaren. Monitoring van losse onderdelen of gebruikte technologie is niet vereist.*

● 5. De exhibit zal de mogelijkheid bieden voor een groep (max. 15 personen) om het artefact te bekijken tijdens museumrondleidingen.	*Het ontwerp houdt een zijde van de vitrine volledig vrij. Hier kan een groep tijdens museumrondleidingen staan om de kunstnier te bekijken zonder dat het AR scherm daarbij in de weg staat. Een rondleider van het museum heeft aangegeven deze ruimte in het ontwerp te waarderen.*
2: Integratie in de fysieke ruimte	
● 6. De exhibit zal passen in de sfeer van de zaal en opgaan in het lichte, frisse en ruimtelijk ontwerp hiervan.	*Het ontwerp sluit aan bij de lichte en frisse sfeer van de zaal. Stakeholders bevestigen deze visuele aansluiting. De haalbaarheid en verdere specificatie van het ontwerp (kleurgebruik, materialen, etc.) zal echter door een ruimtelijk ontwerper moeten worden bepaald.*
● 7. De exhibit zal spelen met de metafoor van een ziekenhuiszaal die in de grotere zaal wordt weerspiegeld.	*Het ontwerp maakt gebruik van de metafoor van een ziekenhuiszaal in het AR-verhaal. Het gevoel van zich bevinden in Stadsziekenhuis Kampen tijdens het AR-verhaal wordt namelijk versterk doordat de rest van de zaal in het museum al een ziekenhuis representeert. Een stakeholder gaf verder aan dat het bewegen van het scherm aanvoelt als "scannen", wat goed past in het medische beeld.*
● 8. De exhibit zal een digimagazine bevatten die voldoet aan de ontwerprichtlijnen die gelden voor alle digimagazines in de zaal.	*In het ontwerp is er plaats gemaakt voor het digimagazine. De exacte invulling van dit magazine vereist verdere aandacht.*
● 9. De exhibit zal een grondoppervlak van maximaal 2200 mm x 1500 mm beslaan.	*Het ontwerp beslaat een grondoppervlak van ongeveer 2000 mm x 1520 mm. Het definitieve fysieke ontwerp zal door een ruimtelijk ontwerper moeten worden vastgesteld.*

● 10. De exhibit zal staand worden gebruikt door bezoekers, maar wel toegankelijk blijven voor rolstoelgebruikers	*Bezoekers bewegen het AR scherm in het ontwerp staand. Met de indeling van dit scherm is rekening gehouden met de FOV van zowel staande als in rolstoel zittende gebruikers. Hoe toegankelijk het daadwerkelijk bewegen van het scherm is voor rolstoelgebruikers zal moeten worden getest.*
● 11. De exhibit zal geen gebruik maken van audio die bezoekers van andere exhibits in de zaal stoort.	*Het ontwerp maakt gebruik van directionele audio. Hierdoor zal naar verwachting enkel de exhibit naast de kunstnier ("Diagnose") geluidsoverlast ervaren. Aangezien de exhibit "Diagnose" geen gebruik gemaakt van audio met gesproken tekst, wordt verwacht dat de mate waarin bezoekers zich gestoort voelen beperkt zal zijn. De daadwerkelijke overlast en hinder die bezoekers hieraan ondervinden, zullenafhangen van de gekozen speakers en moeten dus verder worden getest.*
● 12. De exhibit zal bestand zijn tegen onvoorzichtigheid en ruw gebruik van bezoekers.	*In het ontwerp zijn geen kleine en losse onderdelen verwerkt. Het AR scherm is groot en heeft duidelijke affordances, aldus de gebruikerstest. Echter, de uiteindelijke robuustheid van de exhibit zal worden bepaald door het definitieve ontwerp van het schuifmechanisme en het scherm.*
3: Integratie in de educatieve ruimte	
● 13. De exhibit zal gebruik maken van technologie die in dienst staat van de leerervaring. De focus van de bezoeker ligt op de leerinhoud, niet op de technologie zelf.	*Het ontwerp maakt gebruik van AR. Om de nadruk op de inhoud te leggen, is er bewust gekozen voor een enkele degree-of-freedom in het ontwerp (DOF). Dit limiteert de mogelijkheid van bezoekers om met de technologie te "spelen". Om de informatieoverdracht te ondersteunen, maakt het ontwerp gebruik van een combinatie van gesproken audio en visualisaties die gelijktijdig afspelen.*

	Aldus de Redundancy Principle, Signalling Principle en Temporal Contiguitigy Principle van Mayer's 12 Principles of Multimedia Learning (Mayer, 2014), geeft deze combinatie de gebruiker optimale mogelijkheden om te leren. De gebruikerstest doet vermoeden dat de focus voldoende op de leerinhoud ligt. Of dit voor elke doelgroep geldt, zal verder moeten worden onderzocht.
14. De exhibit zal gebruik maken van technologie die in dienst staat van het artefact. De focus van de bezoeker ligt op het artefact, niet op de technologie zelf.	*Het ontwerp maakt gebruik van AR. De visuele aandacht van de bezoeker ligt op het artefact en de ondersteunende informatie laag die daar overheen wordt getoond. De grootte van het scherm kan bijdragen aan een groter gevoel van immersie en verbinding met het artefact. De succesvolle informatieoverdracht betreffende de werking van de kunstnier in de gebruikerstest, impliceert dat gebruikers voldoende aandacht hebben voor het artefact tijdens de ervaring. Of dit voor elke doelgroep geldt, zal verder moeten worden onderzocht.*
15. De exhibit zal geen geïsoleerde leerervaringen promoten en biedt bezoekers de mogelijkheid om de exhibit samen te ervaren (met minimaal 2 personen).	*Het ontwerp maakt gebruik van een groot scherm in combinatie met directionele audio. Naar verwachting zou een groep van maximaal 4 personen gelijktijdig het AR-verhaal kunnen beluisteren. Bovendien stimuleren de gespreks- en reflectiestarters aan het eind van het AR-verhaal expliciet sociale interactie en discussie. Het willen delen van de ervaring met anderen kwam ook in de gebruikerstest naar voren. De mate waarin en manier waarop groepsinteracties echt plaats zullen vinden, zal moeten worden getest.*
16. De exhibit zal geen gebruik maken van persoonlijke mobiele apparaten die de museumervaring verstoren.	*Het ontwerp maakt geen gebruik van persoonlijke mobiele apparaten.*

17. De exhibit zal comfortabel en intuïtief gebruikt kunnen worden door bezoekers. Benodigde cognitieve inspanningen zullen waarde toevoegen aan de (leer) ervaring.	*Aldus de gebruikerstest, is het gebruik van het ontwerp relatief comfortabel en intuïtief. De benodigde cognitieve inspanningen die AR met zich meebrengen, kunnen worden verantwoord middels het enthousiasme van respondenten over deze functionaliteit. Het grootste obstakel in het huidige ontwerp ligt in de navigatie (te danken aan UI elementen die onjuiste verwachtingen wekken). In hoeverre het AR scherm comfortabel kan worden verplaatst door bezoekers vereist ook verder onderzoek.*
Inhoudelijke restricties Restricties aan de inhoudelijke onderdelen van de exhibit.	
1: Integratie in de fysieke ruimte	
18. De inhoud van de exhibit zal, gemiddeld gezien, binnen twee minuten door bezoekers kunnen worden opgenomen. Aanvullende inhoud zou mogelijk aan ontdekkers kunnen worden verstrekt.	*Uit de gebruikerstest is gebleken dat de totale ervaring ongeveer 4-5 minuten beslaat, in plaats van de beoogde twee minuten. Dit komt voornamelijk omdat de lengte van het audioverhaal is onderschat. Een copywriter en de conservator kunnen, aan de hand van het inhoudelijk concept, het audioverhaal inkorten.*
2: Integratie in de educatieve ruimte	
19. De inhoud van de exhibit zal geschreven zijn op het niveau van een 12- tot 15-jarige.	*De huidige teksten in het ontwerp zijn nagelopen met een copywriter om deze op niveau te krijgen. Een copywriter met een achtergrond in museumteksten zou verdere verbetering aan kunnen brengen voor het definitieve script.*
20. De inhoud van de exhibit zal in het Nederlands en Engels worden verstrekt.	*In het ontwerp is er rekening gehouden met de mogelijkheid om taalinstellingen te veranderen. De inhoud van het ontwerp is op dit moment echter enkel in het Nederlands geschreven.*

Conclusie en aanbevelingen

In dit document is het ontwerp van een nieuw tentoonstellingsonderdeel voor de eerste kunstnier van Rijksmuseum Boerhaave gepresenteerd. In het ontwerpproces lag de focus op het creëren van een ervaring die is afgesteld op de behoeftes van de doelgroep en die van het museum zelf. Door het gebruik van AR wordt zowel de werking van de kunstnier als het team erachter belicht. Hoewel deze ervaring in detail is uitgewerkt en is getest op de gebruiksvriendelijkheid en betrokkenheid van bezoekers in het verhaal, is het ontwerp nog niet direct klaar voor realisatie. Op basis van de testresultaten en bovenstaande reflectie op de visie en restricties, zijn er een aantal belangrijke aandachtspunten geïdentificeerd voor het verder ontwikkelen van het huidige concept.

Aanbeveling #10: Betrekken van andere disciplines
Het huidige ontwerp legt de nadruk op user experience (UX) design. Met name de interacties en de algehele visie voor de ervaring zijn daarom uitgewerkt. Hoewel er feedback is verzameld en geïntegreerd vanuit andere disciplines, zoals visual design en copywriting, zullen deze gebieden bij de verdere uitwerking van het concept meer aandacht vereisen. In het bijzonder is een ruimtelijk ontwerper vereist om te kijken naar de realiseerbaarheid van het concept en de vertaling hiervan naar bouwtekeningen, rekening houdende met de restricties. Het is hierbij aan te raden om de relatief algemene restricties verder te specificeren en meetbaar te maken om dit proces te ondersteunen. Bijvoorbeeld, wat is een acceptabel geluidsniveau van de exhibit? In welke mate moet het scherm bestand zijn tegen onvoorzichtig en ruw gebruik van bezoekers? En welke specifieke kleuren en materialen zullen zorgen voor visuele aansluiting bij de rest van de zaal?

Aanbeveling #11: Wat mag dat kosten?
Kosten zijn aan de start van dit project expliciet weggelaten als restrictie, om de creativiteit van het ontwerp niet te belemmeren. Het is voor de verdere ontwikkeling noodzakelijk een inschatting van deze kosten te maken. Op basis hiervan moet er kritisch naar de haalbaarheid van het ontwerp worden gekeken en kunnen eventuele concessies worden gedaan. Het AR scherm vereist waarschijnlijk veel energie. Om de kosten te beperken, zou dit scherm bijvoorbeeld alleen aan kunnen worden gezet wanneer er daadwerkelijk bezoekers in de zaal zijn. Verder zou het bijvoorbeeld mogelijk zijn om de live video feed van het AR-verhaal, die de immersie ten goede komt, te vervangen met een opname van de kunstnier.

Aanbeveling #12: De kracht van AR
Het ontwerp maakt gebruik van AR in combinatie met directionele audio. De combinatie van doen, kijken en luisteren zorgt voor een immersieve ervaring die wordt gewaardeerd door de respondenten van de gebruikerstest. Het verwijderen van een van deze componenten in de verdere ontwikkeling van het concept zou de beoogde ervaring schaden.

Aanbeveling #13: Inkorten ervaring
De huidige ervaring duurt langer dan oorspronkelijk beoogd. Om binnen de gestelde tijdsduur te blijven, zou het audioverhaal op basis van de expertise van de conservator en copywriter kunnen worden ingekort.

Aanbeveling #14: Uitbreiding testen
De aanbevelingen uit de gebruikerstest zijn gelimiteerd. Het ontwerp zal moeten worden getest met een grotere en meer diverse groep om deze verder te kunnen valideren. Functionaliteitstesten, gericht op het daadwerkelijke functioneren van de fysieke onderdelen van de exhibit, zullen naast de gebruikerstesten moeten worden uitgevoerd. Hiermee kunnen bijvoorbeeld de stabiliteit van de AR technologie en de werking van het schuifmechanisme en het positioneringssysteem worden getest. Ook dat heeft grote invloed op de gebruikerservaring.

Op basis van deze aanbevelingen, en die vanuit de gebruikerstest, kan het team bij Rijksmuseum Boerhaave de stap naar verdere ontwikkeling en uitwerking van het concept zetten. Hopelijk zullen toekomstige museumbezoekers de kans krijgen om via AR een reis te maken naar 1945, waar het inspirerende team achter de eerste kunstnier hen opwacht om hen mee te nemen in de werking en wereld van het artefact.

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Appendix D
Roadmap

In this appendix, the roadmap detailing the OLS is presented as a guide for practitioners to shape and implement their own organisational learning path based on experiential learning principles. The roadmap starts with a brief introduction, explaining its intended audience and metaphor use and introducing the team members involved in executing the OLS. Subsequently, the two different phases of the OLS, discovery and commitment, and the steps involved in their implementation are presented. By following these steps, organisations can utilise experiential learning as a foundation to set long-term goals for broadening expertise in an emerging field, assess the desirability and feasibility of these goals and the changes they require, and actively work towards achieving them through continuous experiential learning.

Roadmap

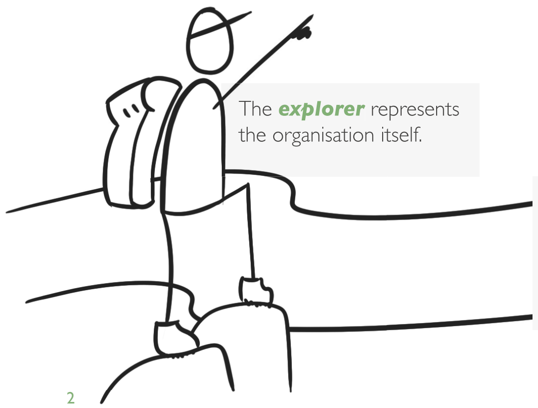
Leveraging experiential learning as knowledge management strategy in the dynamic technological landscape

Nadieh Kaldenbach | 23/04/2024

Introduction

This roadmap is for project-based organisations navigating the dynamic technological landscape that want to strategically broaden their expertise to an emerging field of interest. It is tailored specifically for practitioners responsible for steering learning within their organisation and offers concrete steps and guidelines to harness experiential learning as an organisational learning strategy. To appropriately steer this learning process, knowledge needs to be translated from an individual to organisational level whilst keeping the long-term knowledge goals and objectives of the organisation in mind. Under the right conditions, experiential learning can both help set such long-term goals in the emerging field of interest, as well as offer a subsequent practice of continuous learning to reach these objectives. Within an experiential learning cycle, learners consciously reflect, conceptualize and experiment based on an experience. This provides a structured approach to learning that is suited to develop expertise, particularly in emerging fields that are characterized by a lack of a robust theoretical foundation. In other words, the experiential learning cycle can facilitate employees to broaden their knowledge, skills, and behaviours, enabling them to do the right thing at the right time effectively and efficiently once the organization positions itself within the field of interest.

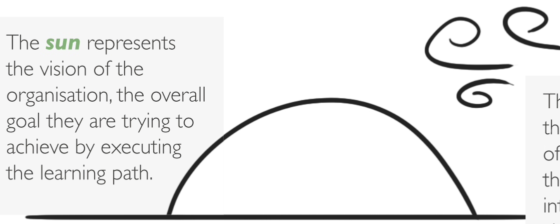
This roadmap consists of two main components: 1) a two-part global visual representation, and 2) their accompanying step guides. The visual representation offers a holistic view of the learning path, outlining the steps involved in executing the learning strategy as part of a visual metaphor centred around exploration. This metaphor is divided into two phases – discovery and commitment – and provides a shared language across the organisation to discuss and understand the learning strategy. Complementing this visual representation, the step guides provide more detailed guidance to practitioners to understand and complete each step, posing guiding questions, providing general guidelines, and identifying participating actors.



The ***explorer*** represents the organisation itself.

The ***canyon*** represents the obstacles that are in the organisation's way in realizing their vision through the learning path.

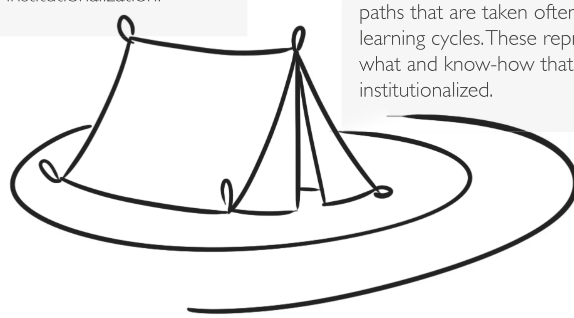
The ***forest*** represents the unknowns in the emerging field of interest. Little theoretical knowledge and practical guidance is yet available for organisations to navigate the complexities of this landscape in their daily operations. An organisation thus needs to rely on explorations within this landscape to formulate such insights for themselves. As time progresses, the forest might start to clear.



The ***sun*** represents the vision of the organisation, the overall goal they are trying to achieve by executing the learning path.

The ***wind*** represents the dynamic nature of the landscape in the emerging field of interest. This landscape changes over time.

The ***camp*** represents the centre of learning within the organisation. It is the space in which and time when knowledge workers can come together to interpret and integrate their knowledge and work towards its institutionalization.



The ***circular learning path*** represents the experiential learning cycle. The path in the forest is obstructed from view, as the exact steps taken in this landscape will differ each learning cycle. Over time, well-trodden paths will take shape in the landscape – paths that are taken often throughout the learning cycles. These represent the know-what and know-how that is becoming institutionalized.

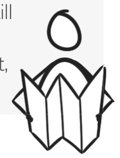
Meet the team

To effectively leverage experiential learning as knowledge management strategy for broadening organisational expertise, several key actors have been identified. Building upon the metaphor, this learning team includes
expedition leaders, scouts, navigators, explorers, guides, and the campsite crew. It is imperative for each organisation to determine the optimal allocation of these roles within their own organisational structure. It is important to note that the roles as presented here are not mutually exclusive. A single individual could take on multiple roles and groups could represent a single role. Where expedition leaders, scouts, navigators, and explorers form the core of the learning team, guides and the campsite crew are recommended for optimal learning processes. To execute the first phase of this roadmap, ensure at least one expedition leader and scout have been identified. Further division of team roles and allocation of these happens in *2. Formulate a vision* and *4. Set up camp* respectively.

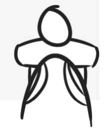
Expedition leaders
Management responsible for the formulation of a vision and for the facilitation of its execution. Expedition leaders set the right culture of trust and motivation and create time and space for learning to take place. They are responsible for determining which learning path direction to pursue and set up desired competencies along this path.

Scouts
The knowledge workers send ahead to explore the landscape of an emerging field of interest. They are responsible for gathering information that can help formulate a vision and the obstacles that might be encountered in realizing this vision.

Navigators
Employees responsible for the practical execution of sustained learning cycles. Navigators translate competencies to concrete learning outcomes for explorers. They steer the learning path and set up different expedition teams based on their past experiences, current competencies, and the defined learning outcomes. Furthermore, they facilitate continuous reflection with knowledge workers to determine if the learning path and camp set-up are still right. If not, navigators instigate a meeting with expedition leaders to initiate change. In other words, the navigator serves as a type of middle management, translating between the overall vision and practical learnings of explorers.



Explorers
The knowledge workers that partake in continuous expeditions. Explorers are part of an expedition team that picks specific learning outcomes with the navigator (preparation). Based on the desired outcomes, an appropriate experience is formulated and executed (learning cycle). The intended and unintended outcomes of this cycle are assessed with the navigator (assessment).



Guides
Experienced explorers in a particular subject that want to share their findings with other expedition teams, either through providing short guided expeditions (e.g. hosting a workshop) or through providing input before/ during expedition cycles. The most well-rounded guides become the experts of the organisation.

Campsite crew
Employees that provide coaching and supervision to help explorers reflect during and after their completed expeditions.

Phase 1: Discovery

The aim of this phase is to assess the desirability and feasibility of broadening organisational expertise in an emerging field of interest. Through an initial experiential learning cycle, insight is created into the strategic opportunities and operational impact that this expansion affords **(1. Understand the landscape)**. These insights can then inform the formulation of strategic objectives and the normative and operative goals needed to realize these objectives **(2. Formulate a vision)**. Subsequently, considering the organisation's current state and resources, obstacles that stand in the way of reaching this vision can be identified **(3. Identify obstacles).** Completing these three steps sets an organisation up for an informed decision-making process: is the organisation prepared to commit to the learning path at this point in time? The answer to this question informs next steps: the organisation can either move forward towards the next phase in this roadmap, decide to revaluate the promise of learning in this emerging field in the future or reject this specific learning path altogether.

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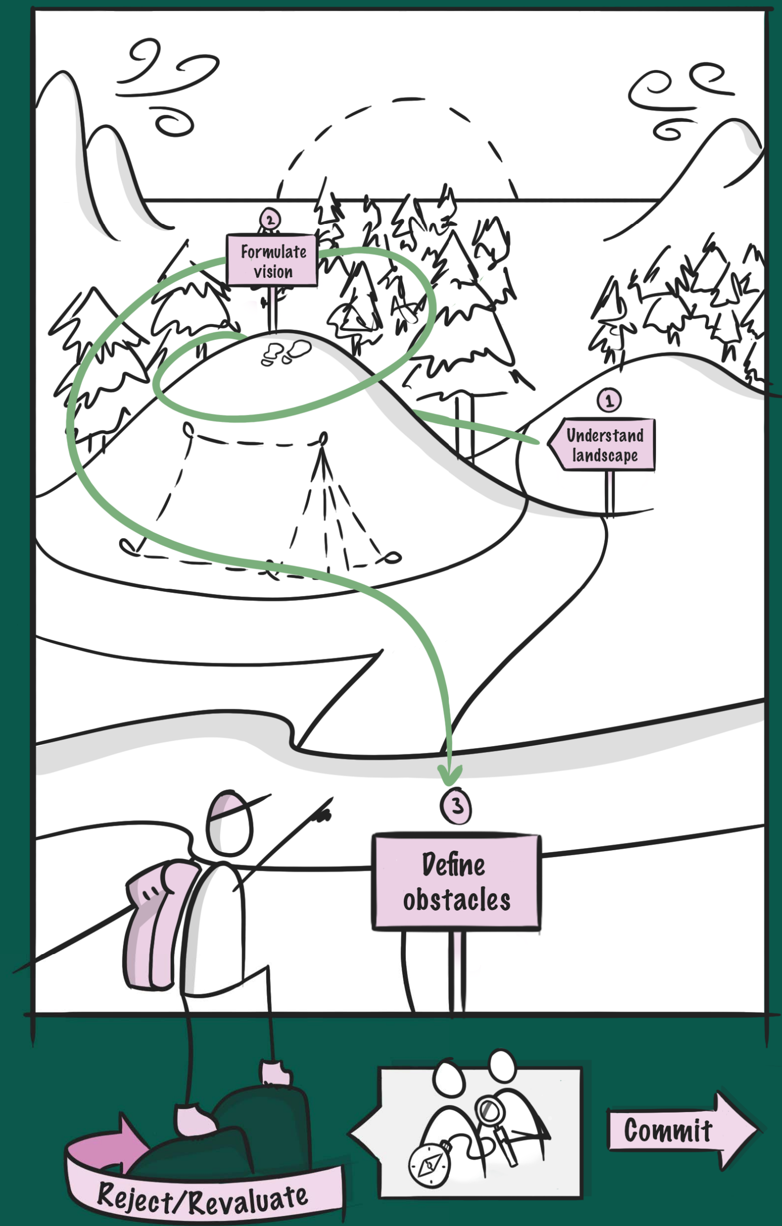

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Step 1: Intial exploration

Understand the landscape

Goal

A single experiential learning cycle in the emerging field to gain insight into the potential strategic opportunities and operational impact that the broadening of expertise to this field might have on the organisation. This cycle is completed by the scout(s) at the request of the expedition leader(s).

Guiding questions

- Based on the gained experience, where do our competencies and way of working align and where do they deviate?
- Based on the gained experience, what are the key challenges and opportunities for us in this emerging field?
- Based on the gained experience, what are the potential directions we could take our organisation in within this emerging field?

Guidelines

- Select a ***complex project scenario*** in the emerging field of interest to gain insight into the maximum potential organisational impact and to discover potential strategic directions effectively. It is easier to downscale such insights than to anticipate the impact of and opportunities within more complex project scenarios. Therefore, the selected project scenario should push the boundaries of what is normally representative of the organization's work (e.g. project type, project member responsibilities and available resources), whilst staying grounded in realism. It should leave ample room for exploration and innovation and not offer a straightforward solution direction.
- Select a project that ***covers all stages in the project lifecycle*** to holistically understand the similarities and differences between current and potential future work processes.
- Select a project for a client operating in a market in which the emerging technology already has a use case. Working with ***real-life stakeholders*** will mimic the complexity of real projects and provide insights into stakeholder management and decision-making dynamics in this new field. This makes gathered insights directly actionable and based on real-life complexities and encountered challenges.

Step 2: Looking ahead

Formulate a vision

Goal

Define a long-term vision for the broadening of expertise in the field of interest. Formulate strategic objectives based on the results of the initial learning cycle and determine what normative and operative goals might facilitate the realisation of this strategy. Whilst the expedition leader(s) are responsible for the execution of this step, the vision formulation benefits from the inclusion of the scout(s) and the input of other employees.

Guiding questions

- What value could we bring clients through the expansion of our expertise in x years?
- How do we want to position our organisation in the emerging field in x years? What is the desired technological and market maturity of the field for us at that point in time?
- How do we expect this positioning to impact our way of working in x years?
- What competencies will we need to develop to reach the desired expertise that makes this vision a reality? And how can we leverage our current expertise?
- What does the role division of our ideal learning team look like?
- What key organisational elements are needed to support the learning path that is required to develop these competencies? E.g. how and when will explorers meet and discuss to interpret and integrate their knowledge?

Guidelines

- Leverage and ***value the tacit and implicit knowledge*** of scout(s) to formulate the strategic vision. Whilst explicit knowledge (articulable knowledge housed at a conscious level) resultant from the completed learning cycle can be clearly communicated to stakeholders involved, implicit (articulable knowledge of which an individual is not directly aware) and tacit knowledge (inarticulable knowledge residing at a subconscious level) can provide valuable, albeit less straightforward, insights for the decision-making process too. These forms of knowledge may offer different perspectives or intuitive insights that enrich the formulation of a vision, albeit not being easily articulated.

- Set the vision with people from ***all levels of the organisation*** to ensure organisation-wide buy-in and to include diverse perspectives.
- Strive for an ***ambidextrous design*** of the organisation that balances exploitative and explorative processes. The organisation should fulfil both short-term goals to meet the needs of its current customers (exploitation) and pursue a long-term vision to meet the needs of potential future customers (exploration). To achieve such balance, the learning path to broaden expertise (exploration) should be separated from the efficient application of current expertise in daily practice (exploitation).
- Strive for a ***personalisation strategy*** that focuses on dialogue and centres around rich means of communication to create and share knowledge within the organisation. Value social processes over collecting, storing, and disseminating explicit knowledge (articulable knowledge residing at a conscious level).
- Strive for a ***culture of trust and motivation***. Define opportunities for mentoring and assisting and facilitate the development of intrinsic motivation that ensures individuals engage in the learning task out of their own interest rather than out of obligation.

Step 3: Peering into the canyon

Define obstacles

Goal

Delineate obstacles that stand in the way of reaching the desired vision, considering the organisation's current state and resources. Whilst the expedition leader(s) are responsible for the execution of this step, the obstacle definition benefits from the inclusion of the scout(s) and the input of other employees to provide a variety of perspectives.

Guiding questions

- What are the main obstacles in reaching our strategic vision, based on the organisation's current and future desired state and the learning path in between?

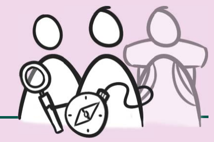
Guidelines

- Approach obstacle definition from ***two vantage points***: future organisational changes required to accommodate the broadened expertise in x years and direct organisational changes required to facilitate the learning path itself.
- Consider obstacles through a ***variety of lenses*** to understand the holistic impact of commitment to the learning path on the organisation (e.g. culture, people, processes, resources (time, finances), systems and leadership).

Time to commit?

Assess whether the broadening of expertise is desirable and attainable in this point in time. Do we want to invest in further explorations of this topic now? Whilst the expedition leader(s) hold final responsibility for this decision, it is advisable to let other stakeholders from different levels in the organisation, such as potential future explorers and other members of management, weigh in to ensure organisation-wide buy-in and to include diverse perspectives in the decision-making process. Pushing to commit to a learning path without such buy-in is likely to lead to its demise.

The answer is yes ▶
Continue to the second phase of this roadmap.



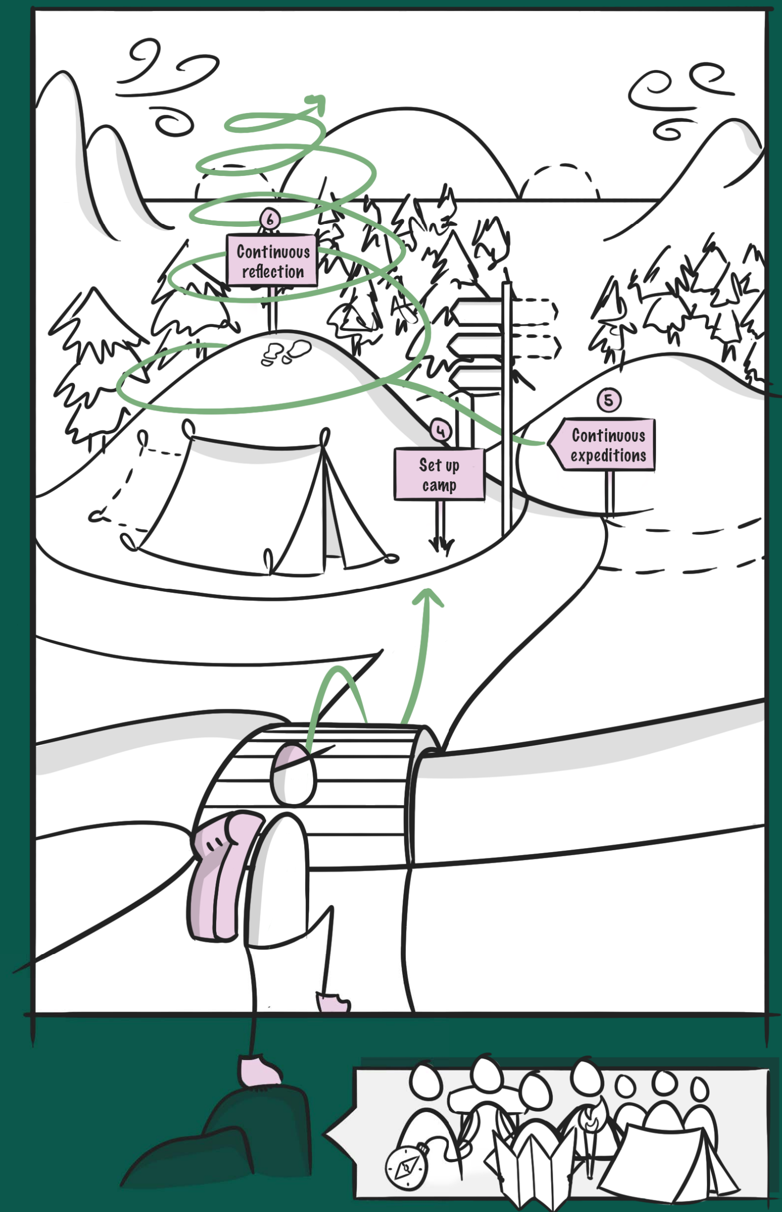
The answer is no
Does the organisation see potential value in committing to the learning path in the future?

◀ Revaluate
If explorations at another point in time are still deemed valuable, the organisation needs to revaluate the promise of this field in the future. Conditions need to be set. When will the organisation send another scout into the landscape? What obstacles need to be removed to be able to commit to the learning path?

✕ Reject
If explorations at another point in time are not deemed valuable, the organisation rejects this learning path entirely. Is there another emerging field that seems promising to explore now?

Phase 2: Commitment

If the organisation has decided to commit to the learning path, change management processes need to be applied to make this learning path a reality. Known obstacles are removed or navigated, the set vision is diffused across the organisation and made more concrete through the setting of learning outcomes **(4. Set up camp)**. These learning outcomes can be used to ensure strategic alignment in the subsequent continuous experiential learning cycles. Each cycle consists of three stages: 1) preparation, 2) going on expedition and 3) the learning assessment **(5. Continuous expeditions)**. The results of aggregated learning cycles and way in which these are facilitated are subsequently reflected upon periodically. Through ongoing reflection and adaption, the change is made sustainable and continuous learning is facilitated **(6. Continuous reflection)**.



Step 4: The right learning environment

Set up camp

Goal

Create the right learning environment in which individual learnings can be translated to organisational knowledge through group processes. Communicate the vision for change, remove the obstacles towards it to ensure its realization and allocate learning team roles based on both interest and skills. Where the expedition leader(s) are responsible for modelling and enacting change, the navigator(s) play a crucial role in translating the overall vision to concrete learning outcomes.

Guiding questions

- How can we effectively enact organisational change to facilitate the learning path?
- How can the roles within the learning team be allocated? Which employees are interested in going on expedition? Who can steer the learning process? And who can stay behind as camp crew, supporting those going on expedition?
- What concrete learning outcomes, derived from the envisioned competencies, will help us reach our desired expertise?
- When do we deem the learning path sufficiently completed to position ourselves and undertake client projects in this emerging domain?

Guidelines

- ***Spread the strategic vision*** from an organisational level to (future) explorers to provide them with a frame of reference in which to interpret their experiences.
- Ensure ***clarity of learning outcomes*** that guide explorers on their expeditions. Formulate learning outcomes in the "I" form and considering progressively higher forms of cognition. Clear intention will help explorers engage in learning cycles more deeply, focus their knowledge sharing efforts and ensure the right competencies are built.
- Run a ***pilot expedition*** before scaling up learning efforts to get feedback on whether the envisioned set-up is right and to showcase the value of the learning path for the organisation.
- ***Celebrate (early) learning successes*** to give momentum to the adoption of the learning path.

Step 5: The group learning process

Continuous expeditions

Goal

Learn continuously through several connected experiential learning cycles. Each cycle consists of three stages: preparation, execution, and assessment of learning outcomes. All learning cycles are steered and guided by navigator(s) whilst explorers are responsible for the actual knowledge work in expedition teams. Explorers may serve as guides for other explorers once they have achieved sufficient competence in a certain area. The campsite crew offers explorers support where needed.

Guiding questions

- What learning outcome is which team trying to achieve with what experience in what timeframe?
- How does this learning cycle connect to other learning cycles?
- What can the organisation learn from this cycle? What are the opportunities, obstacles, and best practices we encountered?
- Has the learning outcome been met adequately?

Guidelines

- Value ***group explorations*** over individual explorations.
- Ensure ***constructive alignment*** between the learning outcome (what is to be learned?), the learning experience (how should this be learned?) and the way in which outcomes are evaluated (two what extend is the learning outcome achieved? Constructive alignment ensures a high-quality learning process and can be achieved by making the verb present in the learning outcome central to the learning experience and assessment task.
- Motivate explorers to function as guides once they have achieved sufficient competency. By providing ***guided explorations*** (i.e. workshops) or feedback to others, learning transcends individual expedition teams.

Preparation

- Enable explorers to indicate which learning outcomes they are interested in pursuing and allow them to pursue these as they see fit to ***promote autonomy and intrinsic motivation***.

- Align the type of experience with the learning outcome whilst ***considering the impact/effort ratio***. Consider when learners need to engage in real-life problems with real-life stakeholders for an extended period and when shorter experiences in a more controlled or simulated project environment suffice.
- Ensure explorers are exposed to a ***variety of experiences*** which are not entirely disconnected from one another and fit their current competency level.
- Compose an expedition team based on their previous experiences and known competencies to ***balance team variety and shared interpretations***.

Execution

- Encourage explorers to ***engage in all four modes*** of the experiential learning cycle.
- Provide coaching and supervision to help explorers ***reflect during*** the learning cycle and enable explorers to keep track of their experience and reflections as a basis for group discussions and assessment.

Assessment

- Provide coaching and supervision to help explorers ***reflect upon*** the learning cycle to evaluate whether the intended learning outcome has been achieved.
- Leave space for desirable, but ***unexpected learning outcomes***.

Step 6: Is the learning path still right?

Continuous reflection

Goal

Periodically evaluate the result of the aggregated learning cycles and way in which these are facilitated. Adjust the vision, competency goals, learning outcomes and the structures and systems that facilitate the learning path accordingly to support continuous learning. Navigator(s) are responsible for this reflection process with input from explorers and should signal expedition leader(s) when change is required. Explorers should keep track of their competency development, supported by the campsite crew.

Guiding questions

- Are we, as an organisation, providing the right tools to our explorers to optimize learning effectiveness? Are there sufficient initiatives and activities undertaken to reach our knowledge goals?
- How are explorers progressing along the defined competencies, measured though learning outcome completion?
- What knowledge is "sticking" across expeditions and showing signs of institutionalization? Is this desired?
- Does our vision and/or set-up need to be adjustment based on the learnings we have gathered from expeditions and the reflection across them? What new obstacles and challenges can we identify that might warrant change processes to take place?

Guidelines

- Consider both ***time-based and event-based reflections***. Where regular time-based evaluations can provide a baseline for reflection and track competency speed development over time, significant changes in market circumstances or organisational resources may impact the learning path greatly. Encourage members of the learning team to request a reflection in response to unexpected developments or obstacles encountered.
- Evaluate the learning path as a ***process*** (knowledge creating activities undertaken), ***output*** (immediate knowledge results) and ***outcome*** (institutionalized knowledge) to gain a holistic picture of the current state of affairs.

- Actively ***search for and respond to obstacles*** to stay ahead of problems that might impede the learning path in the future to enhance resilience in the learning process.
- Provide coaching and supervision to help explorers understand and keep track of their own ***personal development progress*** on the learning path.
- When the learning path is deemed sufficiently completed to officially position and promote the organisation in the emerging domain, ensure knowledge workers ***keep learning from practice*** in client projects.

This roadmap was developed as part of the graduation assignment *"The Strategic Broadening of Organizational Expertise through Experiential Learning: A UX for XR Case Study"* that was completed as part of the Master's program Industrial Design Engineering at the University of Twente.

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