MOVING TOWARDS VIRTUAL IDENTITY: ENABLING ACCESSIBLE MOTION CAPTURE FOR METAVERSE USERS AND THEIR AVATARS

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Abstract

This MSc thesis explores through Design Thinking how Metaverse users can be facilitated in capturing movements for their Metaverse avatars to achieve self-expression and identity creation in the Metaverse. This problem arose from information obtained from the literature research conducted to understand how the Metaverse is structured and to create a framework for companies seeking to prepare for the Metaverse, which can be found in Appendix A. The literature review shed light on a problem faced by individual Metaverse users: motion capture equipment for capturing movements is too expensive and not accessible to Metaverse users and its avatars. Therefore, the stages of the Design Thinking process consisted of brainstorming sessions with Metaverse users and other stakeholders to generate solutions to the aforementioned problem, along with an interview with a Metaverse expert to validate these ideas. This led to two initial prototypes, which a second Metaverse expert then validated to create two final prototypes in the deliver phase of the Design Thinking process. Finally, the two final prototypes were validated by Metaverse users, contributing to the conclusion focused on how Metaverse users can capture her movements in an accessible way for her Metaverse avatars. The solutions to this problem should ultimately assist the individual Metaverse user's self-expression and virtual identity.

INTRODUCTION

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1. Introduction

The Metaverse is a concept that has been around for a long time and has received increased attention in recent years. The COVID-19 pandemic has caused digital developments to accelerate, and consequently, we spend more time online, which plays an essential role in the increased attention (JP Morgan, 2022). The term Metaverse derives from Neal Stephenson's book written in 1992. The book centers around what it looks like to spend time in the Metaverse: a computer-generated imaginary world that can be entered by putting on headphones and glasses (Macedo et al., 2022). Although this is in line with the contemporary definition of the Metaverse, there have been some changes over the years. Today's Metaverse is envisioned as an online world, primarily used by Generation Z, in which there is no longer a distinction between life offline and online (Park & Kim, 2022). Furthermore, the contemporary definition of the Metaverse refers to the use of technologies such as blockchain, which is seen as a technological pillar of the Metaverse (Gadekallu et al., 2022), and Virtual Reality (VR) and Augmented Reality (AR) to create a 3D environment (Kraus et al., 2022). In this 3D environment, users can interact with each other as avatars on different online applications (Duan et al., 2021). These 3D environments can be considered the successor of the internet nowadays. Even though the concept of the Metaverse has been around for more than two decades, there is still a lack of clarity as to whether the Metaverse exists as one or multiple Metaverses.

The ambiguity of the Metaverse also translates into how companies can leverage the Metaverse for their business operations. However, some companies are already applying the concept or an initiative revolving around the Metaverse in their business operations. For example, the Metaverse can be used for corporate branding through VR to improve branding efficiency (Chen & Yao, 2022). Another application of the Metaverse is a virtual campus replicating a real university. This Metaverse aims to enhance students' campus life by offering various incentives when participating in the University's Metaverse (Duan et al., 2021). Similarly, there are examples of applications for the Metaverse in the hospitality and tourism sectors. For example, it is possible for subscribers of National Geographic to discover world wonders through VR (Gursoy et al., 2022). These examples show that companies are slowly adopting Metaverse initiatives.

The Metaverse itself consists of serval components, where personal avatars representing Metaverse users are one of them (Deloitte, 2022). The avatars of Metaverse users here are equivalent to a personal identity where users can manifest their self-expression in these virtual worlds (Darwish & Hassanien, 2022; Joy et al., 2022)**.** The other Metaverse components are discussed in the literature review of this research. To aim at the component this research focuses on, namely the Metaverse avatars, there are some bottlenecks in creating avatars. These bottlenecks concern the difficulty for individual Metaverse users to implement users' nonverbal expressions and movements into the

avatars (Lee et al., 2021). There are, at present, motion capture technologies that can assist in capturing movements for avatars. Only the problem with these motion capture technologies is that they are too expensive for individual users to capture personalized gestures for their avatars. Furthermore, Extended Reality (XR) technologies can assist in capturing movements. The problem with these XR technologies is that the equipment is too costly and cumbersome to use (Ning et al., 2021). Therefore, it is essential to provide solutions for Metaverse users so that capturing movements for their avatars becomes less costly and more accessible.

To focus on the last-mentioned problem regarding Metaverse avatars, this research focuses on how Metaverse users can be facilitated to capture their movements without having to purchase the expensive and cumbersome motion capture equipment themselves. Hence, the following research question was formulated:

> *'How can Metaverse users be facilitated to record their movements in an accessible way for its avatars?'*

A more detailed discussion of the origin of the research question is provided in section 3.2, along with the initial research question, which can be found in table 2 in the same section. To address the above-stated problem, this research is conducted through Design Thinking. Design Thinking can be described according to Brown & Wyatt (2010) as:

> Design thinking incorporates constituent or consumer insights in depth and rapid prototyping, all aimed at getting beyond the assumptions that block effective solutions. Design thinking—inherently optimistic, constructive, and experiential—addresses the needs of the people who will consume a product or service and the infrastructure that enables it (p. 32).

Research through Design Thinking starts with an unknown concept and tries to obtain new knowledge through other concepts (Razzouk & Shute, 2012). Obtaining new knowledge is aligned with abduction-2, which is discussed in more detail in section 3.1.1. Furthermore, the design process is viewed as modifying the problem statement with newly generated information to design a fit between the problem and the solution (Braha & Reich, 2003). It is essential in Design Thinking that multiple solutions are considered concerning the goal of creating solutions for the problem statement, which can then be modified through an iterative process until an ideal solution is obtained (Razzouk & Shute, 2012).
Since this research is conducted through Design Thinking, the Double Diamond model, illustrated in figure 1, is applied as guidance during the process. In this process, the issue is approached by divergent thinking focused on examining the issue more deeply and broadly (Council, 2019). Subsequently, convergent thinking occurs in the process focused on executing the action (Council, 2019). Moreover, the Double Diamond consists of four distinct phases: discover, define, develop, and deliver. These

phases are divided into two diamonds where convergent and divergent thinking occurs for each diamond.

Concerning the phases: the *discover phase* focuses on understanding the problem, after which the insights from the *discover phase* are used as a starting point in the *define phase* to reframe the problem statement in this phase (Council, 2019). The discover and define phase comprises the first diamond. Then in the *develop phase*, answers to the redefined problem are sought to arrive at a new design, followed by the *deliver phase* in which solutions are tested, improved and, where necessary, rejected (Council, 2019). Moreover, in the develop phase, a first prototype is delivered as a solution to the research question, on which feedback is collected in the deliver phase to arrive at a final prototype. The develop and delivery phases comprise the second diamond.

Lastly, utilizing the Double Diamond does not involve a linear process. This is because when more is revealed about the underlying problem, it is normal to go through the Double Diamond process again.

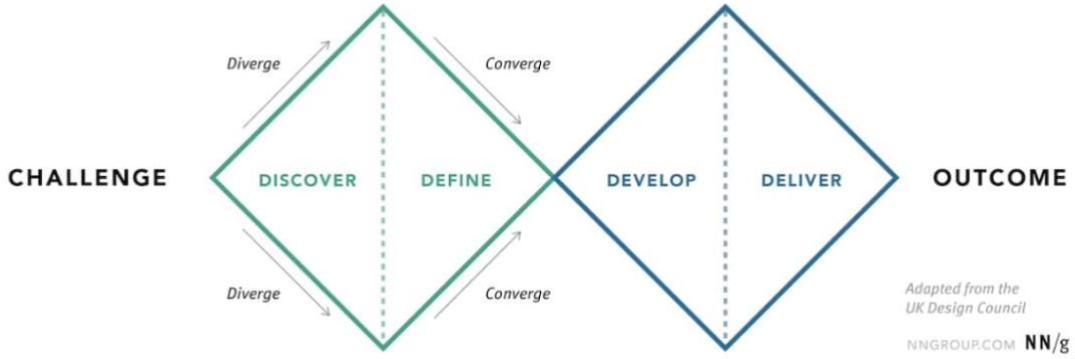

Figure 1: The Double Diamond Model (Douglas, 2021)

Figure 1 shows the Double Diamond model with the four distinct phases of the Design Thinking process. Figure 2 shows the Design Thinking process followed in this research with the steps taken in the different phases. During this research, each phase contains a separate chapter. Herein the methodology used for each phase is discussed.

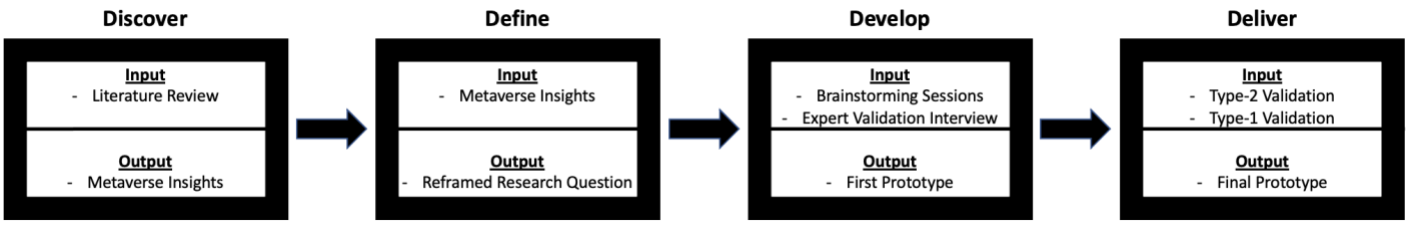

Figure 2: Overview processes of this research

Practice-Based Design Research and Action Research

The process of reframing in the define phase is seen as a design-based approach. Since reframing in the define phase is an integral part of the research, the design-based approach is an addition to the Design Thinking process. Hence the separate description of Design Thinking and the design-based approach.

Design-based approaches can help mix practices across disciplinary areas, ultimately providing innovation to respond to problems (Dorst, 2018). Design-based research focuses primarily on gaining new knowledge about how the practice is constructed to enhance it (Candy, 2006). Moreover, according to Alturki et al. (2012, as cited in Goldkuhl, 2013, p.7), design-based research 'addresses an abstract or a class of problems for a class of organizations and stakeholders'. When carrying out design-based research, the emphasis lies on iterations based on the evaluations of the activities performed (March & Smith, 1995). Hence, during this research, the knowledge generated during the phases must be constantly evaluated to extract different problem statements. Subsequently, a prototype can be generated for the reframed problem statement based on the evaluations of the generated information. Since this research aims to contribute to general practice rather than local practice, this design-based research can be perceived as a practice-based approach (Iivari & Venable, 2009).

In essence, practice-based research has similarities with design-based research, namely: 1) practice-based research aims to acquire new knowledge as well but in cooperation with practice and the outcomes of that practice (Candy, 2006), and 2) in practice-based research, the results and activities carried out need to be evaluated too (Goldkuhl, 2013). Additionally, practice-based research is a tool for translating obtained research results into practice (Marabelli & Vaast, 2020). Thus, practice-based research can serve as a bridge between academia and practice. However, according to Saikaly (2002), practice-based research does not comply with fixed procedures. This is mainly because design practice aims to uncover new ways to implement insights. To conduct practice-based research properly, researchers can apply action research during design processes as a guide (Saikaly, 2002). Action research itself can be defined as research where action and reflection, and practice and theory converge and where the research is conducted in collaboration with stakeholders to ultimately generate solutions to issues (Reason & Bradbury, 2001, as cited in Brydon-Miller et al., 2003). Furthermore, action research aims to transform experiences into data that can be used in the process of scientific reflection (Levin, 2012).

Since this research involves collaborating with stakeholders in the develop and deliver phase to generate knowledge, and since there are evaluations of the actions performed, this research adopts action research. Hence, there is a section in each chapter concerning the four phases where the reflections on the actions taken are discussed and iterated upon. Reflections on the actions performed are essential for the researcher to consider what exactly was performed, which falls under reflection-

on-action, and what exactly happened while performing the actions, which falls under reflection-in-action (Schön, 1982, as cited in Tan, 2020). Reflection-in-action is seen as a solid complement to reflection-on-action as it allows the practitioner to react during the actions being performed, which can make a difference in the result (Tan, 2020). Furthermore, reflection-on-action and reflection-in-action can contribute to reframing the problem statement since there is a constant interaction between the actions performed and the reflection during and after the practitioner's actions (Schön, 1982, p. 131, as cited in Tan, 2020). This interaction ultimately leads to new insights. The reflective sections of the research's phases focus mainly on reflection-on-action since the actions performed are evaluated afterwards. In case reflection-in-action has occurred in the phases contributing to the research, it has also been discussed in the reflective section of the Design Thinking phases.

Outline Research

This research is structured as follows: chapter 2 discusses the discover phase. This phase focuses on the literature review conducted on the Metaverse. In addition, the methodology of the literature is discussed here, along with reflections on the literature review conducted.

Next, chapter 3 discusses the define phase. In this phase, the literature review was analyzed, which resulted in the reframing of the initial research question leading to the current research question, discussed in the introduction. Furthermore, this chapter discusses the methodology of abduction-2, reframing and the reflections on the steps taken in this phase.

Next, chapter 4 addresses the develop phase. In this phase, two brainstorming sessions and an expert interview were conducted to create the first prototypes. In this chapter, the brainstorming sessions and the expert interview are discussed along with the corresponding methodology. Moreover, this chapter focuses on the first prototype that was delivered. The first prototypes, along with their methodology, are discussed in this chapter as well. Lastly, this chapter concludes with a reflection on actions taken in this chapter.

The last chapter related to the Double Diamond model is chapter 5, which addresses the deliver phase. In this phase, the prototypes of the develop phase were first validated by an expert. This then led to the final prototypes, which users then validated. In this phase, the results of the expert interview and the final prototypes with user validation are discussed. The corresponding methodology is also discussed at the beginning of the section. Lastly, the actions taken in this phase are reflected upon.

Finally, a conclusion is given in Chapter 6 on the entire process, in addition to implications, limitations and areas for future research.

DISCOVER PHASE

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2. Discover Phase

The first phase in the Double Diamond model is the discover phase. This phase focuses on divergent thinking aimed at understanding the problem (Council, 2019). To better understand the problem related to the research question, a literature review was first conducted on the Metaverse. The goal of the literature review was to gain an understanding of how the Metaverse is currently structured and what it entails. Subsequently, this gained insight into various uncertainties and bottlenecks of the Metaverse. This allowed the initial research question to be reframed into the research question focused on facilitating the capturing of movements of the avatars of Metaverse users. The reframing is addressed in the define phase.

2.1. Methodology Metaverse Literature Review

In this phase of the Design Thinking process, a description of what the Metaverse entails is provided through available literature. This can be seen as a literature review, defined as an evaluation of the existing literature on a particular topic (Knopf, 2006). The literature review was conducted to gain information about how the Metaverse is structured and what it entails. Furthermore, the literature review ensured that problems and uncertainties of the Metaverse emerged.

To obtain the information for the literature review, the Web of Science database was used first. Here (''Metaverse'') was used as the search term. It was decided to use only Metaverse as the search term and conduct an unsystematic literature search since it is a relatively new concept. Therefore, there are a limited number of articles that address the research question that is formulated. The articles used for the review are from 2021 and 2022, as the most significant developments have occurred recently. Articles that described the Metaverse in depth were selected for the literature review articles. Therefore, many articles were inapplicable as they briefly mentioned the Metaverse and did not contain any valuable information. This may be because only ''Metaverse'' was used as a search term.

Secondly, business reports were used for the literature review. These business reports are from major consultancy companies and banks such as Boston Consulting Group, Deloitte, McKinsey and JP Morgan that have created the reports to focus on the future vision of the Metaverse. The reports, combined with articles from the Web of Science database, provided a view of the vision for the Metaverse.

2.2. Literature Review

This section analyzes the Metaverse literature to gain an understanding of how the Metaverse is currently structured and what it entails. This section is structured as follows: first, it discusses the

definition of the Metaverse and Web 3.0. Then the associated technologies are covered along with the Metaverse components. After covering the Metaverse technologies, the focus is on existing and future business models and niches in the Metaverse. Then, Metaverse bottlenecks and uncertainties are covered. Finally, several steps are discussed on how companies can prepare for the Metaverse.

2.2.1. Definition Metaverse

The Metaverse is a part of the next generation of the internet in which the virtual world will be interwoven with the physical world (Bobier et al., 2022; McKinsey & Company, 2022; Riva & Wiederhold, 2022) and where there is active participation rather than people just watching stuff (McKinsey & Company, 2022). The Metaverse should be realized through various technologies, discussed in section 2.2.2., that will enable the creation of 3D worlds (Davis, 2022; Hirsch, 2022). These 3D worlds act as public spaces where users can meet each other. The 3D worlds that are created are seen as an additional layer on the internet that will enable users to expand and improve their social lives (JP Morgan, 2022). The expansion of users' social lives can be facilitated, for example, by using avatars, which represent the user shaped by their wishes (Darwish & Hassanien, 2022; Joy et al., 2022). The avatars can own assets from clothing to animated actions by the users. In addition to Metaverses' focus on users' social lives, it is also a world where content creators and artists can express their passion by contributing to Metaverse's content (Hirsch, 2022; Joy et al., 2022). So, the Metaverse is not only a virtual world where new use cases are emerging for users but also a world that should provide new business models for companies (Bobier et al., 2022; Davis, 2022). This is one of the reasons why the Metaverse has become attractive to companies in such a short time.

To further elaborate on what the Metaverse entails, some requirements have been formulated by Parisi (2022) to clarify the Metaverse's vision. These requirements state that there should be only one main Metaverse as a successor to the internet that is accessible to everyone. Moreover, Parisi state that it should be an always-open network offering collective control where users with different types of hardware can always enter. Additionally, besides the requirements of Parisi, the Metaverse must provide an immersive feeling through real-time interactions over which the users have complete control (McKinsey & Company, 2022). However, there is another view on the Metaverse besides the perception that there is a single Metaverse. In this view, the Metaverse consists of multiple Metaverses, with interoperability between them being the principle (Bobier et al., 2022; McKinsey & Company, 2022). In these different Metaverses, it must be possible for thousands of people to be in contact with each other simultaneously to carry out various activities that go beyond gaming (McKinsey & Company, 2022). So, there are different visions of the Metaverse regarding whether it consists of one Metaverse or several.

Web 3.0

A concept often mentioned in conjunction with the definition of the Metaverse is Web 3.0, which proceeds two generations of the web. Web 1.0 took place from 1994 to 2004 and represented users who only used the web to read content from static web pages released by publishers (Bobier et al., 2022; McKinsey & Company, 2022). Subsequently, Web 2.0 emerged, which allowed people not only to consume content but also to create content and connect with others via the web (Bobier et al., 2022; McKinsey & Company, 2022). A characteristic of Web 2.0 is that the distribution of all content is made possible by centralized networks. In the emerging Web 3.0, content is still consumed and produced, but the content and associated networks are managed and created by the users themselves (Bobier et al., 2022; McKinsey & Company, 2022). The vision is that Web 3.0 should be enabled by decentralized technologies such as Blockchain (Bobier et al., 2022) and decentralized entities that create the content allowing for virtual social interaction (Schmidt et al., 2022). So, Web 3.0 aims to create a new web where decentralized units manage everything. The Metaverse as a virtual 3D world plays a significant role in this, but the Metaverse is not Web 3.0 itself but a building block for Web 3.0 (Schmidt et al., 2022). Accordingly, the Metaverse plays a supportive role in this transition from Web 2.0 to Web 3.0.

2.2.2. Technologies and Ecosystem Components

Several technologies are mentioned with the development of the Metaverse. These technologies must ensure that the Metaverse can be realized. Hence, the technologies related to the Metaverse are called transformational technologies, which aim to change people's perceptions of reality (Riva & Wiederhold, 2022). This section discusses the technologies related to the developments of the Metaverse. Moreover, this section discusses which components the Metaverse ecosystem can include. The bottlenecks of the discussed technologies will be addressed later in the literature review.

AR/VR/MR

The technologies most often mentioned in association with the Metaverse are Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). These technologies are also called Extended Reality (XR). XR is intended to ensure the transition from 2D to 3D by providing realistic digital experiences (Bobier et al., 2022). XR must also ensure that the virtual world meets the physical world. The convergence of the two worlds can be done, for example, by mobile user interaction techniques using XR to ensure that users can interact in virtual environments (Lee et al., 2021). Interaction with virtual worlds is further enhanced by other techniques, such as multi-model feedback cues that can provide haptic feedback while using XR (Lee et al., 2021) and via spatial sounds implemented in XR headsets

(Bobier et al., 2022). These techniques are designed to give users a better sense of realism and presence.

Among the XR technologies, there are differences in the use cases surrounding the Metaverse. For example, VR should allow users to interact with each other by representing themselves with their avatars, and AR should enhance real-world environments by, for example, providing instructions on objects when focused on them in AR (Darwish & Hassanien, 2022). Furthermore, MR should provide a bridge between AR and VR by, for example, allowing users to use virtual objects outside the virtual worlds (Darwish & Hassanien, 2022). Here the objects outside the virtual world must be interconnected.

There are also some bottlenecks among the XR technologies. The technological bottlenecks will be discussed later in the literature review. Although there are bottlenecks, the developers are working hard to make XR more accessible. For example, XR devices are becoming more power efficient and affordable, contributing to a better user experience (JP Morgan, 2022). Other technologies in combination with XR are also being explored. These include sensors to project the real-time movements of the user when using XR and technologies to provide a replica of the user in the form of an avatar (Riva & Wiederhold, 2022).

Blockchain

Besides the XR technologies, blockchain is also often mentioned in conjunction with the Metaverse. In this, the view is that blockchain will play an essential role in developing the Metaverse. For example, blockchain technology can ensure that all data is stored securely in a decentralized manner (Darwish & Hassanien, 2022). Furthermore, blockchain can provide a virtual economy in the Metaverse, enabled by cryptocurrencies and non-fungible tokens (NFTs) (JP Morgan, 2022; Mystakidis, 2022). A possible use case for NFTs in the Metaverse is that NFTs can enable the creation of a digital replica of a tangible product that can be used in the virtual environment (Treiblmaier, 2021). On the other hand, companies can use cryptocurrencies as issuance, allowing customers to buy assets in the Metaverse (Baumann et al., 2015, as cited in Boukis, 2020). So, these are examples of how blockchain can create a virtual economy. Furthermore, blockchain can help with interoperability when there are multiple Metaverses (Lee et al., 2021). Here, blockchain technology can facilitate the transfer of assets from one Metaverse to another (JP Morgan, 2022).

Other use cases of blockchain are that users who own currencies can, for example, vote on changes in the governance of the respective platform (JP Morgan, 2022). It could also be that no actual companies are in charge but a Decentralized Autonomous Organization (DAO). The DAO, in turn, ensures that proposals submitted by currency owners are approved or rejected (JP Morgan, 2022). Furthermore, blockchain technology can offer the possibility of providing credit to users in the

Metaverse when using its currencies as collateral (JP Morgan, 2022). This is also known as Decentralized Finance (DeFi).

Artificial Intelligence

Artificial Intelligence (AI) may also play an influential role in the developments surrounding the Metaverse. For example, AI can provide automation through deep learning, which can help designers and operators in the Metaverse (Lee et al., 2021). Furthermore, AI can create virtual people with language, text and the ability to recognize images (Deloitte, 2022). These virtual people aim to contribute to the users' experience in the Metaverse (Darwish & Hassanien, 2022). Lastly, AI can take care of processing all data generated by users in the Metaverse (Darwish & Hassanien, 2022). AI can therefore be combined with blockchain, where blockchain takes care of the secure storage of the data and AI with processing it.

Computing Technologies

To render and process everything happening in the Metaverse, it is necessary to have enough computing power. One of the computing techniques is computer vision. Computer vision ensures that all visual information of the performed activities of the users and the corresponding environment can be understood and subsequently acted upon (Lee et al., 2021). For this reason, computer vision is also seen as a technology that can be classified as AI. Furthermore, edge and cloud computing must reduce network latency to provide a streamlined user experience for users of the Metaverse (Deloitte, 2022; Lee et al., 2021). Quantum computing can also be a computing technology which can provide the ability to process all the data (Deloitte, 2022). However, quantum computing is still in development. The final computing technology which can contribute to the Metaverse is spatial computing. Spatial computing can allow computers to be controlled by people using speech and gestures (Mystakidis, 2022).

Other Technologies

Besides the technologies mentioned above, other technologies can play a role in constructing the Metaverse. One of these technologies is a digital twin. Digital twins give the possibility to make replicas of products or machines to provide information about how to design them and information on how they function over time (Darwish & Hassanien, 2022). Moreover, via digital twins, organizations gain insights into operational details, such as when the machine needs maintenance (Deloitte, 2022). To make the connection to the Metaverse, digital twins can contribute here by making replicas of reality and implementing them in the virtual world (Darwish & Hassanien, 2022).

The Internet-of-Things (IoT) is also described as a technology related to the Metaverse. This technology occurs more in combination with other technologies, such as XR. Here, IoT can provide the

blending of the real and virtual world when, for example, using XR technologies (Darwish & Hassanien, 2022).

Another essential technology relates to the network. When the Metaverse is used on a large scale, it is vital that the network on which it runs can handle all the traffic so that there are no throughput and latency issues (Lee et al., 2021). The processing of all traffic on the Metaverse network is also related to the necessary computing technologies.

The last technology concerns game engines. Game engines contribute to the development of 3D worlds and platforms and the experiences in these 3D worlds and platforms (McKinsey & Company, 2022).

Ecosystem Components Metaverse

For the Metaverse, there is already a vision of which technologies will play an important role. Apart from the technologies, there is also a vision of what the ecosystem of the Metaverse should contain. According to Lee et al. (2021), the first component of the Metaverse ecosystem is users' avatars that capture their appearance. The essence is that everyone will have an avatar with personalized assets that the user has paid for (Deloitte, 2022). The second component of the Metaverse is content creation. Here, all stakeholders work together to create the content for the Metaverse, which subsequently should lead to the creation of virtual worlds for the users (Lee et al., 2021). In addition, the Metaverse should also allow users to create their own content through the tools provided by the platforms and give users the ability to devise rules (Deloitte, 2022). The latter could be facilitated by the DAO on the blockchain. The third component, according to Lee et al. (2021), is virtual economies. These virtual economies include similarities with the economic system in the real world today and provide the opportunity for new jobs in these virtual worlds (Chiu, 2021).

Furthermore, the fourth component of the Metaverse revolves around social acceptability. This includes the behavior of Metaverse users, along with opinions about the policies and actions being carried out by users (Lee et al., 2021). The fifth component of the Metaverse ecosystem relates to security and privacy. Here, it is mainly about the security and privacy of the digital assets of Metaverse users and how users should identify themselves when entering the virtual world (JP Morgan, 2022; Lee et al., 2021). Furthermore, because the Metaverse is always online and being developed by user-created content, it is expected that the data amount released will increase. This amount of data also concerns the security and privacy of users (Deloitte, 2022). The final component of the Metaverse ecosystem relates to trust and accountability. As indicated earlier, the Metaverse is likely to generate more data. Here, it is essential that the users' data is processed properly and does not end up in the wrong hands (Lee et al., 2021).

2.2.3. Existing Business Models

The developments around the Metaverse are in progress. This has led to several business models related to the Metaverse. In this section of the literature review, current business models are discussed, as well as future business models that companies can leverage.

One of the business models that already exist in the Metaverse is focused on fashion (Davis, 2022). Users of the Metaverse have the possibility to buy clothes for their avatars (JP Morgan, 2022). Consumers are focused on fashion in the Metaverse because the avatars are a sign of self-expression, creativity, status and a form of exclusivity (McKinsey & Company, 2022). So, companies can capitalize on the demand for clothes in the Metaverse. Additional advantages of fashion in the Metaverse are low production costs, no supply-chain issues, high margins, and a way to develop brand engagement (McKinsey & Company, 2022).

Another business model relates to the real estate market. Currently, buying land plays a vital role in existing Metaverses such as Decentraland and Sandbox (McKinsey & Company, 2022). It is expected that the real estate market will capitalize on this by selling pieces of land in the Metaverse as they do now in the real world (JP Morgan, 2022). Buying land in the Metaverse is aimed at consumers who can buy land with real money to, for example, build houses and at companies who can acquire land to establish their virtual business (Deloitte, 2022).

As mentioned, the creator economy has a significant share in the Metaverse. Existing business models are focused on the creator economy concerning the creation of virtual products that contribute to the overall development of the Metaverse (JP Morgan, 2022). The entertainment industry is also an industry that is established in the Metaverse. These business models relate to virtual concerts or other musical expressions (JP Morgan, 2022) and gaming, which already has a large share of the Metaverse (Davis, 2022; McKinsey & Company, 2022).

The Metaverse also offers opportunities for companies operating in the business-to-business market. For example, the Metaverse can provide a test environment for companies to test their products and entire factories (JP Morgan, 2022; McKinsey & Company, 2022). The testing of products and factories can be done using digital twins. Furthermore, in addition to testing the products, companies can also design products in a Metaverse environment focused on a use case in the real world (McKinsey & Company, 2022). Finally, companies in the financial sector can also use the Metaverse for their activities by applying blockchain technology (McKinsey & Company, 2022).

Business Models to Leverage

As described, there are already business models active in the Metaverse that companies can capitalize on. In addition to the existing business models, it is expected that in the coming years, the Metaverse will offer new business models to which companies can respond.

Overview of Business Models in various Sectors

As mentioned earlier, the Metaverse enables the design and testing of products and factories. This will play an even more critical role for manufacturing companies in the future (McKinsey & Company, 2022). In combination with technologies such as AI and digital twins, the Metaverse offers the possibility to gain insight into the functioning of systems and machines (Darwish & Hassanien, 2022). Nowadays, higher costs are involved in the shorter life cycles of products and the increase of product variants. By testing products in advance in the virtual environment, costs can be saved on these aspects (Darwish & Hassanien, 2022).

Currently, gaming also plays an influential role in the Metaverse and is expected to have an even more significant influence in the future (McKinsey & Company, 2022). For example, gaming in the Metaverse offers the possibility of developing new games through blockchain technology and making difficult jobs easier to perform through gamification (Darwish & Hassanien, 2022).

In addition to gaming being a learning environment in the Metaverse, this also applies to education. For example, the Metaverse can enhance online education by implementing an online 3D campus to improve the online learning experience of students (Mystakidis, 2022). According to Darwish & Hassanien (2022), this creates new opportunities for collaboration between students and new possibilities for teachers to provide learning materials.

The healthcare sector is the next sector where opportunities arise for companies. The Metaverse, as a virtual world, should facilitate the healthcare sector to see real-time changes in the body parameters of patients (Darwish & Hassanien, 2022). In this scenario, the Metaverse is used as a monitoring tool. Furthermore, digital twins can be used to practice medical care (Deloitte, 2022), and through VR and digital twins, doctors can practice medicine (Yang et al., 2022). Finally, the Metaverse can contribute to the healthcare sector by providing remote diagnostic reports of patients (McKinsey & Company, 2022) and building prediction models for patients (Deloitte, 2022).

Other sectors in which new business models are emerging for companies in the Metaverse are related to the culture and art sector and smart cities. For example, virtual exhibitions for the culture and art sector can be held in the Metaverse, where customers can use VR to view the exhibition (Darwish & Hassanien, 2022). In addition, VR can provide additional information about the artefacts on display in the virtual exhibition. Furthermore, focused on smart cities, it is possible to run simulations for the smart cities to obtain, for example, information on environmental data (Darwish & Hassanien, 2022).

The final sector that can capitalize on the Metaverse to develop new business models is the e-commerce sector. Here, companies can interact with customers in the virtual world to sell their products (Darwish & Hassanien, 2022). The offering of the products or services in the Metaverse can

be made through traditional monetization models such as advertising, subscription offers and in-app purchases, as well as newer models such as specific Metaverse marketing, advertising agencies and initial asset offerings (Bobier et al., 2022). Concerning marketing to users in the Metaverse, it is expected that mainly Generation Z will utilize these virtual worlds (Bobier et al., 2022; Joy et al., 2022). Lastly, with the developments in the Metaverse, new opportunities arise for companies to establish new commercial partnerships (Hirsch, 2022). So, with the emergence of the Metaverse, new approaches are created for companies to engage with their target audience.

Niches in the Metaverse

In addition to new business models emerging for companies in specific sectors, there are also business models focused on niches that companies can capitalize on. The first niche companies can capitalize on is offering virtual assets in the Metaverse (Bobier et al., 2022). As indicated earlier, specific sectors such as the fashion industry will play an essential role in this, but also the creator economy that can provide the design and issuance of these digital assets. Moreover, the virtual asset economy will contribute to newly available employment in the Metaverse (JP Morgan, 2022).

The second niche relates to the technology used in the Metaverse. For example, the Metaverse needs software and hardware support focused on XR technologies (Bobier et al., 2022). Furthermore, there will be required technologies in the Metaverse that can contribute to the personalization of avatars with movements and other expressions (JP Morgan, 2022) and blockchain technology to contribute to the overall virtual economies and communication infrastructure (Bobier et al., 2022; JP Morgan, 2022). The last required technologies are aimed at processing the data in the Metaverse to contribute to the cloud and network infrastructure (Bobier et al., 2022). So, companies that can provide the required technologies to the Metaverse can offer them to stimulate the developments.

There are also two other niches that companies can exploit. The first niche is focused on regulations in the Metaverse that are currently still unclear (JP Morgan, 2022). The other niche concerns privacy and security protection for users in the Metaverse (JP Morgan, 2022). Hence, companies operating in the context of regulation and privacy and security can enter these niches to contribute to the Metaverse.

2.2.4. Bottlenecks Metaverse

Before all the opportunities that the Metaverse brings can be exploited, bottlenecks must also be resolved. In this section, the bottlenecks and uncertainties of the Metaverse are discussed. This section focuses on 1) technological bottlenecks and bottlenecks caused by technology, 2) ethical bottlenecks, 3) privacy and security bottlenecks, and 4) bottlenecks in the eco-system of the Metaverse. In addition,

the uncertain factors of the Metaverse are discussed with a specific focus on uncertain factors centered around governance.

Technological Bottlenecks and Bottlenecks Caused by Technology

The first technological bottleneck arises in the use of XR, particularly in the use of VR. For example, VR can cause health problems. Examples of health problems are cybersickness which can cause nausea and dizziness (Bobier et al., 2022; Mystakidis, 2022), sore muscles due to prolonged use of VR hardware, addiction leading to body neglect (Mystakidis, 2022), and mental health problems (Davis, 2022). Furthermore, using AR can lead to user distraction, resulting in accidents in specific scenarios (Mystakidis, 2022). Besides health problems, XR also brings other bottlenecks. These bottlenecks focus on further developing the technology to lower the high cost of the equipment (Davis, 2022; Mystakidis, 2022) and preventing information from being manipulated when using XR to avoid biases (Mystakidis, 2022).

In addition to the XR technology bottlenecks, the same holds for blockchain and AI. There are currently environmental and scalability issues for blockchain because the data is processed through the Proof of Work (PoW) consensus mechanism (Lee et al., 2021). Therefore, it is vital to explore how blockchain should be applied in the Metaverse with respect to sustainable energy to prevent environmental damage (Davis, 2022). However, one of the largest blockchains, Ethereum, is moving to the chain that runs on the Proof of Stake (PoS) consensus mechanism. This transition is being done to prevent environmental damage, as is currently the case with the Bitcoin and Ethereum networks running on PoW (Castor, 2022). So, there are developments in progress. Another issue raised by blockchain technology concerns the privacy of users. This arises because the data is accessible to everyone (Lee et al., 2021). Furthermore, the AI bottleneck refers to the computing power required by devices that cannot process it (Lee et al., 2021).

The last technologies where bottlenecks need to be solved for the Metaverse are network and computing technologies. Currently, the networks are still too slow (McKinsey & Company, 2022). Therefore, the network on which the Metaverse runs needs to become faster to process everything properly. Furthermore, the computing power is currently too weak and needs to be improved to understand and process complex 3D environments (Darwish & Hassanien, 2022; Lee et al., 2021; McKinsey & Company, 2022). So, XR, blockchain, AI, the network, and computing technologies must be further developed for proper implementation in the Metaverse. Furthermore, it must be considered that people do not currently trust and accept some technologies (Darwish & Hassanien, 2022). The trust and acceptance of the technologies are also essential for developing the Metaverse.

Ethical Bottlenecks

The developments of the Metaverse also create ethical bottlenecks. One of these bottlenecks is related to cyberbullying. In the Metaverse, discriminating material can be sent around to bully other Metaverse users (Chesney et al., 2009; Darwish & Hassanien, 2022; Davis, 2022; Lee et al., 2021; Senthilvelkumar, 2013). In addition to cyberbullying, cybercrime can also occur in the Metaverse (Lee et al., 2021). Therefore, it is important to set standards, guidelines and regulations for these aspects and ensure enforcement to prevent damage to Metaverse users and their assets (Darwish & Hassanien, 2022; Davis, 2022).

Furthermore, through algorithms, it is possible to create VR deep fakes of other users, which can lead to identity theft (Mystakidis, 2022). Therefore, research needs to be done on how to block the algorithms to prevent identity theft. Finally, the Metaverse should establish regulations and guidelines for social inequalities and racism (Darwish & Hassanien, 2022; Davis, 2022) and guidelines for people with disabilities to ensure everyone can access it (Darwish & Hassanien, 2022).

Privacy and Security Bottlenecks

Nowadays, there are many issues concerning the processing of customer data. This privacy problem is no different for the Metaverse. Since the Metaverse is an always-online environment in combination with technologies linked to the IoT, this will generate a considerable amount of data. Therefore, it is essential that the processing of all data and personal information has proper guidelines and regulations to guarantee the privacy of Metaverse users (Christopoulos et al., 2021; Darwish & Hassanien, 2022; Davis, 2022; Lee et al., 2021; Riva & Wiederhold, 2022)**.**

While privacy in the Metaverse is of importance to users, the same applies to security. As mentioned earlier, cybercrime in the Metaverse must be addressed to prevent data hacking (Davis, 2022) and the theft of digital assets (Davis, 2022; Lee et al., 2021). Therefore, cybercrime must be enforced. Furthermore, the Metaverse must provide an easy way for users to authorize themselves when entering the various virtual worlds (Lee et al., 2021). Lastly, the design of the decentralized governance of censorship needs to be addressed (Lee et al., 2021). So, before the Metaverse can be a safe experience, guidelines and regulations still need to be drawn up to guarantee the privacy and security of users.

Ecosystem Bottlenecks

The overall Metaverse ecosystem also raises bottlenecks. One of these bottlenecks concerns the virtual economy, which relates to the issue of cryptocurrencies to what extent they will offer functionalities and to what extent these virtual currencies can be trusted (Lee et al., 2021). Therefore, further research needs to be done on how cryptocurrencies can be implemented reliably and safely in

the Metaverse. The issuance of cryptocurrencies also relates to the developments surrounding blockchain technology in terms of what role this technology will play.

Other bottlenecks related to the Metaverse ecosystem concern accessibility and scalability. As indicated earlier, the Metaverse must be accessible to everyone, with users with disabilities being no exception (Davis, 2022). Furthermore, the scalability of the Metaverse also needs to be improved to streamline the throughput and processing of the complex virtual worlds (Darwish & Hassanien, 2022). Scalability is an important aspect that needs to be optimized to enhance the user experience. Improved computing technologies could contribute to this.

The creation of avatars to represent users also faces bottlenecks. Although this is also more of a technological bottleneck, the issue here is mainly how non-verbal expressions and movements of users can be implemented in the avatars and how the avatars interact with other technologies and devices of the IoT (Lee et al., 2021). When the performance of avatar movements can be improved, it allows users to express themselves better, develop online communities, and build social identity (Dwivedi et al., 2022). This can ultimately lead to better user engagement in the Metaverse. Furthermore, avatars can enhance the experience of online work environments by enabling more authentic team communication through personalized emotions and movements of the avatars (Zhou et al., 2022). At present, there are motion capture technologies that can implement movements and expressions in users' avatars, but these technologies have so far been too expensive for individual users to utilize. Also, when using XR technologies to record movements, it is challenging for the individual user to use as the devices can be quite cumbersome and expensive (Ning et al., 2021). Therefore, further research must be done to make it cheaper and easier to record movements for Metaverse users' avatars.

2.2.4.1. Unknown Factors of the Metaverse

The Metaverse presents not only bottlenecks but also other unknown factors that need to be addressed. The first unknown factor relates to standardization. These issues focus on how the interoperability between platforms will be shaped in the multiple Metaverses scenario concerning the virtual economy, digital goods, the identity of users between platforms, and standards for the design and programming of the platforms (Davis, 2022). Furthermore, there should also be a standardization for utilizing the various technologies to enable interoperability in the Metaverse (McKinsey & Company, 2022). The second unknown factor concerns the user interface. These questions are based on how the interface of the Metaverse will interact with our daily physical lives and how user-friendly this will be (Davis, 2022).

Furthermore, the third unknown factor relates to market fragmentation. These factors focus on market leader distribution, the degree of competition, and what use cases the platforms have that

companies can specifically capitalize on (Davis, 2022). So, these three categories of unknown factors should be considered in the future development of the Metaverse.

Furthermore, there are also uncertain factors among executives which emerged from a survey among 3,400 consumers and executives on Metaverse adoption, behavior shift and its potential. The top three uncertainties are 1) uncertainties about the profits to be made in the Metaverse, 2) no clear business model to act upon, and 3) lack of management capacity to apply technologies related to the Metaverse in the company (McKinsey & Company, 2022). These three factors about executives' views on the Metaverse should also be considered.

2.2.4.2. Metaverse Governance

The governance of the Metaverse is another uncertain factor. The unknown governance factors relate to specific platform governance, the regulation of transactions, liability issues, and the protection of users' digital assets (Davis, 2022). Other essential factors for governance are access to the Metaverse, competition for innovation and technologies, distribution and monetization models between stakeholders, intellectual property rights, security and privacy of users and how equality between users is ensured (McKinsey & Company, 2022). These challenges do not yet have concrete answers, but these governance challenges need to be addressed to stimulate the development of the Metaverse.

The underlying key question regarding Metaverse governance is whether it will be governed by companies, the government or by technologies such as AI (Deloitte, 2022). Furthermore, blockchains using DAOs can provide a solution for participation in governance by issuing tokens (JP Morgan, 2022). These tokens can determine the degree of access for governance participation in the Metaverse in a decentralized manner. So, the extent to which technology will play a role in governance is also a fundamental challenge that needs to be addressed. To keep up with governance challenges, policymakers must plan so that a guideline on how to govern the Metaverse can be issued on time (McKinsey & Company, 2022). Here, policymakers must keep up with technological developments.

2.2.5. How to Start

The Metaverse covers many different aspects. Furthermore, there is still a significant amount of ambiguity about exactly what the Metaverse will look like, which business models can be exploited, which technologies will be implemented, and how the existing bottlenecks and unknown factors will be tackled. Therefore, it is useful for companies to know how they can prepare for and orientate to these new virtual worlds.

The first step for companies is to devise strategies to enter the Metaverse (Davis, 2022; Wagner & Cozmiuc, 2022). In these strategies, companies should consider whether the Metaverse affects them positively or negatively (Bobier et al., 2022), learn what it entails (JP Morgan, 2022) and set goals (McKinsey & Company, 2022; Wagner & Cozmiuc, 2022). In addition, they have to determine which target group they will focus on and what their interests are (Davis, 2022; Wagner & Cozmiuc, 2022) and design various scenarios to discover opportunities in the market (JP Morgan, 2022; Wagner & Cozmiuc, 2022). Furthermore, technologies also play a role in the strategy. Here, companies should monitor the development of technologies (Davis, 2022) and look at how the technologies can contribute to their goal (Wagner & Cozmiuc, 2022). Also, companies should look at how the Metaverse will affect them financially (Hirsch, 2022; McKinsey & Company, 2022). So companies need to identify areas where they can deliver value from their capabilities (Bobier et al., 2022).

After determining a strategy, companies need to look at implementation opportunities. For example, companies can look to bring digital content and assets to the market to create experiences for customers that can contribute to the market share (Bobier et al., 2022; Davis, 2022). Here digital assets can be complementary to physical assets (Joy et al., 2022). Besides marketing digital assets, companies can also help build the Metaverse infrastructure (Bobier et al., 2022). This could include supplying the necessary technologies. Furthermore, internal developments are also crucial to get employees to commit to the Metaverse (JP Morgan, 2022), as well as external developments to establish an ecosystem with partners (Bobier et al., 2022; JP Morgan, 2022).

To get the workforce to move toward the Metaverse, companies can implement actions. For example, companies can purchase technological hardware such as VR glasses to give employees a sense of the developments (Bobier et al., 2022). Furthermore, companies can set up a team of people from different departments with expertise (Bobier et al., 2022; Hirsch, 2022). This team can focus on managing all data, outline privacy and intellectual property protection scenarios, and monitor regulatory developments (Hirsch, 2022).

Furthermore, it is also necessary to monitor how the overall implementation is going (Davis, 2022; Hirsch, 2022; McKinsey & Company, 2022), with special attention to how customers are interacting with the company (McKinsey & Company, 2022) and how to maintain customers' trust (Davis, 2022). It is also essential that the implementation is done responsibly concerning the environment, customer privacy and accessibility (Davis, 2022). After carefully monitoring the implementations, companies can look at scaling up the previous implementations (McKinsey & Company, 2022).

So, companies should start with small steps. The first steps should include strategic planning for the implementation. Subsequently, customer and employee engagement should be monitored, as

well as the entire implementation, before companies can scale up. A visualization of what companies can do to start with Metaverse initiatives can be found in Appendix A.

2.3. Reflection on Action Discover Phase

In the discover phase, a literature review was conducted to gain insight into what the Metaverse entails. This literature review ensured that different aspects of the Metaverse were identified, such as 1) the definition of the Metaverse and Web 3.0, 2) the technologies associated with the Metaverse, 3) different ecosystem components, 4) existing and future business models focused on sectors, 5) the Metaverse uncertainties and bottlenecks, and 6) ways companies can prepare for the Metaverse.

Since the Metaverse is a fairly new concept, there is a scarcity of academic articles that go deep into how the Metaverse is structured. Since the Metaverse has received a significant amount of attention recently, at the time of writing, only articles from the years 2021 and 2022 were used. For this reason, information may be missing in the literature review from articles written before 2021. Hence, only Web of Science database articles from 2021 and 2022 focusing on what the Metaverse entails were used in the literature review. However, many articles were technical in nature that wanted to apply, for example, a blockchain or VR solution to the Metaverse. As a result, these articles did appear in the search results since (''Metaverse'') was used as a search term, but these technical articles were not used for the literature review since they did not contribute to the in-depth question of what the Metaverse will look like in the future. Further, besides scientific articles, several reports from major banks and consultancy companies were used. These reports were a good addition to the scientific articles allowing for a solid frame of what the Metaverse will look like.

As mentioned, the literature research has led to insights into various Metaverse components with related uncertainties and bottlenecks. As a result, an initial research question could be reframed into the current research question focused on capturing movements for the avatars of Metaverse users. The process of reframing is part of the define phase in the double diamond model. Hence, the process of reframing is discussed in the next section.

DEFINE PHASE

03

3. Define Phase

The second phase in the Double Diamond model is the define phase. This phase focuses on convergent thinking, where the insights from the discover phase are used as a starting point to define the problem statement in this phase differently (Council, 2019). Hence, this phase focuses on how the initial research question was reframed and how the current research question was established. Furthermore, this phase mainly reflects on the methodology used to reframe the initial research question.

3.1. Methodology Define Phase

Several methodologies were used to reframe the initial research question. This section reflects on why this research is a form of abduction-2, what Dorst's (2010) 'four layers of practice' model entails and why it is utilized in reframing. Next, this section discusses the origin of the reframed problem statement. Lastly, the reframing process from the perspective of the reframed research question is described, enabled by Dorst's (2010) 'four layers of practice' model.

3.1.1. Abduction-2

Since only the end value is known – a solution for Metaverse users to make it more accessible to capture movements for their Metaverse avatars – this research is a form of Abduction-2 (Dorst, 2010). Abduction-2 distinguishes itself with Deduction, as here the 'What' and the 'How' are known, and with Induction, where the 'What' is known (Dorst, 2010). This is the counterpart of Abduction-2, as here, only the end value is known, whereas, with Deduction and Induction, one works towards the end value. Furthermore, the difference between Abduction-1 and Abduction-2 is that in Abduction-1, the 'Value' and the 'How' are known (Dorst, 2010). The 'How' is the working principle that functions as a tool to achieve the 'Value' (Dorst, 2010). The unknown 'How' in Abduction-2 indicates the difference between the two Abduction approaches. In Table 1, a formulation of deduction, abduction and induction can be found.

Deduction	What + How = ?
Induction	What + ? = Value
Abduction-1	? + How = Value
Abduction-2	? + ? = Value

Table 1: Formulation deduction, induction and abduction (*Dorst, 2010)*

This research is a form of abduction-2 since the 'What' and the 'How' are unknown and need to be uncovered. The only thing known is the ‘Value’. Section 3.3 discusses in more detail the application of abduction-2 in this research.

3.1.2. The Four Layers of Practice

An essential aspect of Design Thinking is the framing of problem statements. Dorst (2010) describes the process of framing as follows:

> 'Framing' is the term commonly used for the creation of a novel standpoint from which a problematic situation can be tackled—this includes perceiving the situation in a certain way, adopting certain concepts to describe the situation, patterns of reasoning and problem solving that are associated with that way of seeing, leading to the possibility to act within the situation (p. 134).

Furthermore, reframing can be a tool for understanding underlying complex problems (Dorst, 2018). In the process of reframing, it is vital to obtain feedback through interventions (Dorst, 2018). Ultimately, the interventions should lead to the identification of existing relationships regarding the reframed problem statement.

After reframing the problem statement, Dorst's (2018) *'the four layers of practice'* is used to uncover the 'What' and 'How' central to Abduction-2. The four layers of the model entail 1) the value attempted to be obtained, 2) the strategies and principles for obtaining the value, 3) the methods for achieving the goal, and 4) the actions as part of the practice (Dorst, 2018). Hence, the first two layers are the *'Why'*, the third layer is the *'How'*, and the fourth is the *'What'*. Moreover, the model of Dorst (2018) aims to establish solutions to the problem statement while considering multiple actions. Considering multiple actions brings advantages since the most reasonable action does not necessarily have to reach the appropriate value. Additionally, taking several actions into account helps in the process as different values can be obtained (Dorst, 2018). This process of reframing is seen as a design-based approach that can help mix practices across disciplinary areas, ultimately providing innovation to respond to problems (Dorst, 2018).

In section 3.2, an explanation of why the initial research question was reframed to the current one is discussed. Next, section 3.3 discusses the reframed research question from Dorst's (2018) *'the four layers of practice'* perspective.

3.2. Origin Reframed Research Question

The research started to create a framework focusing on how organizations could prepare to enter the Metaverse. Subsequently, a literature review was conducted to gain insights into how the Metaverse is constructed and what it entails to clarify which step companies can take to enter. Hence, a visualization of how companies can prepare can be found in Appendix A.

Through the conducted literature review, it emerged that currently, the existing motion capture equipment is either too expensive or too cumbersome for individual users making it difficult for them to capture the movements of their Metaverse avatars. Therefore, it is not accessible to Metaverse users preventing them from implementing their nonverbal expressions and movements in their avatars, even though this is an essential aspect of personalizing avatars. So, through the literature review, light was shed on a fundamental problem focused on capturing movements for the avatars of Metaverse users.

This problem was also acknowledged by the internship company where the researcher did his internship. The internship company is a leading supplier of high-quality inertial motion capture equipment. Furthermore, the acknowledgement of the problem statement came through organic conversations the researcher held with employees of the internship company. The employees of the company indicated that, due to the high equipment prices, they operate only business-to-business rather than business-to-consumer. Therefore, the high-quality equipment that Metaverse users should utilize to capture movements for their avatars is not accessible due to high prices. As stated, this is a fundamental problem because of the personalization aspect of the Metaverse. Accordingly, the problem statement is reframed to the reframed research question in Table 2. The organic conversations between the researcher and employees are not documented; therefore, the problem of high prices is substantiated by the literature review conducted.

Initial research question	*'How can companies dynamically prepare themselves to become Metaverse-ready?'*
Current/reframed research question	*'How can Metaverse users be facilitated to record their movements in an accessible way for its Metaverse avatars?'*

Table 2: Initial and current research question

3.3. Four Layers of Practice of Reframed Research Question

As stated, framing is a tool used to understand underlying problems. This is why it has emerged that motion capture equipment is not accessible to Metaverse users to capture movements for their avatars. For this reason, a key principle of the Metaverse cannot be fulfilled; personalizing your digital identity.

In Table 3, the new frame from the perspective of the 'Four Layers of Practice' can be found aimed at making capturing movements more accessible to Metaverse users and its avatars. In this, the 'Why', as in the value and principle, are known, but the 'How' and 'What' needs to be composed in the subsequent phases of this research. Hence, this research is a form of abduction-2 since the 'How' and

'What' are unknown. How the 'How' and 'What' are composed will be discussed in section 6.1, where the discussion section of this research can be found.

Why (Values)	Making motion capture equipment more accessible for Metaverse users
Why (Principles)	Enabling personalization and self-expression in the Metaverse
How (Methods and Tools)	?
What (Action)	?

Table 3: The Four Layers of Practice: New Frame

3.4. Reflection on Action Define Phase

The purpose of the literature review was to obtain information about what the Metaverse will look like, what it entails and how companies should prepare for it. This subsequently allowed the reframing to be carried out on the initial research question. The action taken to get to the new frame of the research question was analyzing the literature review. This analysis revealed that personalized avatars are an essential part of the Metaverse. Only personalizing avatars brings some bottlenecks, as mentioned earlier. The bottlenecks also became evident during the research through organic conversations with employees of the researcher's internship company who operate in the motion capture industry by providing high-quality equipment. The internship company allowed the researcher to interact with the motion capture equipment, ultimately leading to better empathizing with the problem.

So, by connecting the literature review and the environment where the researcher conducts his research, the research question could be reframed. Thus, the bottlenecks regarding the inaccessibility of capturing movements for Metaverse users' avatars have emerged through the two actions performed in the define phase, namely: 1) analyzing the literature review and 2) organic conversations with people operating in the corresponding market.

DEVELOP PHASE

04

4. Develop Phase

The third phase in the Double Diamond model is the develop phase. After convergent thinking in the define phase, this phase focuses on divergent thinking aiming to generate answers to the redefined problem to ultimately arrive at a new design or prototype (Council, 2019). The essence of the develop phase is to generate as many ideas as possible, focusing on the research question to work through the best ideas into prototypes subsequently. So, in this phase, many ideas were generated aimed at facilitating Metaverse users to capture movements for their Metaverse avatars in an accessible way. A Metaverse expert then validated these ideas from the two brainstorming sessions during an interview to determine which ideas could be prototyped. So ultimately, the brainstorming sessions and the validation interview with the expert resulted in an initial prototype.

This chapter will elaborate on the two brainstorming sessions, the expert interview for validating the ideas for the prototype and the first prototype created. In addition, the associated methodology is discussed first in section 4.1. This also addresses why an initial prototype was created in this phase aimed at making capturing movements more accessible to Metaverse users and its avatars.

4.1. Methodology Develop Phase

In the develop phase, several methodologies were used. This section covers the methodology used for the two brainstorming sessions, the methodology for the validation interview for determining the prototype idea with the Metaverse expert and the methodology for the first prototype.

4.1.1. First Brainstorming Session

In this phase, brainstorming sessions were chosen to collaborate with respondents with a Metaverse background to generate as many ideas as possible since they can empathize with the problem, allowing for a clear understanding of the need. Brainstorming can be defined as the generation of ideas in a team environment to come up with solutions to design problems (Interaction Design Foundation, n.d.). Brainstorming sessions often involve 'How should we' questions to produce several ideas to make connections to potential solutions (Interaction Design Foundation, n.d.). To make connections to solutions aimed at the proposed problem statement, a brainstorming session was conducted with an audience with a background matching the research question. The goal of the first brainstorming session was to generate as many solutions as possible to make motion capture more accessible to the avatars of Metaverse users. The solutions from the first brainstorming session act as a starting point to subsequently develop the solutions further during the Design Thinking process to ultimately provide an interpretation of the 'How' and 'What' central to obduction-2. To generate solutions, a 'How should

we' question was formulated during the first brainstorming session, which aligns with the research question.

The first brainstorming session took place with respondents who have a Metaverse background. Respondents with a Metaverse background were chosen since they have some knowledge of the Metaverse and can better relate to the research question. The respondents from the first brainstorming session were all men (n = 5) from the Netherlands (n = 5) with an average age of 24.6 years (MIN = 23 years, MAX = 26 years). Furthermore, respondents spend an average of 14.2 hours (MIN = 1 hour, MAX = 30 hours) per week on related Metaverse activities. Related Metaverse activities include research, investing, work-related activities, and spending time in online virtual worlds.

Furthermore, the brainstorming session took place in Microsoft Teams and Miro. Miro is an online tool that functions as a digital whiteboard that can facilitate collaborative brainstorming sessions (InnovationTraining., n.d.). The brainstorming session began with an approximately 15-minute presentation to familiarize respondents with the research question and context. Respondents then spent 25 minutes for themselves brainstorming ideas focused on the reframed research question. Finally, for 20 minutes, respondents collectively came up with ideas. It was chosen to have the respondents brainstorm ideas for themselves first since, otherwise, they were likely to copy things from each other. If the choice had been made to have all respondents discuss together from the beginning, there was a high probability that the phenomenon of groupthink would occur. Group thinking is a phenomenon where the group reaches a prompt agreement on a particular solution without consultation or discussion (Mueller et al., 2022). For this reason, it was chosen to have the respondents of the first brainstorming session first generate ideas for themselves focused on the problem statement so that there was no agreement on a particular idea from the beginning. This ultimately resulted in the respondents coming up with several ideas independently without biasing each other. The results of the first brainstorming session are discussed in section 4.2.1.

4.1.2. Second Brainstorming Session

After the first brainstorming session with Metaverse users, a second session was conducted with employees of the researcher's internship company. This brainstorming session served as a follow-up stage to the first session. The purpose of this brainstorming session was to 1) determine which ideas from the first session were relevant and feasible and 2) to further develop the best ideas from the first session. Hence, a second brainstorming session was chosen since brainstorming can facilitate idea generation, which was the premise of generating applications and modifications on the ideas from the first brainstorming session.

So, the second brainstorming took place with employees of the researcher's internship company. This was chosen since they are familiar with the technology and internal developments focused on the Metaverse and can therefore use their expertise to come up with ways to facilitate Metaverse users in making capturing movements more accessible for their Metaverse avatars. This was chosen because they are familiar with the technology and internal developments focused on the Metaverse and, therefore, can use their expertise to further advance the ideas from the first session focused on how Metaverse users can be facilitated in capturing movements more accessible for their avatars. Furthermore, it was chosen to select employees from different departments to have a mix of expertise related to the research question. The job titles of the employees are marketing manager (n = 1), UX designer (n = 2) and software engineer (n = 1). This mix of employees allowed for thinking about how to monetize the idea, how the user experience would be structured, and what software would be required to create the solution.

Furthermore, three men (n = 3) and one woman (n = 1) attended this brainstorming session whose average age was 34.3 years (MIN = 27, MAX = 51). In addition, the average number of hours they engaged in Metaverse-related activities here was lower than the first brainstorming session, which was 5.3 hours per week (MIN = 0, MAX = 21). This is because, internally, the UX designers and software engineers are not directly tied to the company's Metaverse activities, unlike the marketing department.

The second brainstorming session lasted two hours and took place in real life as opposed to the first, conducted through Microsoft Teams. Moreover, Miro was used for the different brainstorming techniques. The session began with a 15-minute presentation to give the employees an overview of the research, the Metaverse and information about the first session with Metaverse users. The first activity was then conducted for 30 minutes. This activity was a two-by-two matrix aimed at determining how relevant and feasible the ideas generated from the first session were. A two-by-two matrix is a technique that can support decisions by a square where the axes are decision criteria (Gecis, 2020). It then determines which quadrant each idea will be placed on. For this session's two-by-two matrix, the terms infeasible/feasible and irrelevant/relevant were used, as shown in Appendix B. Here, feasibility focuses on how easy it is for Metaverse users to capture its movements related to accessibility and cost. In addition, relevancy focuses on the relevance related to the research question. During the execution of the two-by-two matrix, it was decided that the employees could decide together where the ideas should go on the matrix, which allowed for a synthesis of employees' views. On the other hand, this may have caused group thinking, but unfortunately, there was no other alternative due to the time available. The results of the two-by-two matrix are discussed in section 4.2.2.1.

The second brainstorming activity had a duration of 75 minutes. This involved the SCAMPER technique. The SCAMPER technique is an ideation tool that can help generate new ideas to further develop the existing ideas for a service or product by approaching the idea from seven different angles to help innovate and improve the idea (Dam & Siang, 2020). The seven angles are based on the seven letters of SCAMPER: Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse (Dam & Siang, 2020). The inputs used in the SCAMPER technique were the most feasible and relevant ideas from the two-by-two matrix. These were ultimately four ideas on which the employees all independently tried to devise applications and modifications focused on the seven letters of scamper for 15 minutes per idea. In the last 15 minutes, all ideas were discussed with each other, making some adjustments where necessary. Furthermore, the input in executing the SCAMPER technique among the employees was practically the same as they approached the idea from their expertise. The results of the SCAMPER technique are discussed in section 4.2.2.2 and illustrated in Tables 8, 9, 10, and 11.

4.1.3. Expert Validation Develop Phase

The SCAMPER results were discussed during a one-hour interview with a Metaverse expert via Teams to determine which SCAMPER applications and modifications should be included in the prototypes. An open-ended interview was chosen for this interview. An open-ended interview is an interview in an open situation which offers more freedom and flexibility to the interviewer and the person being interviewed (Gubrium & Holstein, 2002, as cited in Alshenqeeti, 2014). This freedom and flexibility are related to the planning, execution, and content of the questions. Furthermore, this type of interview ensures that the interviewer can continue to ask about specific issues to allow the person being interviewed to elaborate on the issue (Dörnyei & Skehan, 2003, as cited in Alshenqeeti, 2014). An open-ended interview was chosen as it provides the freedom and flexibility to ask the expert further about his opinions on the SCAMPER applications and modifications discussed.

The expert interviewed is involved with the Metaverse on a daily basis. Because of the expert's expertise in these Metaverse worlds, this expert was chosen to be interviewed. He conducts lectures on the Metaverse and visits several existing Metaverse worlds to gain insight into what works and what does not. The education the expert has taken and completed is a Bachelor’s degree in International Relations and a Master’s degree in Language. Additionally, the expert has obtained several sales, marketing and cloud computing certifications. The expert is a male who is 39 years old. Lastly, the expert is not employed by the researcher's internship company.

The validation interview aims to determine with the expert which aspects of the results from Scamper should be included in the first prototypes. The SCAMPER results are discussed in section 4.2.2,

and subsequently, the findings of the validation interview focusing on the SCAMPER results are discussed in section 4.3.

4.1.4. First Prototype

The choice was to create an initial prototype in the develop phase to work out the improvements and modifications on this prototype in the deliver phase. Due to the scope of this research, this seemed a logical step in the Design Thinking process because it allowed for iterations to be made on the first prototypes. A final prototype could then be created in the deliver phase based on the generated deliver phase information, discussed in section 5.3.

To focus on the prototype at this phase; this prototype consists of a word web set up in Miro. This word web aims to get an overview of what aspects are included in the prototype. This type of prototype allowed the sketches to be forwarded in the form of the word web to an external party, creating the prototypes as 3D virtual environments. The prototype in this phase is discussed in section 4.4.

4.2. Results Brainstorming Session

To deliver the first prototype in the develop phase, two brainstorming sessions were conducted. The first brainstorming session was conducted with Metaverse users and aimed at generating as many ideas as possible focused on the research question. The second brainstorming was held with several employees of the company where the researcher is doing his internship. This brainstorming session aimed to determine which ideas from the first session were the best and which were then improved upon. This section discusses the results of the brainstorming sessions.

4.2.1. Results 1st Brainstorming Session

The first brainstorming session, conducted with Metaverse users, led to an initial set of ideas on facilitating Metaverse users to make it accessible to capture their movements. The brainstorming session provided 32 ideas, of which 28 came individually from the respondents, and 4 originated during the collaborative discussion with all respondents. The average number of ideas per respondent was 5.6 (MIN = 4, MAX = 8). Thus, there was a difference in the number of ideas between respondents. Afterwards, during the group discussion, it emerged that some respondents were too concerned with the quality of ideas rather than quantity. This may be a reason for the difference.

Furthermore, during the group discussion, it was asked if each respondent could explain what he meant by his idea so that new ideas could emerge as a group. So this eventually led to 4 additional ideas. Unfortunately, this session could not be reviewed due to a recording error in Teams. However,

the information obtained was all documented in the Miro board. In figure 3, all the generated ideas can be found. This concerns 27 ideas since 5 duplicated ideas are filtered out. In this regard, the duplicated ideas are documented in the Miro board to clarify which ideas have been mentioned more frequently.

Figure 3: Ideas deriving from the first brainstorming session

4.2.2. Results 2nd Brainstorming Session

After the first brainstorming session with Metaverse users, a second session was conducted with employees of the researcher's internship company. The goals of this session were to 1) determine which ideas were the best that were generated from the first session through a two-by-two matrix and 2) further develop the most relevant and feasible ideas from the two-by-two matrix through the use of SCAMPER.

4.2.2.1. Two-By-Two Matrix

The first technique executed during the second brainstorming session was the two-by-two matrix. This technique was used to determine which ideas generated were the most relevant and feasible. This technique was performed collectively with the employees to determine where the ideas should go on the matrix. The results for each quadrant can be found in Tables 4, 5, 6 and 7. The four quadrants drafted in Miro can be found in Appendix B.

Relevant and Feasible Ideas

If successful, have Metaverse equipment mass-produced, reducing the cost
Video capturing
Submit a video to an organization that can convert the video to 3D (video made with or without a green screen)
Fiverr
Pay company X amount per scan
Subscription per 'X time' to capture movement (at a hub or home)
Create an online environment where you can capture yourself and then send it to a company that converts it (webcam-based / capturing movements in advance)
Develop EA Gameface into a system where it can scan a body with related movements
Open pop-up Metaverse stores that allow users to capture movements (physical with an explanation on Metaverse)
Capture movements in a gym and forward them to an organization that can convert movements to 3D animations (and other sports, e.g., football clubs)
As an organization doing this provide Metaverse users with equipment (physically on a fixed) location as a hub

Table 4: Relevant and feasible ideas

Irrelevant and Feasible Ideas

Produce live motion action capture on small scales and have it given away as a test
An online platform where you have to fill in everything you can about yourself
Create a "filter" so that "customers" can create their own basic avatars. You can then further monetize this by offering more expensive avatars (such as Snapchat filters)
One-time scan of yourself with a camera (scan in cabin/webcam-based/phone-based)

Table 5: Irrelevant and feasible ideas

Irrelevant and Infeasible Ideas

Greenroom recording
As an organization engaged in this provide Metaverse users with equipment (someone comes to your home)
Shoes that track everything
Clothing (sports gear to capture your movement/lifestyle clothing)
In water with waves (water as motion capture)
A chip embedded in your body that takes over everything from your brain
Watching/technical bracelet that records you with a hologram

Table 6: Irrelevant and infeasible ideas

Relevant and Infeasible Ideas

Equipment rental + consulting
Make accessible at game stores to scan there for a specific price (for example, FIFA, NBA, UFC)
A suit that captures everything once (sort of a greenscreen suit with sensors)
Sonar/echolocation
Having someone sketch/animate you

Table 7: Relevant and infeasible ideas

Clustering of Ideas 2-By-2 Matrix

After determining where the ideas should go on the two-by-two matrix, it was observed that some ideas overlapped. This led to collectively determining which ideas were related to each other during the brainstorming session to assign an overarching term to them. The clustered relevant and feasible ideas can be found in Figures 4, 5, 6 and 7, along with an explanation of the overarching term with its associated ideas.

Capture at Hub

The first overarching term is the capturing of movement in a hub. The focus here is that movement is recorded in a fixed location where Metaverse users can go. For example, this could be a hub facilitated by a company in the motion capture industry, a Metaverse community hub or a facility in a gym or sports club where related movements can be captured. Additionally, there is the idea here that Metaverse users can take out a subscription to modify movements as they age and their movements change, for example.

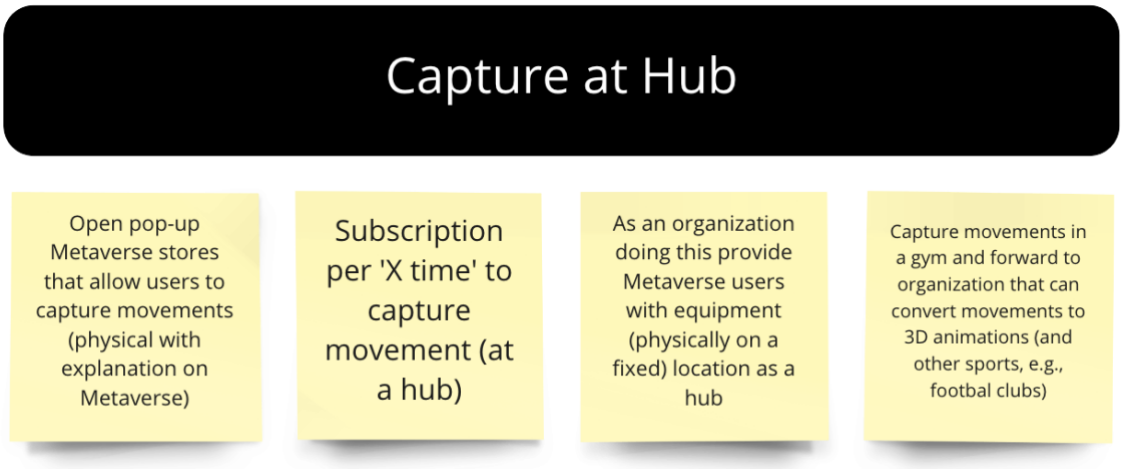

Figure 4: Capture at Hub

Capturing at Home using AI

The second overarching term is home capturing through AI. This refers to capturing movements by taking a video of all the required movements so that it can be sent to a company in, for example, the motion capture or gaming industry so that they can implement it in the avatars of Metaverse users. Electronic Arts (EA) is already using similar technology with their Game Face technology, where you can play as yourself in EA's games. Finally, this refers to capturing movements in an online environment which is then sent to a company that can convert the movements into avatars.

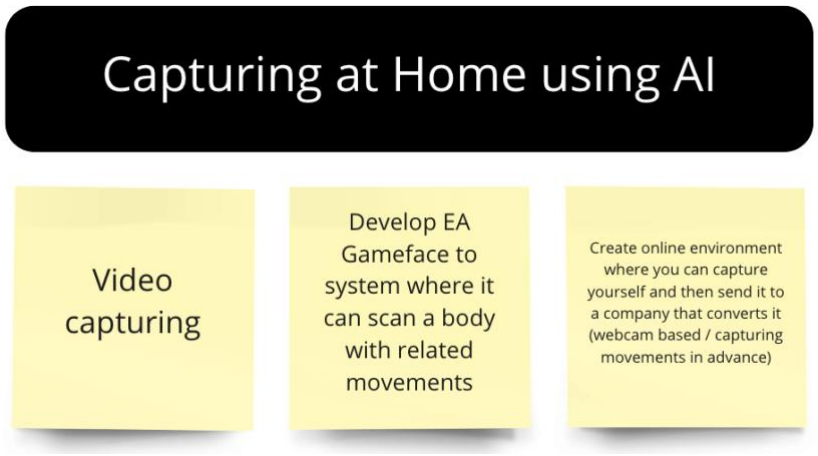

Figure 5: Capturing at Home using AI

Use Freelancer for Recording

The third overarching term is using a freelancer. This refers to utilizing a freelancer with the right equipment to capture movements for the Metaverse user for the avatars. For example, a freelancing platform such as Fiverr can be used here. Another option is to record movements through a video and send it to a freelancer, who then converts it to movements in the avatar. In addition, using a freelancer is centered around paying a certain amount per capturing.

Figure 6: Use Freelancer for Recording

Capture at Home with Sensors

The final overarching term is capturing movements in a home environment. This should be accomplished by mass-producing motion capture technology so that it becomes more affordable. Subsequently, when this technology is affordable to Metaverse users, they can record movements at home without needing a company.

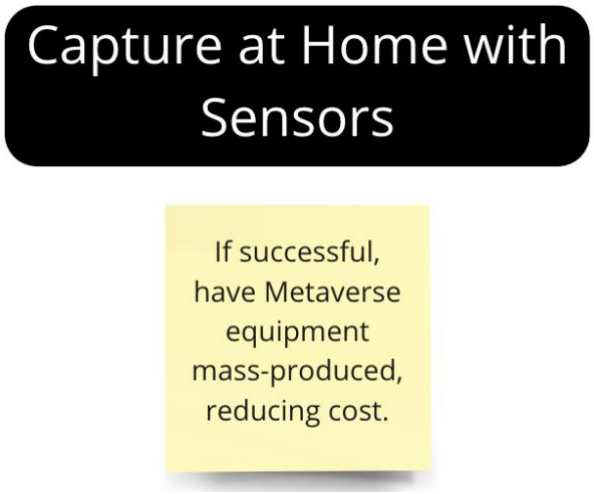

Figure 7: Capture at Home with Sensors

4.2.2.2. SCAMPER

The second technique performed during the second brainstorming session was the SCAMPER technique. Here the goal was to come up with applications and modifications for the four concept ideas emerging from the two-by-two matrix (Figures 4 through 7). The applications and modifications are based on the seven letters of SCAMPER, which serve as different perspectives. Tables 8, 9, 10 and 11 present the results of the SCAMPER technique applied to the four concept ideas. In Appendix C, the entire SCAMPER technique can be found for each idea. This data has not been further modified.

SCAMPER - Capture at Hub

Substitute	Do it at other places (for example, sports clubs and offices)
Combine	Combine it with sports or gaming while recording
	Advise the user on health/movement-related problems
	Combine it with a workout routine
	A guideline of movements that users must perform to get a total set of movements
	Also, add a scanning booth where the user is scanned into a 3D avatar
Adapt	Make it more of a community hub where you can do lots of stuff
Modify	Add more spaces to capture (scale up)
	Hold a motion capture festival where every attendant is captured
	Generates insights the more you use the space/hub
Put to other use	Sell the data to game studios, so they have a lot of different walks
	Sell data to researchers
	Record yourself weightlifting and get advice from a pro
	Advise on the best running shoes for the person
Eliminate	Equipment which limits a bigger demographic
Reverse	The hub pays you to capture your data
	The hub comes to you. You can request it, and it will come to your town
	Make the hub come to you
	Travelling hub

Table 8: SCAMPER – Capture at Hub

SCAMPER - Capturing at Home using AI

Substitute	Send a description instead of a video
	Use your phone instead of a webcam
Combine	Capture surroundings as well
	Combine with some motion sensors
Adapt	Use a set of cameras instead of one webcam
Modify	It could also be outside, anywhere where you have a camera
	Able to choose between quicker results versus higher quality

Put to other use	Use all the data to build a motion capture library that you can sell
	Make your own moving WhatsApp avatar
	Use the video data to create deep fakes of the users
	Create an AI model of yourself for when you are not there
Eliminate	Do not send the data to a company but process it locally to extract movement
	Processing time and making it available live
Reverse	Make videos for users that want certain movements

Table 9: SCAMPER - Capturing at Home using AI

SCAMPER - Use Freelancer for Recording

Substitute	Use AI instead of people
	Have a library with a lot of movement sets and match the user to one of those movement sets
Combine	Add a subscription and let them make social content for you
	Get a 3D avatar of yourself
Adapt	Use the input and output to train an AI
	Make a freelancer come to your home to record you
Modify	Let them create more, for example, an avatar or V-tuber video
	Freelancer also implements motion capture data into the game engine or Metaverse application
Put to other use	
Eliminate	Make an easy animation tool so you can convert the data yourself
Reverse	Sell your data to freelance artists or researchers

Table 10: SCAMPER - Use Freelancer for Recording

SCAMPER - Capture at Home with Sensors

Substitute	Do not use regular motion capture sensors but let the user tape phones to his arms and use the accelerometer and gyro of the phone as a sensor
Combine	Combine with facial data
	Combine with GPS or other positional data
	Use fewer sensors and combine them with webcam data
Adapt	Use the motions for games

	Use the motions as alternative passwords (a pass motion)
Modify	The user gets cheap sensors at home so he can record his movement when it is most convenient
	Increase the accuracy of the data
Put to other use	Also give ergonomic feedback on how the user is sitting and or moving
	Suggest other movements from a library which are quite similar
	Be able to create your own styles or small animations for games you play
	The health market can use this data
Eliminate	Be able to capture with fewer sensors to reduce the cost even further
	Long and complicated setup times
	Need for technical know-how
	Let the user 3D print the housing themselves
	Eliminate the involvement of a second person to help
Reverse	Have costly motion capture equipment, so it becomes a status symbol to have natural movement in the Metaverse

Table 11: SCAMPER - Capture at Home with Sensors

Follow-up Step SCAMPER Results

The results of the SCAMPER technique performed on the four concept ideas are incorporated into a validation interview with a Metaverse expert. Based on this interview, it will be determined which generated ideas from SCAMPER per concept should be taken into account towards the prototypes. So, together with the expert, it is determined which SCAMPER ideas will be excluded and which will not. Section 4.3 discusses the results of this interview.

4.3. Results Expert Idea Validation

The execution of the two brainstorming sessions in this phase resulted in the creation of four idea concepts. These four concepts aim to make capturing movements more accessible to the avatars of Metaverse users. The four concepts are as follows: 1) Capture at a hub, 2) Capturing at home using AI, 3) Using a freelancer for recording, and 4) Capture at home with sensors. This validation interview aims to determine which ideas per concept should be integrated into the concept prototypes based on the expertise of the Metaverse expert. However, during the interview with the expert, it emerged that, according to the expert, two of the four idea concepts are feasible and relevant in the future, and the

other two are not feasible and relevant. The two feasible and relevant ideas are: 1) capturing movements in a hub and 2) capturing movements by using AI in a home environment.

The Metaverse expert interviewed indicated that the concept of ‘using a freelancer for recording’ was a concept with too many short-term obstacles. This is because, in this scenario, the Metaverse user must already have equipment at home to capture the movements, which must then be sent to someone who, in turn, has expertise in converting movements to a Metaverse world. Additionally, in the scenario that the freelancer has the equipment, then the user would have to find the right person nearby to visit there. The Metaverse expert indicated that this would probably be too difficult to find the right freelancer in the area to capture movements for the Metaverse user. Hence, the concept of the freelancer was not included in the development of the first prototype. This choice was made since the Metaverse expert has expertise in the Metaverse field, and for this reason, his input in this area is considered leading.

Furthermore, the Metaverse expert indicated that ‘capture at home with sensor’ is still far from feasible compared to ‘capturing movements by using AI in a home environment’. The reason for this, according to the Metaverse expert, is that AI developments are already on the horizon, and the process of making capture sensors cheaper will take many years. In those years, the Metaverse expert expects capturing with AI to be perceived as normalized. Hence, the concept of making the sensors cheaper was not included in the first prototype as the Metaverse expert makes a valid point based on his technological expertise centered on the fact that AI is already slowly becoming more mainstream. So, the concept of 'using a freelancer for recording' and the idea of 'capture at home with sensos' are not considered relevant and feasible by the Metaverse expert. For this reason, it was decided to drop these two concepts as the Metaverse expert herein had valid arguments towards dropping these two concepts. Furthermore, concepts 'capture at a hub' and ' capturing at home using AI' are included in the prototyping process. Sections 4.3.1 and 4.3.2 elaborate on why these concepts are being prototyped and what aspects of SCAMPER are integrated. The transcript of the interview can be found in Appendix D. The transcription of this interview does not involve an official transcript. This is because it was an open-ended interview, and a lot of conversation was not focused on the actual objective. Therefore, the transcription is based on all critical takeaways from the interview that contribute to the process.

4.3.1. Validation Interview – Capturing at Hub

The interview with the Metaverse expert indicated that he considered capturing movements at a hub concept quite feasible and relevant. The Metaverse expert suggested that the hub could work if you clearly understand which target group you will be aiming at, for example, people with health-related

issues. However, testing this to gain insight into the target groups and associated needs is vital. As indicated, due to his expertise in Metaverse and technological fields, capturing movements at the hub was selected as a prototype concept, keeping in mind that it is essential to gain insight into target groups. All ideas of SCAMPER, as drawn up in Table 8, were discussed with the expert.

The expert suggested that the hub would work as long as it is clear which target group it aims at, and he envisions Metaverse users going to a hub to interact with what the Metaverse has to offer. In addition, the hub can help users who want to know their posture while performing certain sports or wish to gain insight into other health-related issues. Besides capturing movements for the Metaverse, the hub can also serve as a place where users can capture movements for various sports games.

Other aspects of the hub are that there should be a section where users can create their avatars for a Metaverse world or social media platforms such as Snapchat and WhatsApp. Furthermore, hub users can earn tokens or NFTs for interacting with the hub, which is made possible by blockchain.

Lastly, the interview highlighted that the hub should have suits of different sizes so that anyone with any type of body type can use them and that the hub should reuse the data it generates to learn from itself. The latter is to make the hub more efficient over time.

Table 12 shows all the results of the applications and modifications of SCAMPER aimed at capturing movements in the hub. Table 12 has the same setup as Table 8; only the focus of Table 12 here is on the applications and adaptations that are colored green. The expert perceived the green applications and modifications during the interview as elements that should be included in the prototype. Hence, some applications and modifications in Table 12 are colored green to give insight into the applications and adaptations included in the prototype for capturing movements in the hub.

Substitute	Do it at other places (for example, sports clubs and offices)
Combine	Combine it with sports or gaming while recording
	Advise the user on health/movement-related problems
	Combine it with a workout routine
	A guideline of movements that users must perform to get a total set of movements
	Also, add a scanning booth where the user is scanned into a 3D avatar
Adapt	Make it more of a community hub where you can do lots of stuff
Modify	Add more spaces to capture (scale up)
	Hold a motion capture festival where every attendant is captured

	Generates insights the more you use the space/hub
Put to other use	Sell the data to game studios, so they have a lot of different walks
	Sell data to researchers
	Record yourself weightlifting and get advice from a pro
	Advise on the best running shoes for the person
Eliminate	Equipment which limits a bigger demographic
Reverse	The hub pays you to capture your data
	The hub comes to you. You can request it, and it will come to your town
	Make the hub come to you
	Travelling hub

Table 12: SCAMPER – Capture at hub after validation interview

4.3.2. Validation Interview – Capturing at Home using AI

The interview with the Metaverse expert indicated that the concept of 'capturing at home using AI' is feasible and relevant. According to the expert, this is because developments around AI are becoming increasingly accessible to users. Therefore, the Metaverse expert sees the potential for users to have an accessible way to use motion capture equipment in their home environment through AI. According to the Metaverse expert, an essential aspect of this is that users do not have to go somewhere physically. Hence, the concept of capturing at home using AI is further developed into a prototype as the expert's opinion is considered through his Metaverse and technological expertise. All SCAMPER ideas were discussed with the expert as drawn up in Table 9.

The expert suggested that capturing movements through AI in a home environment is viable when users can use their phones to capture them. Furthermore, here users can opt for additional extra cameras to increase the capture quality or use no extra cameras with less capture quality. When the user chooses to capture by using only a phone, this should positively affect the data processing time and vice versa for capturing with multiple cameras.

Other aspects of this idea concepts are that users can upload their captured movements to a public library where they can earn tokens or NFTs through blockchain. Furthermore, this concept should allow users to create an AI replica/deep fake of themselves so that their (avatar) can be present in the Metaverse when they cannot be physically present.

Table 13 shows all the results of the applications and modifications of SCAMPER aimed at capturing movements in a home environment using AI. Table 13 has the same setup as Table 9; only the focus of Table 13 here is on the applications and adaptations colored green. The expert considered the green applications and modifications during the interview as elements that should be included in

the prototype. For this reason, some ideas in Table 13 are colored green to give insight into the applications and adaptations included in the prototype for capturing movements through AI in a home environment.

Substitute	Send a description instead of a video
	Use your phone instead of a webcam
Combine	Capture surroundings as well
	Combine with some motion sensors
Adapt	Use a set of cameras instead of one webcam
Modify	It could also be outside, anywhere where you have a camera
	Able to choose between quicker results versus higher quality
Put to other use	Use all the data to build a motion capture library that you can sell
	Make your own moving WhatsApp avatar
	Use the video data to create deep fakes of the users
	Create an AI model of yourself for when you are not there
Eliminate	Do not send the data to a company but process it locally to extract movement
	Processing time and making it available live
Reverse	Make videos for users that want certain movements

Table 13: SCAMPER - Capturing at home using AI after validation interview

Additional Ideas of SCAMPER – Capturing at Home using AI

In addition to the green-colored applications and modifications from the concept idea of 'capturing at home using AI' as seen in Table 13, applications and modifications from the concept of 'capture at home using sensors' (Table 11) were included in the elements of the concept focused on 'capturing at Home using AI'. This derives from the expert's view. As such, the expert suggested that the following applications and modifications should be included in this concept idea: 1) use the movements for games, 2) use the movements as alternative passwords (a pass-motion), 3) provide ergonomic feedback on how the user sits and moves, and 4) the health market can use the ergonomic feedback data for which the user receives compensation in tokens or NFTs. For this reason, these four applications and modifications of 'capture at home using sensors' were included as prototype elements focused on 'capturing at home using AI'. Table 15 illustrates which elements of the 'capturing at home using AI' prototype come from which concept.

In the next section, the first prototypes are discussed in more detail. This will include the modifications and applications discussed in this section.

4.4. First Prototype

The objective in the develop phase is to deliver the first prototype. As stated, the choice was made to create two simplistic prototypes in Miro in the form of a word web to get an overview of all aspects of the prototypes.

Prototype 1 – Capture at Hub

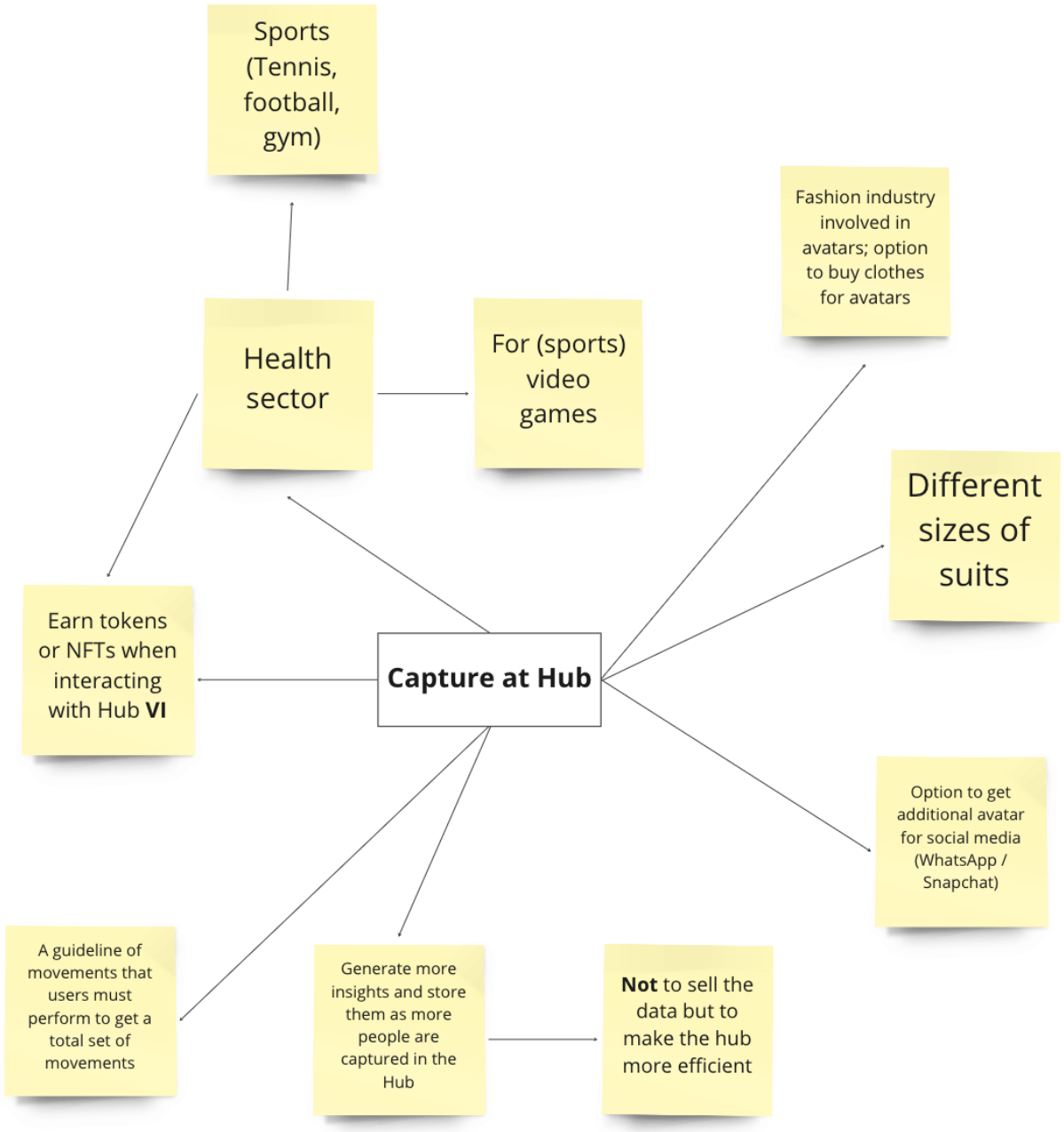

Figure 8: First prototype – Capture at Hub

The first prototype created in the develop phase focuses on capturing movements in the hub. Most aspects of the prototype have been covered in the expert validation section. In addition to those aspects already covered, this prototype concerns two new elements essential for the hub.

The first aspect is the option in the hub to purchase assets in the form of NFTs for the avatars of Metaverse users. This stems from the literature review indicating that the fashion industry will play a prominent role in the Metaverse in creating the avatars and the form of self-expression surrounding the avatars. Therefore, it was chosen to integrate the option for buying avatar assets into the prototype since self-expression is an essential aspect of the avatars.

The second aspect relates to having a guideline that focuses on all the movements the Metaverse user has to perform to get the most realistic representation of their movements which can provide a realistic experience in the Metaverse. During the expert interview, it emerged that the expert did not consider this aspect essential. After a spar session with the company where the researcher is doing his internship, it appeared that this aspect is essential. The reason for this is that the internship company has a lot of experience in the entertainment/gaming sector and therefore has insight into how essential a guideline of movements is. For this reason, the motion guideline was included in the prototype. Table 14 provides an overview of the origin of all aspects of the prototype.

SCAMPER Aspect	**Origin**
Sports (tennis, football, gym)	**SCAMPER (Capture at Hub)**
Health sector	**SCAMPER (Capture at Hub)**
For (sports) video games	**SCAMPER (Capture at Hub)**
Earn tokens or NFTs when interacting with Hub	**SCAMPER (Capture at Hub)**
A guideline of movements that users must perform to get a total set of movements	**Internship Company**
Generate more insights and store them as more people are captured in the Hub (aimed at making the hub more efficient, and not to sell data)	**SCAMPER (Capture at Hub)**
Option to get an additional avatar for social media (WhatsApp / Snapchat)	**SCAMPER (Capture at Hub)**
Different sizes of suits	**SCAMPER (Capture at Hub)**
Option to buy clothes for avatars	**Literature Review**

Table 14: Origin aspects of the Capture at Hub prototype

Prototype 2 – Capturing at Home using AI

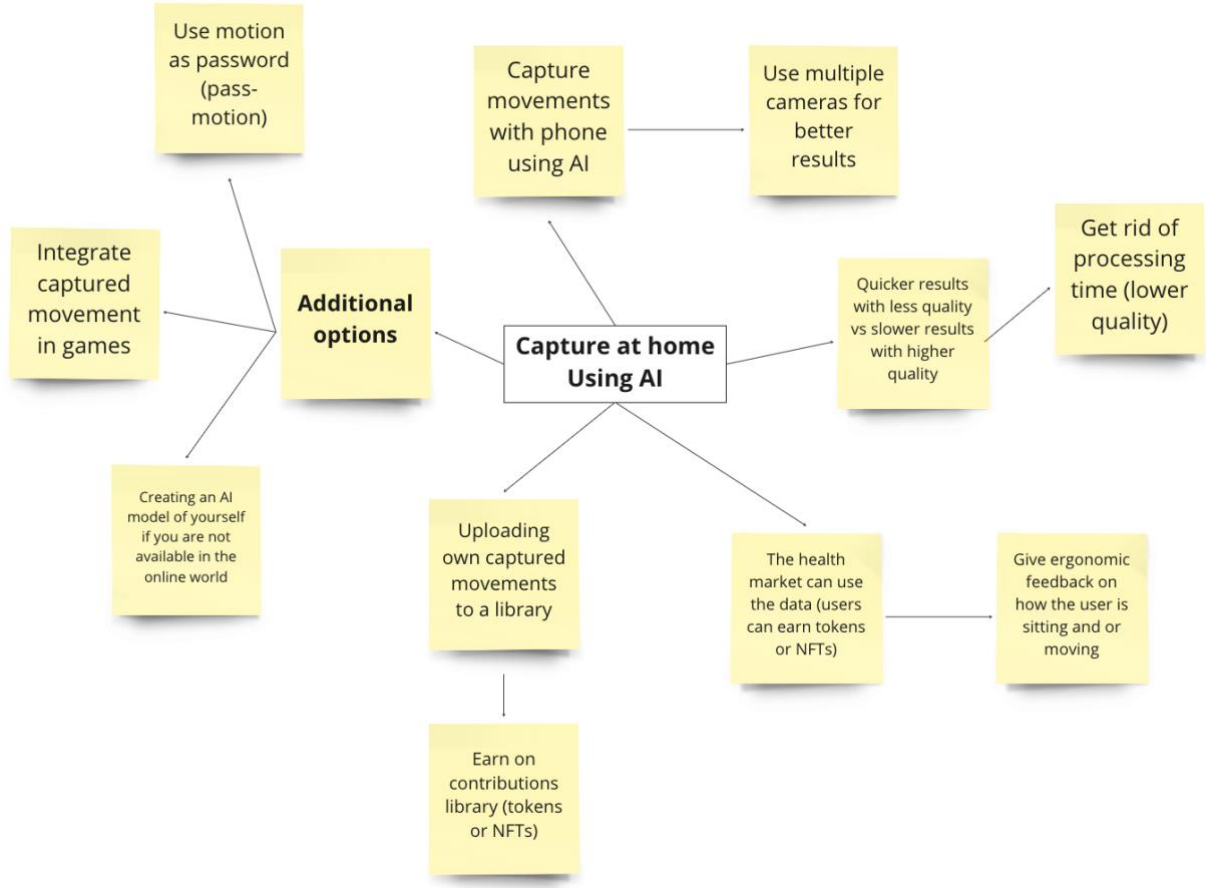

Figure 9: First prototype – Capturing at Home using AI

The second prototype created in the develop phase focuses on capturing movements through AI in a home environment. All aspects of the prototype were covered in the expert validation section. An overview of where all elements of the prototype came from can be found in Table 15.

SCAMPER Aspect	**Origin**
Capture movements with a phone using AI	**SCAMPER (Capturing at Home using AI)**
Use multiple cameras for better results	**SCAMPER (Capturing at Home using AI)**
Quicker results with less quality vs slower results with higher quality	**SCAMPER (Capturing at Home using AI)**
Get rid of processing time (lower quality)	**SCAMPER (Capturing at Home using AI)**
The health market can use the data (users can earn tokens or NFTs)	**SCAMPER (Capture at Home using Sensors)**
Give ergonomic feedback on how the user is sitting and or moving	**SCAMPER (Capture at Home using Sensors)**

Uploading own captured movements to a library	**SCAMPER (Capturing at Home using AI)**
Earn on contributions library (tokens or NFTs)	**SCAMPER (Capturing at Home using AI)**
Use motion as password (pass-motion)	**SCAMPER (Capture at Home using Sensors)**
Integrate captured movement in games	**SCAMPER (Capture at Home using Sensors)**
Creating an AI model of yourself if you are not available in the online world	**SCAMPER (Capturing at Home using AI)**

Table 15: Origin aspects of the Capturing at Home using AI prototype

4.5. Reflection on Action Develop Phase

The goal in the develop phase was to come up with as many ideas as possible regarding the research question. Subsequently, the ideas generated were put together into two initial prototypes. To create these prototypes, this phase first conducted two brainstorming sessions. Here, the first brainstorming session led to the generation of the first solutions to the problem. The session went smoothly, and all participants were able to come up with several solutions. To list some areas of improvement, it would have been wiser to start the first brainstorming session with an exercise not related to the research question to get the participants more focused. The reason for this is that in the beginning, the participants had difficulty coming up with solutions since they needed time to familiarize themselves with the research question and because some participants were too focused on coming up with high-quality solutions. Suppose an exercise had been conducted at the beginning unrelated to the research question. In that case, it could have been that the participants had more creativity when solutions had to be devised for the research question. In addition, when the generated solutions were discussed in a group setting, there was almost only interaction with the respective participant and the facilitator of the brainstorming session. The facilitator could have chosen to encourage the other participants to participate in discussing the solutions generated by the individual participant. This could have provided a synthesis of ideas.

During the second brainstorming session conducted with employees of the researcher's internship company, the facilitator emphasized discussing the solutions devised together. This ensured that the different expertise of employees came together in devising these solutions. A point of improvement of the second brainstorming session was that more time should be devoted to the second technique performed during this session (the SCAMPER technique). Since time was running out at a particular moment, there was little time left to discuss all the SCAMPER solutions with each other as a group. The time had expired because the employees had other appointments after the session, so

there was a maximum of two hours to execute everything. So, it would be wise to allocate more time to discuss all the solutions in the future.

In addition to the brainstorming sessions conducted in this phase, a validation interview was also conducted with an expert. This validation interview was an open-ended interview to discuss which idea concepts from the second brainstorming session should be made into prototypes. This interview provided valuable information. Only there was a miscommunication between the researcher and the expert regarding time. When contacting the expert, it was indicated that this was a one-hour interview. The expert approved this as well. Only during the interview itself did the expert indicate after 30 minutes that he had to leave since he thought the interview would last only 30 minutes. However, the expert was able to complete the whole hour, so the elements to be discussed were discussed rather quickly. In the scenario that more time could have been taken for all the elements, it could have been that the expert would have had different opinions about the ideas from the second brainstorming session. On the other hand, everything that needed to be discussed was discussed. Hence, the assumption can be made that the necessary information was extracted during this interview to create the prototypes.

The last thing carried out in this phase is the creation of the two prototypes based on all the information obtained from the develop phase. As indicated, the prototypes (section 4.4) are created in the deliver phase as 3D virtual environments to make them more tangible. Only the creation of the 3D virtual environments was planned for this phase to make adjustments in the delivery phase. The modifications in the 3D virtual environments would eventually be the final prototypes in the deliver phase. However, no 3D virtual environments were made in this phase because creating the 3D virtual environments and then modifying them again was beyond the available budget of the research. For this reason, it was decided to only deliver a word web as a prototype for both ideas in this phase and then develop them with all elements into 3D virtual environments in the deliver phase.

The develop phase synthesized information that first emerged in the define phase. For example, the literature review revealed that the health market could utilize the Metaverse in various aspects. This aligns with the brainstorming sessions in which the respondents mentioned elements of the health market integrated into both prototypes. The same goes for the fashion industry focused on assets for avatars which emerged in the literature research as well as the brainstorming sessions. Furthermore, blockchain and AI technologies are mentioned in conjunction with the Metaverse. Focusing on the latter two technologies, several elements of blockchain and AI can be found in the prototypes made in the develop phase based on the output of this phase. Finally, the literature review revealed that the creator community is essential to the Metaverse. Elements of the creator community can be found in the prototypes, such as uploading movements into a library that other Metaverse users

can purchase. Thus, it can be concluded that there are connections between the outcomes of the actions taken in the define and develop phases.

DELIVER PHASE

05

5. Deliver Phase

The deliver phase is the fourth and last phase in the Double Diamond model. After divergent thinking in the develop phase, this phase focuses on testing the solutions, improving them, and, where necessary, rejecting them (Council, 2019). In this phase, the first action was an interview with a Metaverse expert to test and improve the solutions. This interview is based on the prototypes created in the develop phase (section 4.2.). This interview involves a second Metaverse expert interview, which differs from the one conducted in the develop phase. The improvements from this phase's interview were then taken into the final prototypes created in this phase. The purpose of the final prototype was to present it to Metaverse users to assess whether certain aspects should be omitted or improved. The reason for this order is to perform an initial validation on the first prototype made in the develop phase to create next the second prototype, including improvements, which is finally delivered to Metaverse users to determine if any modifications are needed from the end user's perspective.

To summarize, this chapter first focuses on the methodology regarding 1) the interview with the Metaverse expert for validation, 2) how the final prototypes were created, and 3) the interviews conducted with Metaverse users focused on validating the final prototypes. Next, the results of 1) the interview with the Metaverse expert held in this phase, 2) the final prototypes created, and 3) the validation interview with the Metaverse users are discussed. Finally, this chapter reflects on the actions taken in the deliver phase.

5.1. Methodology Deliver Phase

In the deliver phase, several methodologies were used. This section covers the methodology used for the interview with the Metaverse expert, the creation of the final two prototypes and the interviews conducted with Metaverse users.

5.1.1. Expert Interview Deliver Phase

The prototypes created in the develop phase (section 4.4) were discussed during a one-hour interview with a Metaverse expert. Since this concerns an interview with a Metaverse expert, this is a type-2 test related to testing prototypes with experts (Van Zeeland, 2022). The interview aimed to determine if the prototypes created needed any adjustments. These adjustments ultimately created the final prototype that was delivered in this phase. An open-ended interview was chosen for this interview, like the interview conducted in the develop phase. The same reason applies here: an open-ended interview provides the freedom and flexibility to ask the Metaverse expert further about his opinion on the first prototypes.

The expert interviewed focuses his work entirely on the Metaverse. Because of the expert's expertise in these Metaverse worlds, this expert was chosen for the interview. As such, he is the founder of two Metaverse-related companies. One company focuses on creating a Metaverse world that companies can exploit to get in touch with customers through this online world. Furthermore, his second company focuses on visiting existing Metaverse worlds to see which use cases work and which do not and organizing networking events in these worlds. The education the expert has taken and completed is a Bachelor's degree in Media and Entertainment Management and a Master's degree in Humanities/Humanistic Studies. Furthermore, the expert is a male who is 32 years old. Lastly, the expert is not employed by the researcher's internship company.

5.1.2. Prototype Creation

As mentioned, a first prototype was made in the develop phase in the form of a word web aimed at creating an overview of the solutions. Then, in this phase, contact was established with an external party specialized in creating virtual 3D environments. A virtual prototype was chosen as it is a cheaper and faster solution than a physical prototype (Christie et al., 2012, as cited in Camburn et al., 2017). This then allows for quick iterations (Camburn et al., 2017). In addition, virtual prototypes can lead to high performance due to simplicity, and producing virtual prototypes has the characteristic of being produced faster (Hamon et al., 2014, as cited in Camburn et al., 2017). For this reason, a virtual prototype was chosen as it is relatively quick to make and test and therefore fits well with the scope of this research.

The external party ensured the creation of two virtual environments. This concerns a hub where users can capture their movements alongside other activities and a home environment where Metaverse users can capture their movements through their phones and additional cameras. The programs used to create the prototypes are Google SketchUp, V-Ray and Enscape.

Furthermore, it was chosen to develop both concepts of the hub, and the AI solution into virtual prototypes since the interview with the Metaverse revealed that he envisions potential in both concepts. Furthermore, the Metaverse expert indicated that it would be favourable to present both concepts to Metaverse users to gain insight into the Metaverse users' different reactions to the two concepts. The complete results of this interview are discussed in section 5.2.

5.1.3. Metaverse User Validation

After the type-2 validation was performed with a Metaverse expert and after developing the prototype, several validation interviews were conducted with Metaverse users. This concerns a type-1 test, as this type of test is focused on users (Van Zeeland, 2022). For validation, five Metaverse users

were selected to be interviewed. According to Knapp (2016), five respondents are enough to uncover 85% of the problems associated with the prototype. Furthermore, Knapp pointed out that if you interview more than five respondents, it is difficult to detect more problems, and it takes more work. Hence, it was decided to interview five Metaverse users.

The interviews were conducted using an open-ended interview as this provides freedom and flexibility, as mentioned earlier. During the interview, it was indicated that the respondents should look at the prototypes to ultimately show which aspects they like and which aspects they do not. When a respondent indicates that certain aspects are positive, it is called an 'indication'; when negative, it is called a 'contraindication' (Van Zeeland, 2022). So, the purpose of the interview was to gather indications and contraindications about both prototypes. These indications are collected through the 'Dot Democracy' principle. This means that respondents can use stickers to indicate what they consider positive about a certain aspect of the prototype (indication) and what aspect they consider negative (contraindication) (Van Zeeland, 2022). This is done on all elements of the prototypes, as presented in section 5.3, using green and red stickers. Subsequently, It is possible to overlay the prototypes' results to form a heatmap (Van Zeeland, 2022). From this heatmap, indications and contraindications can then be extracted.

Furthermore, during the implementation of the Dot Democracy principle, 'think out loud' was used. This means that respondents should indicate why they think something is an indication and something is a contraindication. This allows insight to be gained into why certain aspects of the prototype do not resonate and why they do. Finally, during the interview, all respondents were asked two additional questions; namely, 1) 'What do you think of the concepts of the two prototypes separately?' and 2) 'Which of the two prototypes would you choose if you had to choose one?'. These answers are incorporated into the overall conclusion to substantiate respondents' feelings about both prototypes.

Additional Survey

To gain extra validation on the two prototypes, a survey was sent to the respondents to judge the specific criteria of both prototypes. Since a survey also takes place in addition to the interview, this is considered a mixed-method approach. A mixed-method approach is a research strategy that combines both qualitative and quantitative methods for data collection and analysis (Creswell, 1999). This study type allows for a more comprehensive understanding of a topic as it uses qualitative and quantitative techniques to gain insights. Qualitative methods like interviews and observations provide in-depth understanding, while quantitative methods like surveys and statistical analysis provide numerical data (Creswell, 1999). The purpose of the survey is to complement the interview and provide additional substantiation regarding how respondents perceive the prototypes presented. The reason for the

complementary nature is that the number of respondents is low for a survey, so statistical statements cannot be made with high reliability and validity. Furthermore, the survey results contribute to the gap analysis being conducted. A gap analysis is a suitable method for multiple prototypes since, based on the same criteria, both prototypes can be compared with each other, which then can determine which prototype can finally be developed (Van Zeeland, 2022). During this research, no real-life prototype will be created due to the scope of this research. However, a gap analysis can help gain insight into which prototype scores better on the criteria. Hence, a gap analysis was performed.

The gap analysis utilizes the five E's (efficiency, effectiveness, efficacy, ethicality, and elegance), used in testing Soft Systems as part of Soft Systems Methodology (SSM). SSM is a framework for addressing complex and ill-defined problems by structuring the problem and facilitating learning for the stakeholders involved (Checkland et al., 1990, as cited in Kotiadis et al., 2013). It is a way of approaching problematical situations where there may not be an obvious problem or solution. The ultimate goal of using SSM is to empower stakeholders to learn about the situation and make informed decisions on actions that will lead to improvement (Checkland et al., 1990, as cited in Kotiadis et al., 2013). Because the survey focuses on stakeholders who evaluate the prototypes and bring out improvements, the choice was made to test the five E's in a survey based on a 5-point Likert Scale. Furthermore, the choice of the five E's was made since ethics is an essential aspect of the Metaverse, and in terms of the physical aspect, the prototypes can be judged on elegance. Besides, the other three E's, namely efficacy, efficiency, and effectiveness, include criteria focused on the objective of the research question. Hence, the choice was made to use the five E's for the criteria as these criteria can provide insight into the perception of the prototypes in line with the research question.

In addition to the five E's, two additional criteria are asked which relate to the research question throughout the research: namely, 1) accessibility and 2) price. Accessibility here relates to how much effort the prototypes require, and price relates to whether respondents find the price described reasonably. To arrive at a reasonable price for capture in the Hub, a realistic price was considered with the researcher's internship company, which has expertise in the motion-capture industry. Lastly, the choice was made to attach higher weightings to the accessibility and price criteria since these two criteria are central to the research question. Therefore, these two criteria are weighted double compared to the five E's. The weightings ensure that both prototypes can be given a final average, discussed in section 5.4.4.

Table 16 and 17 illustrates the statements for the criteria asked in the survey for both prototypes. The statements mention 'desired output', 'achieve goal', and 'long-term objective'. It was communicated to the respondents in the survey that this refers to the following: The research aims to provide Metaverse users with an accessible and cheaper way to capture their movements for their Metaverse avatars.

Criteria	Question
Efficacy	The motion capture hub provides the desired output for Metaverse users
Efficiency	The motion capture hub ensures that the minimum required resources are used to achieve the goal
Effectiveness	The motion capture hub provides the desired long-term objective for Metaverse users.
Ethics	The motion capture hub is morally correct.
Elegance	The motion capture hub is an attractive solution for Metaverse users.
Accessibility	The motion capture hub is an accessible solution for Metaverse users to capture their movements for their avatars.
Price	I consider a price of $250 reasonable for capturing movements in the motion capture hub for my avatar.

Table 16: The Five E's Criteria and Additional Criteria – The Motion Capture Hub

Criteria	Question
Efficacy	The use of AI technology with a phone and optional extra cameras provides the desired output for Metaverse users
Efficiency	The use of AI technology with a phone and optional extra cameras ensures that the minimum required resources are used to achieve the goal
Effectiveness	The use of AI technology with a phone and optional extra cameras provides the desired long-term objective for Metaverse users
Ethics	The use of AI technology with a phone and optional extra cameras is morally correct
Elegance	The use of AI technology with a phone and optional extra cameras is an attractive solution for Metaverse users.
Accessibility	Using AI technology with a phone and optional extra cameras is an accessible solution for Metaverse users to capture their movements for their avatars.
Price	I consider the price of having at least one newer generation phone in my home (for example, an iPhone X or higher) reasonable to capture my movements for my avatar at home.

Table 17: The Five E's Criteria and Additional Criteria – Capturing at Home using AI

Demographic Data Respondents

The validation interview and survey were conducted with potential Metaverse users from Generation Z. The average age of the respondents was 25.2 years (n = 5). Furthermore, the respondents were all male (n = 5) and were from the Netherlands (n = 5). Three respondents have a master's degree (n = 3), one has a bachelor's degree (n = 1), and one has an MBO degree (n = 1). An MBO diploma refers to a degree you obtain before your bachelor's degree.

5.2. Results Expert Prototype Validation

To validate the prototypes created in the develop phase, a validation interview was conducted with a Metaverse expert. During this interview, all elements of both prototypes were discussed. For the idea of the hub, almost no adjustments were necessary, according to the expert. However, according to the expert, the only adjustment needed is that it is important to take time when capturing movements. This is essential to capture all the movements with high quality. The expert further stated that the other hub elements were fine and required no further adjustments.

The expert also reviewed the prototype aimed at capturing movements using AI in a home environment. Here the expert indicated that no further adjustments were necessary since, according to the expert, all the elements are present in the prototype.

So, the solution of the hub should be adjusted in terms of taking into account the time required for capturing movements to get the most realistic view of the movements for the avatars of the Metaverse users. Furthermore, no adjustments are needed in the solution of capturing at home with AI.

The Metaverse expert indicated that it was challenging to come up with modifications since, according to him, you need Metaverse users to get an indication of their feelings on both concepts. Additionally, the expert indicated that it is useful to create both concepts as virtual prototypes and subsequently present them to Metaverse users to analyze their perception. Hence, two virtual prototypes were made, discussed in section 5.3. A transcript of the interview can be found in Appendix E. The transcription of this interview does not involve an official transcript. This is because it was an open-ended interview, and a lot of conversation was not focused on the actual objective. Therefore, the transcription is based on all critical takeaways from the interview that contribute to the process.

5.3. Final Prototype

For the final prototype, the choice was made to create a website containing all the elements. The website contains all information about the elements of the solutions, along with images of the virtual 3D environments created by the external party. The website can be accessed at the following URL: www.metaverse-motionprint.com.

5.3.1. Prototype 1: The Motion Capture Hub

This section discusses the final elements of the prototype aimed at capturing movements in a hub for Metaverse users' avatars. The information in this section is a replica of the information on the website.

Motion Capture Section

The hub's main section is where Metaverse users can put on a motion capture suit and capture all necessary movements*. When capturing movements, there is a guideline for all the movements the user needs to perform. This guideline aims to get the most realistic reflection of the Metaverse users' movements compared to how he performs them in real life**. In addition, the hub also features different sizes of motion capture suits so that every body type can use the hub.

*For the section where movements are captured, it is essential to have a large space available since Metaverse users need to run, for example, to get a realistic result for their Metaverse avatars. This prototype concerns only an example of the necessary sections.

**It is essential that sufficient time is devoted per person to capturing movements for the Metaverse avatars to obtain a realistic result.

Figure 10: The Motion Capture Hub (1/4)

Avatar Creation Section

The second section of the hub is where Metaverse users can create their avatars for a Metaverse or to use them on social media platforms such as Snapchat or WhatsApp. The captured movements can then also be converted to the created avatars.

Figure 11: The Motion Capture Hub (2/4)

Avatars Web Shop Section

The hub's third section is where users can purchase clothes for their avatars (NFTs). This allows Metaverse users in the hub to create an entire avatar by 1) capturing the movements, 2) composing an avatar, and 3) buying assets for the avatar to personalize it further.

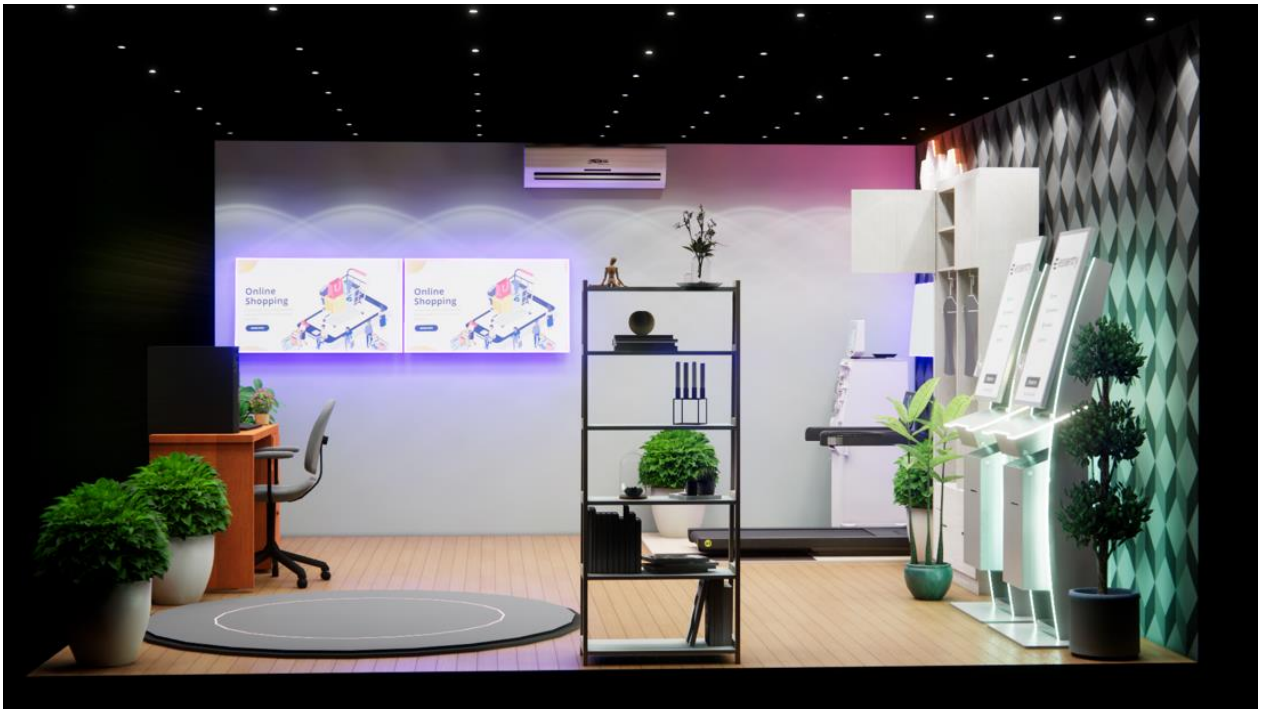

Figure 12: The Motion Capture Hub (3/4)

Health Analysis Section

The fourth section of the hub focuses on analyzing movements and recording movements, for example, for a specific sports game. This section thus provides the opportunity to 1) gain insights into health-related issues, 2) gain insights into how users perform sports movements, and 3) capture movements for a specific sports game such as FIFA or NBA.

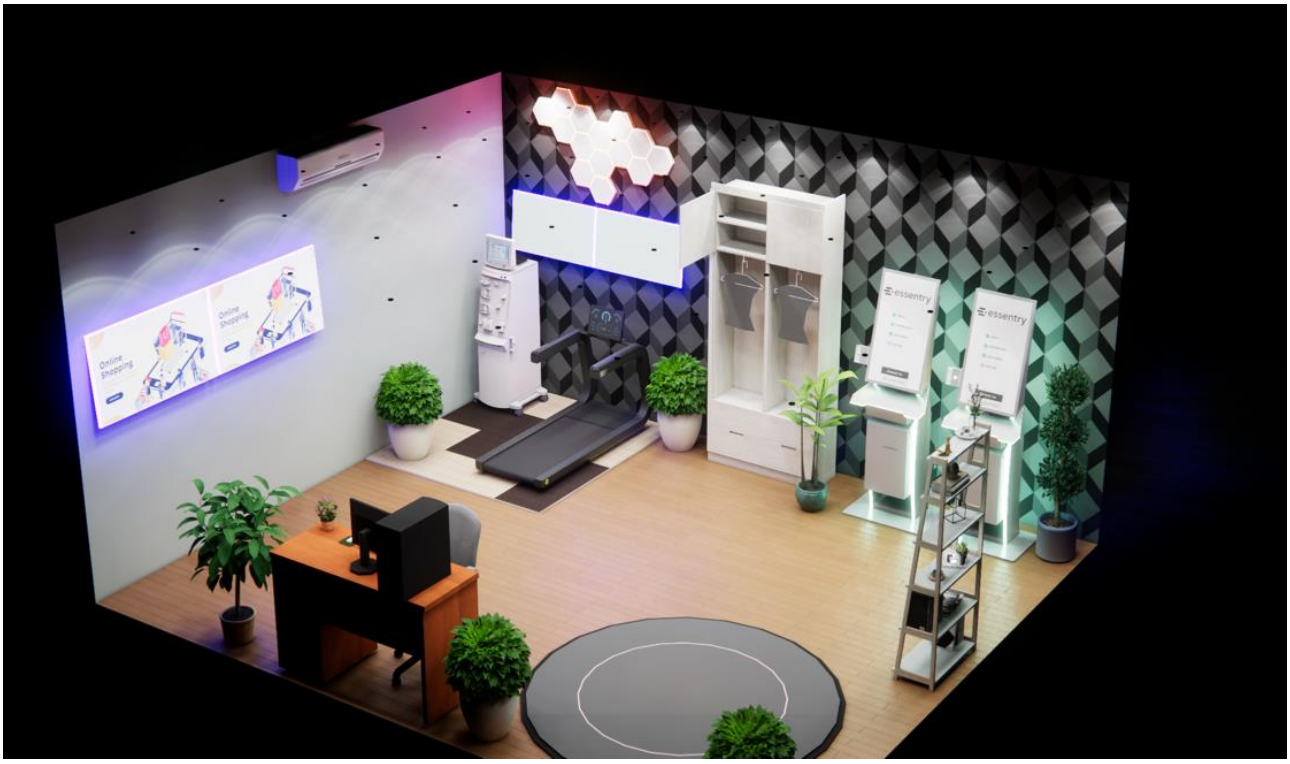

Figure 13: The Motion Capture Hub (4/4)

Other Aspects Hub

Finally, the hub has two other aspects, namely:

1. Users can earn tokens while interacting with the hub. This is made possible by blockchain technology. Users can then, for example, use the tokens to buy assets for their avatars.
2. The hub itself gains more insights the more the hub is used to become more efficient. This is made possible by machine learning.

5.3.2. Prototype 2: Capturing at Home using AI

This section discusses the final elements of the prototype aimed at capturing movements in a home environment using AI. The information in this section is a replica of the information on the website.

AI to Capture Movements

This prototype revolves around capturing movements for Metaverse users' avatars by using their own phones in a home environment. This is made possible by AI. After capturing movements, Metaverse users can convert their movements to the Metaverse to use their avatars there with the recorded movements.

Users can choose to purchase more cameras to improve the results. So, users can choose one camera (cheaper and less quality) or multiple cameras (more expensive and better quality). If users choose one camera, they will have better processing time.

Figure 14: Capture at Home using AI (1/4)

Additional Features (1/2)

Capturing movements through the use of your phone and extra cameras can also provide additional features. These features are: 1) create a motion password as a login (pass-motion), 2) integrate captured movements into (sports) games such as FIFA and NBA games, 3) ability to upload captured movements to a library that others can use and 4) create an AI model of yourself when you are not online/available in the Metaverse worlds.

Furthermore, when the user contributes to the movement's library, the users can earn tokens or NFTs for their contributions. These tokens and NFTs can be utilized in the Metaverse. This feature is enabled by blockchain technology.

Figure 15: Capture at Home using AI (2/4)

Additional Features (2/2)

Finally, there are two additional features. These features are: users can share their captured movements as data with the health market and earn tokens and NFTs on this, and 2) users can receive ergonomic feedback on, for example, how the user is sitting and moving.

Figure 16: Capture at Home using AI (3/4)

Figure 17: Capture at Home using AI (4/4)

5.4. Results Metaverse User Validation

For the Type-1 validation, five potential Metaverse users were interviewed. This section first discusses the results of the aspects of the prototypes addressed in section 5.3. The results are described using the Dot Democracy principle along with the respondents' substantiation of the aspects obtained by using think out loud during the interviews, which are combined in the conclusion of the elements for

each prototype in sections 5.4.1 and 5.4.2. The results of the Dot Democracy principle on the prototypes can be found in Tables 18 and 19. Herein, the frequencies of green, red and stickers placed in the middle are reported on all elements of both prototypes as presented in section 5.3. Appendix F presents the Dot Democracy results, which contain the stickers. In addition, the respondents' individual responses per aspect and the summary of the respondents' responses per aspect concerning the think out loud protocol during the interview can be found in Appendix G. The transcription of this interview does not involve an official transcript. This is because it was an open-ended interview, and a lot of conversation was not focused on the actual objective. Therefore, the transcription is based on all critical takeaways from the interview that contribute to the process.

After discussing the results of the Dot Democracy principle, the survey results are discussed. The survey aimed to gain additional insight into the criteria of both prototypes through the five E's and additional criteria described in section 5.1.3. This allowed a gap analysis to be performed on both prototypes.

Finally, this section provides an overall conclusion on the type-1 validation. This conclusion was drawn using the data from the Dot Democracy principle, think out loud protocol and the survey. Tables 21 and 22 in section 5.4.4 summarize all indications and contraindications from the type-1 validation.

5.4.1. Results Prototype 1: The Motion Capture Hub

For the motion capture hub prototype validation, all aspects were reviewed with the respondents, as described in section 5.3.1. In Table 18, the results of the Dot Democracy principle focusing on the motion capture hub prototype can be found.

Prototype 1 (The Hub): Aspects	Results Dot Democracy Frequency Stickers		
	Green	***In Between***	***Red***
Motion Capture Section	N = 4	N = 0	N = 1
Guideline for movements	N = 4	N = 1	N = 0
Different sizes of suits	N = 5	N = 0	N = 0
Avatar Creation Section	N = 4	N = 0	N = 1
For use on social media (Snapchat and Whatsapp, for example)	N = 3	N = 1	N = 1
Convert captured movements to an avatar	N = 5	N = 0	N = 0
Avatar Webb Shop Section	N = 5	N = 0	N = 0
Buy assets (NFTs) for avatars for personalization	N = 4	N = 1	N = 0
Health Analysis Section	N = 3	N = 0	N = 2
Gain insights into health-related problems	N = 3	N = 1	N = 1
Gain insights on how users perform a sport	N = 2	N = 1	N = 2
Capture movements for a sports game	N = 5	N = 0	N = 0
Other Aspects Hub			
Earn tokens (via blockchain) while interacting with the hub	N = 4	N = 0	N = 1
Hub gets more efficient when being used more	N = 4	N = 0	N = 1
The Motion Capture Hub	N = 4	N = 0	N = 1

Table 18: Dot Democracy Results – The Motion Capture Hub

Motion Capture Section

Respondents generally responded positively to the motion capture section. This is because they saw this section as the essence of the hub. The guideline for executing movements and the different suits

sizes were also seen as good additions to the section. The contraindication that emerged was that a respondent might find the physical aspect an obstacle if the hub is not close to home.

Avatar Creation Section

Most respondents were positive about the avatar creation section as an additional feature of the motion capture hub. All respondents indicated that they felt it was essential to be able to see movements directly in their Metaverse avatars. In addition, there was also a positive response that you can integrate the avatars created in the hub directly into your social media accounts. The contraindication on the avatar creation section was that respondents preferred to create their avatar in an online environment rather than physically in a hub.

Health Analysis Section

Concerning the health analysis section, respondents had mixed feelings. For example, respondents indicated that they thought gaining insight into health-related issues could be good for attracting new audiences to the hub. Attracting new audiences also applies to gaining insight into sports movements. Furthermore, everyone responded positively to integrating movements into sports games.

The contraindications to this section were mainly that the respondents themselves would not quickly use the health analysis section as they would sooner go to a specialist outside the hub. Additionally, some expressed doubts about how the data was analyzed, privacy concerns, and that there might not be enough space for some sports.

Other Aspects Hub

The other aspects of the hub are: 1) earning tokens when you interact with the hub and 2) the hub becoming more efficient as it is used more. Most responses were positive towards these two aspects. It emerged that respondents thought it was a good initiative to earn incentives through interacting and that it could also be a way to introduce people to blockchain. In addition, most respondents also acknowledged that machine learning could be a good addition to making the hub more efficient.

The contraindications here were mainly focused on the fact that one respondent does not see the essence of going to one hub more often. In addition, that same respondent indicated that he did not see machine learning as the right option to make the hub smarter over time.

5.4.2. Results Prototype 2: Capturing at Home using AI

For the validation of the concept revolving around capturing at home using AI, all aspects were reviewed with the respondents as described in section 5.3.1. In Table 19, the results of the Dot Democracy principle focusing on the 'capturing at home using AI' prototype can be found.

Prototype 2 (AI Solution): Aspects	**Results Dot Democracy Frequency Stickers**		
	Green	***In Between***	***Red***
AI to Capture Movements			
More cameras for better results (more expensive)	N = 3	N = 1	N = 1
Fewer cameras for lower quality but cheaper + better processing time	N = 5	N = 0	N = 0
Additional Features (1/2)			
Creating a motion password as login (pass-motion)	N = 2	N = 1	N = 2
Integrating captured movements into sports games such as NBA/FIFA	N = 4	N = 0	N = 1
Upload captured movements to a library so others can use it	N = 3	N = 2	N = 0
Creating an AI model of yourself if you are not there in the Metaverse	N = 2	N = 2	N = 1
Additional Features (2/2)			
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	N = 2	N = 1	N = 2
Receive ergonomic feedback on, for example, how the user is sitting and moving	N = 5	N = 0	N = 0
Capturing Movements with AI and cameras	N = 5	N = 0	N = 0

Table 19: Dot Democracy Results – Capturing at Home using AI

AI to Capture Movements – Camera Quantity

The first aspect that respondents validated from the second prototype focused on the option of camera quantity. The respondents indicated that having a cheaper entry-level camera model is

essential. The reason for this is that it is then more accessible to beginning Metaverse users. It was also indicated that it might be an option to purchase more expensive cameras for users considering multiple cameras. The respondents themselves would all choose the cheaper alternative since they see it as more accessible.

Additional Features (1/2)

The second aspect of the prototypes that have been validated relates to the following additions: 1) the motion password, 2) integrating movements into sports games, 3) uploading movements into a library, and 4) creating an AI model of yourself when you are not available in the Metaverse.

Regarding the motion password, respondents were somewhat more negative. This is because most had preferences toward a traditional solid password, and concerns were expressed about privacy issues that may arise. However, some respondents indicated that it could be an additional reason to buy cameras.

For uploading movements to a sports game, all respondents were very positive. Respondents indicated that this could be a good reason for them to buy cameras to capture movements at home.

Regarding uploading movements into an online library, respondents had mixed feelings. It was indicated that they would not buy movements from unknown people, but in their view, there could be a market for people who would purchase movements from famous people. Furthermore, one respondent indicated that copyright issues might arise and that he does not see it working because of this.

There were also mixed feelings about having an AI model of yourself in the Metaverse when you are not there. Here it was indicated that it was not necessary but that if it was there, it could enhance the Metaverse experience. Further, concerns were expressed about the AI replica that would cause a bad reputation when the AI would act with negative consequences.

Additional Features (2/2)

The third aspect of the prototypes that have been validated relates to the following additions: 1) sharing movements with the health market for incentives and 2) obtaining ergonomic feedback on, for example, how you sit.

Regarding movement sharing with the health market, there were mixed feelings. Here, respondents indicated that there would probably be a market for people who do not care about privacy. Since the respondents indicated they were privacy conscious, they would not use this. So, the idea was considered a good one, but specifically for non-privacy-conscious people who are open to earning incentives.

The idea of getting ergonomic feedback on individual physical aspects was considered positive by the respondents, with no real contraindications. The reason for this is that respondents would be willing to take cameras into their homes to, for example, obtain information in this way that you could normally only receive from a physio. It was also indicated that this could be used in offices to give employees feedback on how they sit. However, concerns were raised about privacy.

5.4.3. Results Survey

During the survey, respondents were asked how they would rate the criteria of both prototypes measured on a 5-point Likert scale. The criteria were based on the five E's and two additional criteria, namely, 1) accessibility and 2) price. When discussing the results, prototype 1 refers to the motion capture hub, and prototype 2 refers to the AI solution in a home environment. The statements with associated criteria can be found in Tables 16 and 17. In Table 20, the survey results can be found.

	Prototype 1 (The Hub) Average	**Prototype 2 (AI Solution) Average**		**Prototype 1 MIN / MAX**	**Prototype 2 MIN / MAX**
Efficacy	4.2	3.8		MIN = 4, MAX = 5	MIN = 3, MAX = 5
Efficiency	3.6	4.2		MIN = 2, MAX = 5	MIN = 4, MAX = 5
Effectiveness	4.2	3.6		MIN = 3, MAX = 5	MIN = 3, MAX = 5
Ethics	3.4	3.8		MIN = 3, MAX = 4	MIN = 3, MAX = 4
Elegance	3.2	3.8		MIN = 2, MAX = 4	MIN = 2, MAX = 5
Accessibility	2.8	4.4		MIN = 1, MAX = 4	MIN = 4, MAX = 5
Price	3.6	4.4		MIN = 3, MAX = 4	MIN = 4, MAX = 5

Table 20: Survey Scores Criteria Prototype 1 & 2 (Average, Minimum, and Maximum)

Efficacy

Efficacy relates to whether the prototype delivers the desired output. The mean of prototype 1 is 4.2 (MIN = 4, MAX = 5), and the mean of prototype 2 is 3.8 (MIN = 3, MAX = 5). According to the respondents, the first prototype is more likely to deliver the desired output for metaverse users.

Efficiency

Efficiency refers to whether minimal resources are needed to achieve the goal. The average of prototype 1 is 3.6 (MIN = 2, MAX = 5), and the average of prototype 2 is 4.2 (MIN = 3, MAX = 5).

According to the respondents, the second prototype is more likely to need minimal resources to achieve the goal.

Effectiveness

Effectiveness refers to whether the prototypes contribute to the long-term goal for Metaverse users. The average of prototype 1 is 4.2 (MIN = 3, MAX = 5), and the average of prototype 2 is 3.6 (MIN = 3, MAX = 5). According to the respondents, they see the first prototype making more contributions to the long-term goal for Metaverse users.

Ethics

Ethics refers to whether the prototypes are morally correct. The average of prototype 1 is 3.4 (MIN = 3, MAX = 4), and the average of prototype 2 is 3.8 (MIN = 3, MAX = 4). According to the respondents, they see the second prototype as being more morally correct.

Elegance

Elegance refers to whether the prototypes are an attractive solution for Metaverse users. The average of prototype 1 is 3.2 (MIN = 2, MAX = 4), and the average of prototype 2 is 3.8 (MIN = 2, MAX = 5). According to the respondents, the second prototype is a more attractive solution for Metaverse users.

Accessibility

Accessibility refers to how much effort it takes to capture movements for their Metaverse avatars focusing on both prototypes. The average of prototype 1 is 2.8 (MIN = 1, MAX = 4), and the average of prototype 2 is 4.4 (MIN = 4, MAX = 5). According to the respondents, the second prototype takes less effort to capture movements for their Metaverse avatars. Hence, the second prototype is seen as a more accessible solution.

Price

To gain insight into how respondents would rate the price of both prototypes, a price was provided, described in Tables 16 and 17. The average of prototype 1 is 3.6 (MIN = 3, MAX = 4), and the average of prototype 2 is 4.4 (MIN = 4, MAX = 5). Thus, respondents felt that having at least one newer generation phone for prototype 2 was a more affordable solution than paying $250 for prototype 1

5.4.4. Conclusion Type-1 Validation

The first prototype aimed at capturing movements in a hub received generally positive feedback. As such, it came out that the hub sections would all be good additions. This is because respondents indicated that it is essential that you can perform more related Metaverse activities than just capturing movements. This is mainly true about the avatar creation and shop section. However, there were contraindications about the health section centred around that respondents were more likely to go to a physio, for example, to gain insight into health issues. There were also some doubts about gaining insight into sports movements as this is less likely at the amateur level. However, they did see a use case in the health section for capturing movements for sports games. Another contraindication that emerged was that physically going somewhere is seen as an obstacle, especially when the hub is not nearby. There were also signals about a preference for creating avatars in an online environment rather than in the hub. Still, the avatar creation section was found to be favourable. The other aspects, such as the guideline for movements, the use of avatars on social media, earning tokens through interaction and the smart hub through machine learning, were seen as good additions to the hub. The reasoning is that if the hub ever really becomes a thing, these aspects will improve the hub. The different sizes of suits were also seen as necessary. Hence the dominance of green stickers to these additions in the dot democracy results in Table 18. Lastly, some suggestions came up from the respondents: 1) testing out a hub in a mall / large store, and 2) testing out the hub at a health-related company with an emphasis on the health section. This would be related to the shop-in-shop principle.

The second prototype focused on capturing in a home environment through AI mainly had positive responses. It emerged, however, that there was a preference for cheaper cameras as entry-level models. Respondents did say it was good to have the option for multiple cameras combined with better quality for people who could consider the more expensive option. Furthermore, respondents reacted to most of the additional features of the AI solution as good additional use cases. There was a very positive reaction to capturing movements for sports games and getting ergonomic feedback on, for example, how you sit. This is because respondents saw a future in having themselves as an avatar in sports games and that it would be accessible to have an online appointment with, say, a physio to discuss health-related issues. Uploading movements to a library was also responded positively, but this could then be focused more on buying movements of famous people. There were, however, some contraindications about pass-motion, sharing data with the health market, and having an AI model yourself. Most of the contraindications were about privacy-related issues. Respondents indicated that a pass-motion might be too easy to guess and preferred a traditionally strong password. Furthermore, there were concerns about sharing data with the health market regarding whether it could be used against you. Finally, signals emerged that an AI model might cause reputational damage since you do not actually control and oversee the AI. For the ideas with privacy concerns, it was indicated that there

could be a use case for non-privacy-conscious people. Hence the green stickers on the dot democracy result in Table 19.

The survey revealed that the second prototype focused on the AI solution scored better on five criteria. However, it did emerge that respondents felt the hub contributed more to the desired output and long-term objective, seen from the higher score on efficacy and effectiveness. A substantiation of this could be, which emerged from the interviews, that respondents felt the hub's capture data quality was better due to the presence of professionals. On the other criteria, the AI solution did score higher. In other words, respondents find this solution more efficient and attractive than the hub. In addition, the respondents see the AI solution as more accessible with a better price, which for these four criteria matches the signals received from the respondents during the interviews. However, respondents expressed concerns during the interview about the privacy of the AI solution on certain prototype additions, which is therefore inconsistent with the survey results. However, respondents were asked to assess the statement from the overall goal of the research: making motion capture more accessible to Metaverse users and their avatars. For this reason, the ethics criteria could be higher than the stances from the interview on certain prototype additions.

To conclude, the respondents expressed mixed opinions on the choice between the hub and AI solution. Some preferred the hub for privacy, while others preferred the AI solution for convenience. Overall, there was a positive reaction to the additions of both prototypes, such as the relationship with the health market in the prototypes. When considering the Metaverse, some participants indicated that the AI solution with cheaper cameras would be a good starting point for capturing avatars' movements. But others felt the hub could be a better option for those already more engaged with the Metaverse. As such, there was a sense among the hub that it could be a cool place to get new Metaverse users excited when they would go with an experienced friend. On the other hand, the idea of the hub is seen as a drawback when travelling too far. So, to tie it back to the purpose of this research, it appears that the respondents' preference is for the AI solution mainly due to its accessibility and price. To further substantiate this, the AI solution scored a higher mean based on all criteria (mean = 4.1) compared to the hub (mean = 3.5) from the survey based on the 5-point Likert scale. Herein, as indicated, the criteria of accessibility and price were double-weighted compared to the five E's criteria. An overview of all indications and contraindications of the hub prototype and the AI solution prototypes can be found in Tables 21 and 22.

Prototype 1 (The Hub)	
Indications	Essential to have more sections to perform more activities in the hub.

	Avatar creation and web shop section are essential additions to the hub.
	Capturing movements for a sports game concerning the health section.
	Aspects like the guideline for movements, the use of avatars on social media, earning tokens through interaction and the smart hub through machine learning are perceived as aspects that will improve the hub.
	Hub would be a good solution for people already more engaged in the Metaverse.
	Hub could introduce new people to the Metaverse.
Contraindications	Physically going to a hub concerning accessibility.
	Perceived as more expensive than the Ai solution concerning the price.
	Preference of going to a real-life physio concerning the health section.
	Capturing movements for sports is perceived as an aspect with no actual use case since professionals would have that equipment, and it is perceived as not essential on an amateur level concerning the health section.

Table 21: Indications and Contraindications Prototype 1 (The Hub)

Prototype 2 (AI Solution)	
Indications	Preference for cheaper cameras as entry-level, which is considered a reasonable price.
	The option for additional cameras with better results would be suitable for people who could consider it.
	Capture movements for sports games.
	Receiving ergonomic feedback via cameras at home.
	Elements with privacy issues, such as the pass-motion and sharing data with the health market, could be good additions for non-privacy-conscious people.
	The AI solution is perceived as convenient since you do not have to go somewhere physically, concerning accessibility.
Contraindications	A library for buying movements could work only if you can buy the movements of famous people.
	Pass-motion is perceived as an addition with no use case since a traditional password is preferred.

	Privacy issues concerning sharing data with the health market.
	Having an AI model of yourself could lead to reputational damage.

Table 22: Indications and Contraindications Prototype 2 (AI Solution)

5.5. Reflection on Action Deliver Phase

The goal in the deliver phase is to test the solutions to adjust and reject aspects of the solution. To achieve this, actions were taken. Accordingly, testing of the prototypes was done in this phase through a type-2 interview with a Metaverse expert focused on the prototypes presented in section 4.4. Next, a type-1 interview was conducted with Metaverse users focused on validating the prototypes, as presented in section 5.3. Finally, the final prototypes were created during this phase.

The type-2 interview went smoothly and was natural. This ensured that the Metaverse expert had almost no areas of improvement on the prototypes of the develop phase. The areas of improvement that existed, as stated by the expert, were added in this phase. Since the expert was viewing the prototypes for the first time at the interview, he had to come up with his areas of improvement on the spot. An option would have been to send the expert the prototypes of the develop phase in advance so that there was more time to reflect. This could have led to additional comments as the expert would have had more time to review the prototypes.

Furthermore, during this phase, there was contact with an external party specialized in creating virtual 3D environments. This external party made the prototypes that were presented in this phase. As mentioned, the intention was to create virtual 3D environments as the first prototypes in the develop phase. However, due to a misunderstanding about the price, this was not possible as it would have exceeded the available budget. For this reason, the decision was made to create the prototypes only after all the information had been gathered so that the external party would not have to make adjustments. This decision ensured that the research remained within the available budget. Hence it is vital to make clear agreements about the price so that this can be taken into account during the research.

Finally, a type-1 interview was conducted in this phase for prototype validation with Metaverse users. These interviews generally went very smoothly and allowed for the disclosure of valuable information focused on the prototypes. In addition to the interview, a survey was sent to the respondents to assess the criteria of the prototypes. A 5-point Likert scale was used for the survey, whereas the intention was to use a 7-point. This was because an incorrect URL was sent to the respondents containing an older version. Despite the 5-point Likert scale, the survey provided valuable insights as it allowed the prototypes to be compared based on predefined criteria.

From the type-1 validation interview, several aspects from the define and develop phases reappeared. For example, the AI solution received positive responses to the health-related additions that emerged earlier in the literature review and the brainstorming sessions in the develop phase. Furthermore, the related Metaverse technologies, such as AI and blockchain, were perceived as good additions in both prototypes. Finally, the presence of the fashion industry with the web shop section in the hub prototype was seen as a good contribution. From the steps taken in the deliver phase, the theme from the define and develop phase emerged again. Hence it is essential to keep these aspects in mind as they recur during the Design Thinking process.

CONCLUSION

06

6. Conclusion

This section delivers a discussion focused on both research questions central to this research. Next, the implications of the research are discussed. Finally, the limitations are discussed, followed by directions for future research.

6.1. Discussion

The motivation for this research was to provide a framework for companies to dynamically prepare for the Metaverse. This originates from the increased attention surrounding the Metaverse emerging in the fall of 2021. As a result, the following initial research question was established:

'How can companies dynamically prepare themselves to become Metaverse-ready?'

The research started with a literature review focused on that initial research question. Here the focus was on gaining insight into what the Metaverse entails by examining associated technologies, current and future business models, and bottlenecks. Furthermore, the literature review provided the framework for companies to prepare for the Metaverse, which can be found in Appendix A. The framework clarifies 1) how to build a strategy for the Metaverse, 2) how to identify opportunities, 3) how to get stakeholders internally and externally on board, and 4) how to monitor implementations. The creation of the framework can be seen as an answer to the initial research question.

The literature review subsequently contributed to uncovering a fundamental problem of the Metaverse. This problem relates to a key component of the Metaverse, namely the personalization of avatars which are equivalent to the online identity of Metaverse users. Personalization relates not only to the avatars' looks and assets but also to how the avatar moves. This becomes even more relevant because much of our real-life communication is nonverbal. But to bring this personalization to the Metaverse, motion-capture technologies are needed. Here is where the problem emerges: currently, high-quality motion capture technology is not accessible to individual Metaverse due to high prices and cumbersome equipment. However, this high-quality equipment is necessary to get the avatar personalization realistically to enhance non-verbal communication. Accordingly, the initial research question was reframed to:

'How can Metaverse users be facilitated to record their movements in an accessible way for its avatars?'

On the above research question, following the Design Thinking process, initial prototypes were created with the essence of making motion capture more accessible to the Metaverse avatars. The first prototypes were developed through several brainstorming sessions and a validation interview with a Metaverse expert. The two prototypes were then reviewed by a second Metaverse expert, which resulted in two final prototypes appropriate to the scope of this research. The first prototype concerns a motion capture hub where users can go to capture their movements for their Metaverse avatars. In this hub, there are other sections where Metaverse users can perform other related activities. The different sections mainly aim to increase the reason to visit the hub. The second prototype relates to getting cameras to capture movements in a home environment through AI for the Metaverse avatars. To increase the motivation to purchase the cameras, other aspects have been devised to which the cameras can contribute.

A type-1 interview was subsequently conducted on these prototypes with potential Metaverse users to gain insight into the indications and contraindications of both prototypes. During this interview, the prototype focused on the AI solution was perceived as more accessible with a more reasonable price. Overall, reactions to both prototypes were positive, with some exceptions about certain additional features of the prototypes. For this reason, a good follow-up step would be to develop both prototypes into real-life versions to examine how users interact and whether it achieves the desired goal.

The real-life prototypes could provide insight into the trade-offs mentioned in section 5.4.4. For example, concerns about the privacy of some additions to the AI solution made respondents prefer the hub. On the other hand, the AI solution was preferred due to its convenience. Furthermore, respondents indicated that the AI solution could be a good first step for novice Metaverse users who can purchase the cheaper version of the cameras, where the hub was seen as a place where there is more of a use case for experienced Metaverse users. Further research into these trade-offs may provide insight into whether these trade-offs hold when the prototypes are presented in real life. To take it even further, for example, elements such as privacy and convenience and a solution for novice and experienced Metaverse users could be combined to create future prototypes focused on a related research question.

The Four Layers of Practice

The research conducted is a type of abduction-2 aimed at discovering the 'What' and 'How' central to abduction-2. The 'What' and 'How' are focused on the value and principle (the 'Why') of making motion capture equipment more accessible to Metaverse users to enable personalization. The 'What' and 'How' are answered through Dorst's (2018) *'the four layers of practice'*. Table 23 shows *'the four layers of practice'* focused on both prototypes.

	Prototype 1 (The Hub)	Prototype 2 (AI Solution)
Why (Values)	Making motion capture equipment more accessible for Metaverse users	
Why (Principles)	Enabling personalization in the Metaverse	
How (Methods and Tools)	A Metaverse hub where users can capture their movements, among other related Metaverse activities.	AI and a newer generation phone with an option of additional cameras for better quality
What (Action)	Let Metaverse users use motion capture equipment at an external location	Let Metaverse users buy an affordable and easy-to-use solution to capture movement in a home environment

Table 23: The Four Layers of Practice: Capture at Hub & Capturing at Home using AI

Synthesis of the Actions taken

During this research, several actions were taken together with stakeholders on which reflections were carried out in the phases of the Design Thinking process. This is in line with action research used during this research. From the actions taken, several elements reappeared. For example, it emerged that the fashion industry and the health market have various opportunities to leverage the Metaverse. The same goes for technologies linked to the Metaverse, such as AI, blockchain and Extended Reality technologies. Finally, the phases revealed that content creation by Metaverse users is an essential part of the Metaverse. So, these are different elements that recurred in the actions taken in the phases, which traces can also be found in the final prototypes delivered in the deliver phase. In section 6.4, future research focused on the aforementioned recurring elements of the Metaverse will be discussed in more detail.

6.2. Practical Implications

The research conducted addressed two different research questions. There are implications for both research questions. As such, the research question aimed at creating a framework for companies to prepare for the Metaverse has provided insights into what steps companies can take. Through this framework, companies can think about a future strategy accompanied by an implementation plan. In addition, the framework can help companies get internal and external stakeholders towards the Metaverse and monitor the implementations. The framework aims to familiarize companies with the Metaverse so they can take the first step in building and leveraging the Metaverse.

The second research question, on which most of the focus was during this study, also has several implications. The research question focused on making capturing movements more accessible to Metaverse users' avatars. The research led to two prototypes which should improve accessibility in capturing movements for their avatars. These solutions are aimed at the end user of the Metaverse so that users can take advantage of the complete personalization.

As such, there are several practical implications for the motion capture hub. To establish the hub, companies could focus on facilitating the hub. For example, these can be companies in the motion capture industry in combination with companies that can provide the space for the hub. It then can be considered whether it should be a stand-alone location or a shop-in-shop. Furthermore, the web shop section needs assets available for Metaverse users to purchase, where facilitation is also required. The fashion industry can contribute here, which is frequently linked to the Metaverse. In addition, a bridge for the web shop section needs to be laid with blockchain technology to establish this addition. Another aspect of the hub is a section focused on health, in which not all responses were equally positive, but where research can be done on how the health sector can be facilitated in the scenario of presence in the hub. Focusing on the health section, there were positive responses to motion capture for sports games. Herein, for example, the hub can partner with game developers and publishers so that users can capture motion for their games. Thus, the hub can provide different implications in which different industries can leverage the hub.

The prototype of capturing movements in a home environment through AI brings several implications as well. For example, companies need to get involved in facilitating the capturing of movements by providing low- and high-quality cameras and software to let Metaverse users convert their movements to the avatars and the Metaverse. Furthermore, the health-related additions to this concept received a positive response. For example, respondents saw great value in getting ergonomic feedback from home. In this, for instance, physios and other health institutions should engage in the facilitation so that Metaverse users can receive feedback on ergonomic matters from home. Motion capture for sports games was seen as a good addition here as well, where game developers and publishers, for example, can provide the equipment when purchasing Metaverse-related video games. The AI solution thus offers different angles for companies to engage with Metaverse and facilitate motion capture for Metaverse avatars.

6.3. Limitations

This research involves some limitations. The main limitation is that the two prototypes could not be made in real life due to the scope of this study. This makes it difficult to assess how the Metaverse

would interact with real-life prototypes. Besides that, a real-life prototype could provide more insight into the additions of both prototypes.

Another limitation is that the first brainstorming session in the develop phase and the type-1 interview in the deliver phase was conducted with male respondents. This is because it was difficult to find female respondents who fit the Metaverse persona suitable for this research. Therefore, the results may have been grounded from the male perspective, which could have been different from the female perspective or a combination of both. A direction for future similar research could be a study with female respondents.

The survey conducted as a complement to the type-1 interview also brings limitations. These relate to 1) the low number of respondents preventing reliable and valid statistical statements, and 2) the difference in the stance on ethics in the survey compared to the signals picked up during the interview focused on the AI prototype. No further substantiation can be found on the latter since no additional explanation could be given during the survey. Hence, substantiation is difficult.

6.4. Future Research

This research has also led to areas for future research. As mentioned earlier, it is interesting to create both prototypes in a real-life setting to see how Metaverse users interact with the prototypes. A real-life prototype could then contribute to research on the additions of both prototypes. For the hub, it could be investigated whether 1) all additional sections are considered essential, 2) to what extent the location, as in the distance from home and the shop-in-shop principle, plays a role in the willingness to go and 3) the price since for the hub, during the survey this was based on the expertise from the researcher's internship company. Another direction for future research involves creating personas of target groups based on the prototypes. This could provide insight into how the individual audiences interact with them to uncover needs. Furthermore, for the additions of the AI solution through the real-life prototype, it can be examined whether 1) a motion library targeting famous people has a use case, 2) how the price-quality ratio of the option of one or more cameras should be structured, and 3) the different privacy concerns of the additions to the AI solutions.

In addition to the prototypes created from this research involve areas of future research. This applies to different aspects of the Metaverse as well. For instance, several technologies are expected to play a role in the Metaverse. Further research can be done on how Extended Reality technologies such as AR, VR and MR can enhance the real world and how these technologies can bridge the Metaverse by, for example, understanding how virtual products can have use cases outside the Metaverse. Blockchain is another commonly discussed technology of the Metaverse. Herein arise areas of future research on what the virtual economy will look like in the Metaverse enabled by

blockchain, storing data on the blockchain and how assets can be transferred from one virtual world to another virtual world. Additionally, regarding the two prototypes created during this research, research can be done on how blockchain can play a role in buying assets for avatars and storing data on the blockchain released by the prototypes. This could subsequently examine how blockchain can contribute to the privacy concerns of the AI solution created. Lastly, AI offers several areas of future research, for example, focused on how AI can contribute to automating the Metaverse and avatars. This is also focused on the prototype aimed at using AI in a home environment where the technology can contribute to creating movements, thus personalizing Metaverse avatars.

Content creation by users is at the heart of the Metaverse. Herein arise interesting areas to further explore, such as how the created content of Metaverse users can be integrated to contribute to shaping the Metaverse. Blockchain emerges in this again focused on how content is stored and can be transferred from one virtual world to another in the scenario of multiple Metaverse. Furthermore, content creation is focused on different industries that should make this possible such as the fashion industry. The fashion industry is a recurring theme during this research aimed at personalizing the avatars regarding the assets they wear. Further understanding of how the fashion industry will play a role in the Metaverse is essential as they are a facilitator in the personalization of the avatars. Another industry which frequently recurred in this research is the health market. This is where facets of the health market should be explored to what extent it can play a role in the Metaverse, such as how patients can be monitored remotely. Finally, other industries are linked to the Metaverse, such as the real estate market focused on selling virtual property, manufacturing industries that can use the Metaverse as a test environment with digital twins, and the financial sector on how they can apply blockchain technology to their financial activities in the Metaverse. The last-mentioned industries should be further explored in their contributions to the Metaverse as well.

The literature review conducted in this research further sheds light on business models that can be leveraged in the Metaverse. Examples include the gaming industry focused on how traditional games can be integrated into the Metaverse, how education can be implemented in the Metaverse to enhance student experiences and convenience, how the culture and arts sector can utilize online exhibitions and how e-commerce addresses new business models and partnerships.

Finally, there are still many bottlenecks and uncertainties of the Metaverse where further research is needed to make the Metaverse experience as fluid as possible to achieve mass adoption. For example, there are several ethical bottlenecks, such as cyberbullying and crime, racially offensive behaviour, and how people with disabilities can enter the Metaverse, which needs to be tackled, to name a few. There are also privacy and security bottlenecks that need answers, such as how the data will be stored and processed since the Metaverse is expected to generate a lot of data. Another privacy bottleneck is how to prevent identity damage by, for example, doing further research on eliminating

deep fakes that can cause identity damage in the Metaverse. Finally, there also needs to be proper security focused on the assets of the avatars of Metaverse users. The latter is central to the research's research question since the assets of avatars are central to the personalization and self-expression of Metaverse users. Therefore, the assets should be stored securely by, for example, a proper authorization procedure.

Other bottlenecks that require further research are how interoperability of the Metaverse will look like between the different virtual worlds and standardization between these worlds. Finally, the governance of the Metaverse is an uncertainty, in which more clarity is needed on 1) specific platform governance, 2) the regulation of transactions, 3) liability issues, 4) the protection of users' digital assets, 5) competition for innovation and technologies, 6) distribution and monetization models between stakeholders, 7) intellectual property rights, 8) security and privacy of users and 9) how equality between users is ensured. An underlying question of these elements is how blockchain technology can contribute here. Metaverse governance thus needs attention since there are several elements with question marks.

As can be concluded from the future research directions, there are still many questions surrounding the Metaverse. As stated at the beginning of the research, the Metaverse is still a relatively new development which can be the reason for the questions and directions for further research. In this, Metaverse enthusiastic companies should become pioneers to offer the general public answers about what the virtual worlds will look like. Moreover, they can inspire other companies to start with the Metaverse to implement different initiatives. Expected is that we will spend much of our time in these virtual. Therefore, the relevance to continue researching this new space.

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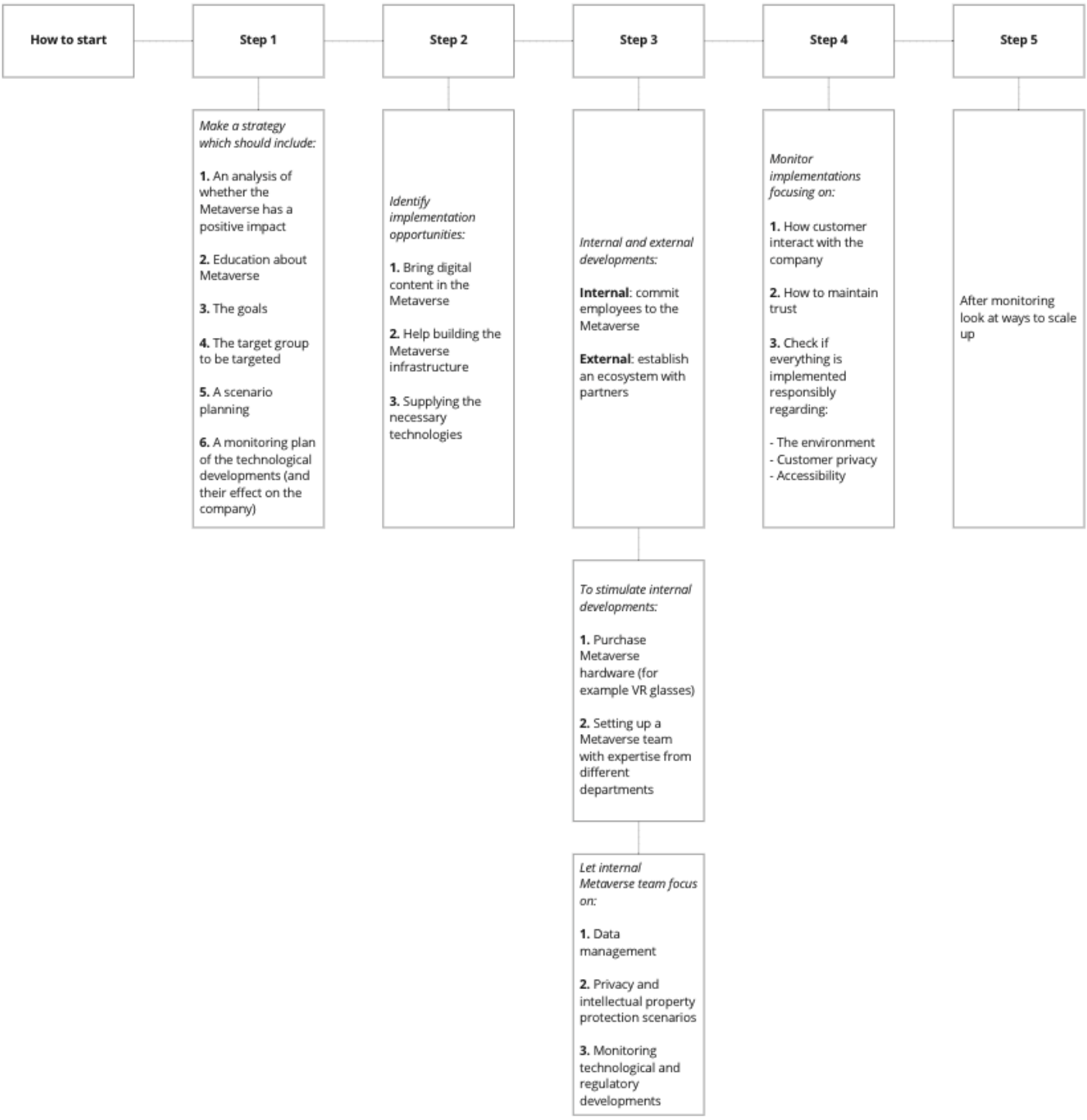
APPENDIX

08

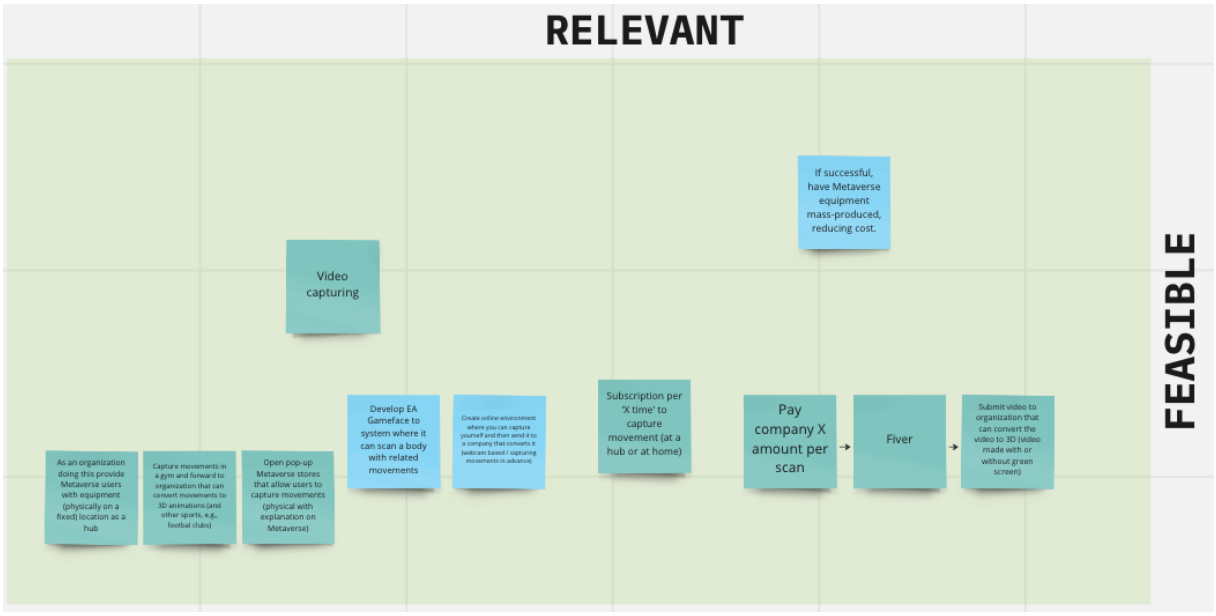
Appendix A: Visualization of How to Start

Visualization of how companies can get started with the Metaverse

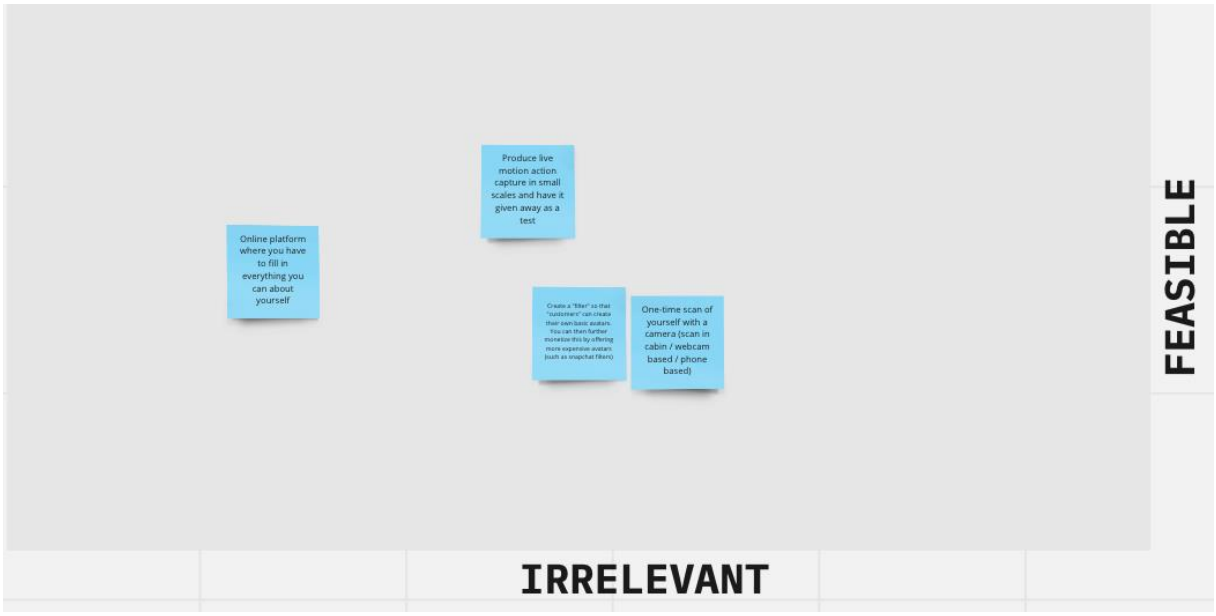


Appendix B: Quadrants Two-by-Two Matrix

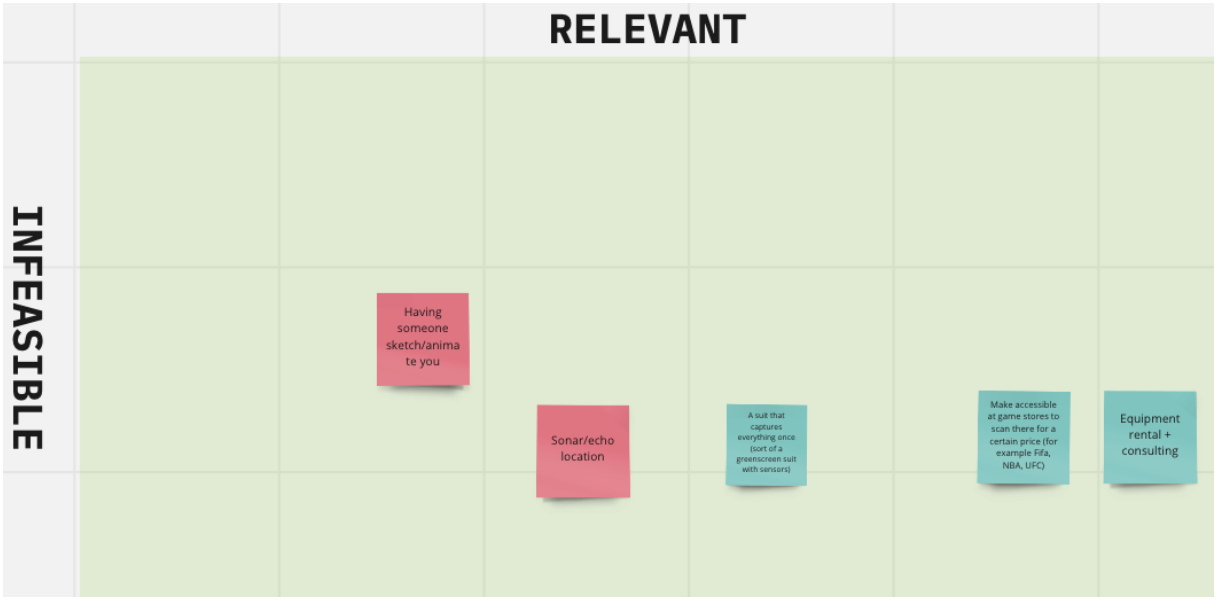
Relevant and feasible ideas



Irrelevant and feasible ideas



Relevant and infeasible ideas

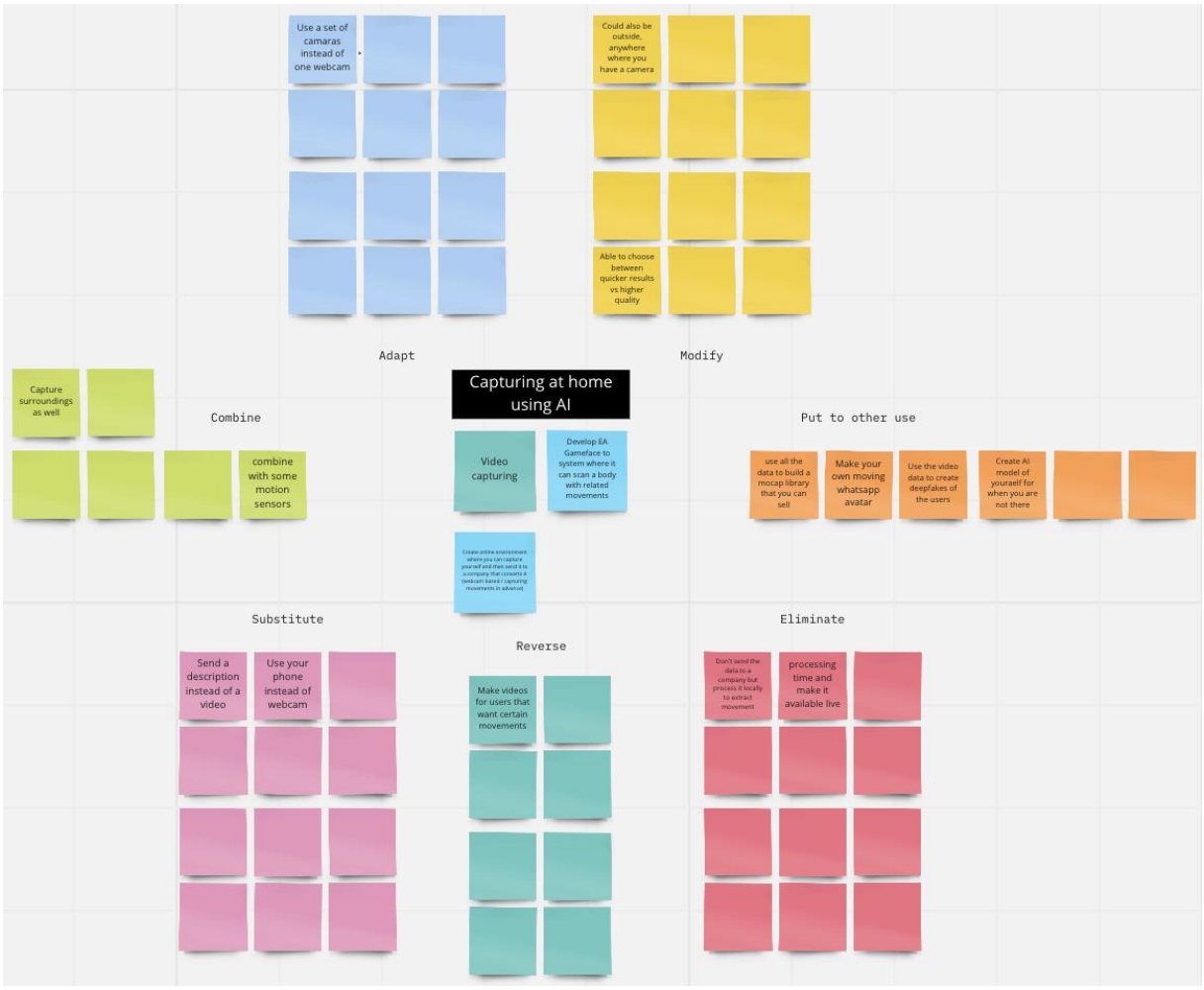


Irrelevant and infeasible ideas

Appendix C: SCAMPER

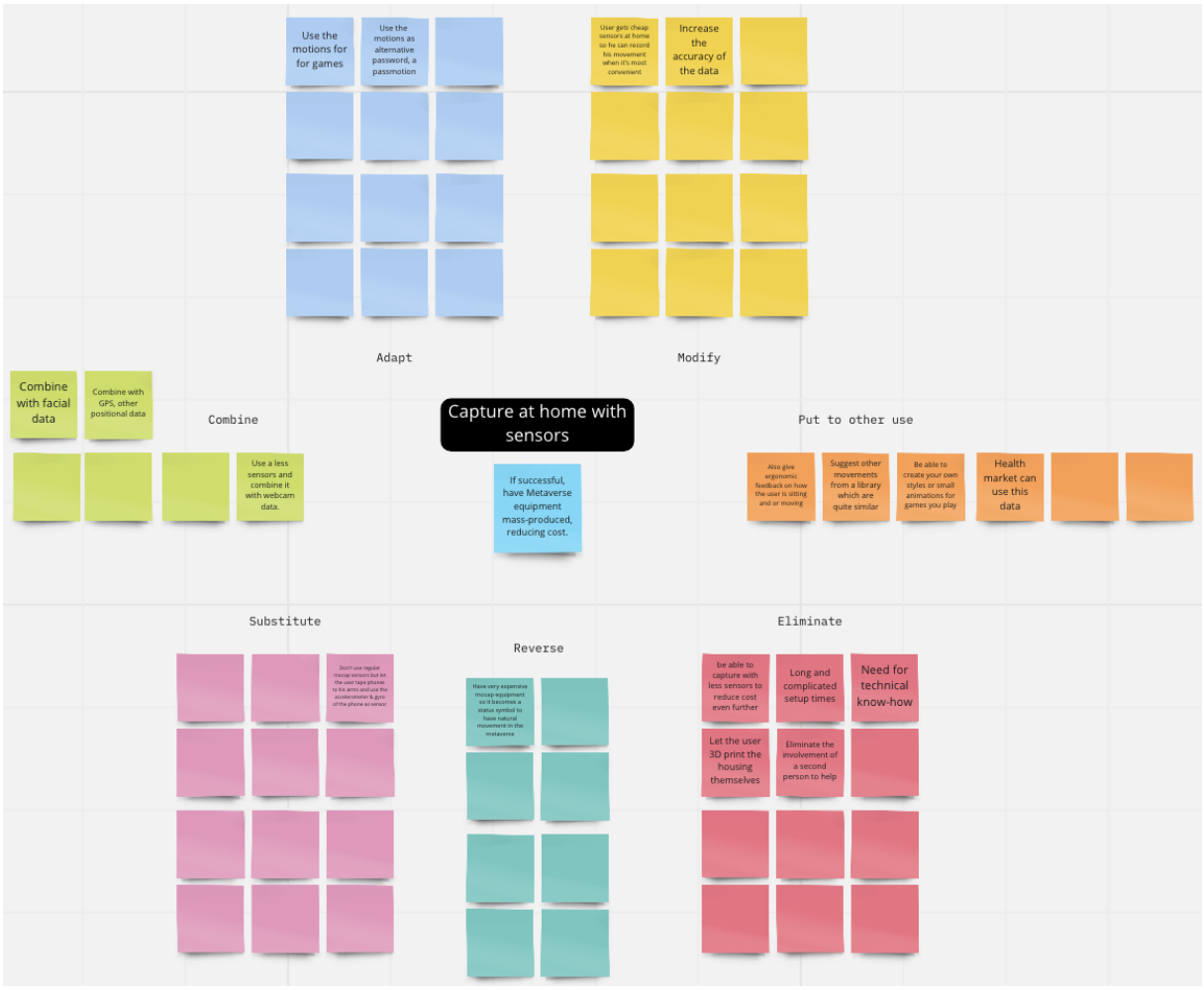
Capture at Hub

Capturing at Home using AI



Use Freelancer for Recording

Capture at Home with Sensors



Appendix D: Metaverse Expert Interview Develop Phase

Below is the transcript of the expert interview in the development phase. Section 4.1.3 discusses the corresponding methodology of the interview, and in section 4.3, all results are presented. The transcript is not an official transcript since it was an open-ended interview with a lot of conversation not focused on the purpose of the interview. Therefore, the interview contained a lot of non-useful information. This was filtered out, resulting in the following summary of the expert interview. In the transcript, the M stands for the researcher, and the E stands for the expert.

Concept 1: Capture at Hub

M:

So, the first idea is capturing motion at a hub. The first idea at substitute is 'Do it at other places (for example, sports clubs and offices).'

E:

It would be valuable if it is complimentary. For example, if it is at a football club and you can upload it in FIFA, it would definitely work. So, if it is a specific target group, then it would work.

M: What do you think about 'Combine it with sports or gaming while recording' and 'Advise the user on health/movement-related problems'?

E: If it is for a specific sport in combination with gaining insight into health-related problems, then it can certainly work. This is mainly because it has a particular use case and a clear added value.

M: A guideline of movements that users must perform to get a total set of movements; what are your thoughts about this?

E: In my opinion, users do not get happy if they have to do a specific set of movements. It is better just to let it be more free flow.

M: What are your thoughts about 'Combine it with a workout routine'?

E: Same story here; this is a specific use case, so this does add value.

M: What are your thoughts about 'A scanning booth where the user is scanned into a 3D avatar?'

E: In my opinion, this would only work if the avatar became immediately available on a social media platform. Besides, I personally do not see people going to a hub just to create an avatar.

M: Now for adapt, what do you think about 'Make it more of a community hub where you can do lots of stuff?'

E: The hub could work for capturing movements, only I am not so sure what to think about the whole community idea. This is hard to answer since, as a Metaverse enthusiast, I do not necessarily get excited about this.

M: Now, for put to other use, what do you think about 'generating hub insights the more you use the space/hub?

E: Yes, that would be practical. I would add this.

M: What do you think about a 'motion capture festival where every attendant is captured?'

E: Here, I see little added value. There could be some applications, but I think you do not want that because of the low return on investment and the additional privacy issues.

M: What do you think about 'adding more spaces to capture (scale up)?'

E: This would only work if you knew a hub is a great success. Then it seems logical to me to scale up.

M: Concerning put to other use, what do you think about 'selling the data to game studios, so they have a lot of different walks' and 'selling data to researchers?'

E: This is not something you want to do anymore. Selling data is a business model that will only get you into trouble in these times. So, I would not make this an aspect of the hub.

M: And what do you think about 'record yourself weightlifting and get advice from a pro' and 'getting advise on the best running shoes for the person'?

E: This again has a specific target audience and use case associated with it, so see this working in practice.

M: Now for eliminate, what do you think about 'equipment which limits a bigger demographic?'

E: Yes, this is definitely a good one. It is essential that everyone, regardless of their body type, can wear motion capture suits.

M: Now for reverse, what do you think about 'The hub pays you to capture your data', 'The hub comes to you. You can request it, and it will come to your town', 'Make the hub come to you,' and 'Travelling hub'.

E: A good web-3 model would be that you can earn incentives when you interact with the hub. So, I would include this. Furthermore, I would not include that the hub comes to you since that would take away the essence of the hub.

Concept 2: Capturing at Home using AI

M: The second concept focuses on capturing in a home environment through AI. Here at substitute, the first idea is: 'Send a description instead of a video', and the second is 'Use your phone instead of a webcam'. What do you think about this?

E: Sending a description of your movements is not something I see working, in my opinion. Furthermore, it is good to be able to use your phone instead of a webcam since everyone has a phone at home. So, I would incorporate the second idea of substitute.

M: Now for combine, what do you think about 'Capture surroundings as well' and 'Combine with some motion sensors'?

E: As for the idea of surroundings, I see no added value. And neither does combining sensors since the AI principle would be lost.

M: Now, for adapt, what do you think about 'Use a set of cameras instead of one webcam'?

E: I see added value in this for people who are already more advanced in the Metaverse when they want better quality.

M: Now for modify, what do you think about 'It could also be outside, anywhere where you have a camera' and 'Able to choose between quicker results versus higher quality'?

E: If you can do it outside with your cameras, I can see value in that. So, I would include that. Also, I think it is important that you have an option for better quality for people willing to pay more for better quality.

M: Now, for put to other use, what do you think about 'Use all the data to build a motion capture library that you can sell', 'Make your own moving WhatsApp avatar', 'Use the video data to create deep fakes of the users', and 'Create an AI model of yourself for when you are not there'?

E: I think all these four ideas of put to other use are good ideas. The reason is that it can provide an additional reason to buy cameras. In addition, integrating movements in social media avatars and creating an AI model of yourself is good added value. The same goes for the motion capture library on which you can earn incentives.

M: Now for eliminate, what do you think about 'Do not send the data to a company but process it locally to extract movement' and 'Processing time and making it available life'?

E: The first one is unclear to me, so I do not see a use case in this. Further, I would include that if it is possible to reduce processing time.

M: Now, for reverse, what do you think about 'Make videos for users that want certain movements'?

E: I think the idea of video tutorials will not work. Then it just gets too complicated.

Concept 3: Use a Freelancer for Recording

E: I do not see the whole freelancer idea working, as these are too many obstacles. So this would mean I would have to contact someone online who would convert everything for me. In addition, I still have to capture everything at home, assuming that most freelancers would not be in the area. So, this

means I would still have to have, for example, the AI solution at home to take advantage of the freelancers. So I would drop this entirely because this will create too many obstacles.

Concept 4: Capture at Home with Sensors

M: I do not see this idea working either and would drop it. Capturing with sensors is much more complicated than capturing with AI by using your phone and cameras. Also, it would still be a long way before sensors have a price affordable for individuals. Besides, professionals already have those sensors at home, so this idea already exists but is aimed at professionals.

I do see some ideas from the sensor idea that could be incorporated into the concept of capturing at home by AI. Like capturing movements for (sports) games, I see a real use case. Pass-motion could also definitely work for the AI solution as long as it is accurate. Lastly, I see the ideas of the health market working well for the AI solution. I see the health market as a good starting point for early adoption. Like capturing movements for a physio, I see working as these ideas are already slowly emerging in the real world. Also, selling data to the health market is a good use case as long as there are incentives associated with it.

Appendix E: Type-2 Validation Interview Deliver Phase

Below is the transcript of the expert interview in the development phase. Section 5.1.1 discusses the corresponding methodology of the interview, and in section 5.2, all results are presented. The transcript is not an official transcript since it was an open-ended interview with a lot of conversation not focused on the purpose of the interview. Therefore, the interview contained a lot of non-useful information. This was filtered out, resulting in the following summary of the expert interview. In the transcript, the M stands for the researcher, and the E stands for the expert.

Prototype 1: Capture at Hub

M: What do you think of the aspects of the hub and the hub itself?

E: The hub seems like a good idea in the scenario that there will not be a more accessible way to capture movements. In that case, it may be attractive for Metaverse users to visit a hub to capture movements here. Also, it should not be too expensive. I do think that if there is a more accessible solution, it should be rethought. Furthermore, I see the additional sections of the hub as good additions because it seems essential that you can do multiple things in the hub to increase its value. The only aspect to consider is that you need to take enough time to capture the movements of each individual in the hub.

Prototype 2: Capturing at Home using AI

M: What do you think of the aspects of the capturing at home using AI concept and the concept itself?

E: Right now, developments around AI are going pretty fast, so I think within a few years, this is going to become very accessible to Metaverse users. Plus, this would be an affordable way to capture movement. Furthermore, in my opinion, the extra additions are essential because if there are more use cases for buying the cameras, the more attractive it becomes. However, the individual additions do need to be tested, of course, when the AI solutions reach the mainstream market.

Appendix F: Type-1 Validation Dot Democracy Results

Capture at Hub

Aspect	Yes	No
Motion Capture Section		
Guideline for movements		
Different sizes of suits		
Avatar Creation Section		
For use on social media (Snapchat and Whatsapp, for example)		
Convert captured movements to an avatar		
Avatar Webshop Section		
Buy assets (NFTs) for avatars for personalization		
Health Analysis Section		
Gain insights into health-related problems		
Gain insights on how users perform a sport		
Capture movements for a sports game		
Other Aspects Hub	-	-
Earn tokens (via blockchain) while interacting with the hub		
Hub gets more efficient when being used more		
The Motion Capture Hub		

Capture at Home using AI

Aspect	Yes	No
AI to Capture Movements		
More cameras for better results (more expensive)		
Fewer cameras for lower quality but cheaper + better processing time		
Additional Features (1/2)		
Creating a motion password as login (pass-motion)		
Integrating captured movements into sports games such as NBA/FIFA		
Upload captured movements to a library so others can use it		
Creating an AI model of yourself if you are not there in the Metaverse		
Additional Features (2/2)		
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)		
Receive ergonomic feedback on, for example, how the user is sitting and moving		
Capturing Movements with AI and cameras		

Appendix G: Type-1 Validation Interview Deliver Phase

Respondent 1

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	I would see the physical aspect as more of an obstacle if it were not nearby since it would cost more money.
Guideline for movements	I like the guideline if it is there, as it makes sense to have a list of the movements you need to perform.
Different sizes of suits	It seems convenient to have different sizes since some people may be thicker.
Avatar Creation Section	The whole section seems like a good addition.
For use on social media (Snapchat and Whatsapp, for example)	This seems like a valuable addition if you can directly create your avatar with your movements in it.
Convert captured movements to an avatar	This also seems convenient since you can make your whole avatar with the movements in it.
Avatar Webshop Section	I also see this section as a good addition to the hub.
Buy assets (NFTs) for avatars for personalization	I also like the shop section since, like making the avatar, you can get the whole thing at once.
Health Analysis Section	I myself would not go to a hub to gain insight into my health problems.
Gain insights into health-related problems	Nonetheless, this could be a good section to target an additional audience.
Gain insights on how users perform a sport	Personally, I do not see the need to gain insight into how I perform sports. But I can understand if people would like to.
Capture movements for a sports game	For a sports game, I might consider going to a hub more.

Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	This also seems to be a good addition to the hub so that people get something in return.
Hub gets more efficient when being used more	If this is possible, this is always good to have.
The Motion Capture Hub	From my own perspective, I would not go there if it were not nearby. But it would be different if it were nearby, and if I were taking the Metaverse seriously at this point, I would go there.

Prototype 2: Aspects	**Summary Answers Respondents**
AI to Capture Movements	
More cameras for better results (more expensive)	The choice of more or fewer cameras does seem like a good addition. Especially for people who either want to spend a lot of money or do not want to spend money.
Fewer cameras for lower quality but cheaper + better processing time	The choice of more or fewer cameras does seem like a good addition. Especially for people who either want to spend a lot of money or do not want to spend money.
Additional Features (1/2)	
Creating a motion password as login (pass-motion)	This seems like nothing to me since I prefer to use normal passwords with, say, two-factor authentication.
Integrating captured movements into sports games such as NBA/FIFA	As I indicated at the hub, I think this is a good use case. I would really do this if possible.
Upload captured movements to a library so others can use it	This could work well if well-known people would sell their movements through a library. Then I can see this working.
Creating an AI model of yourself if you are not there in the Metaverse	This could be a good addition, but not so sure what to make of this.

Additional Features (2/2)	
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	I personally am not a fan of selling my health data. It could work as a person if you want it to. But I would not do it because of privacy reasons.
Receive ergonomic feedback on, for example, how the user is sitting and moving	If I myself had complaints about something hurting me when I sit, I would favour this.
Capturing Movements with AI and cameras	For example, it seems sensible that you could remove the cameras when you go to sleep. This is for privacy reasons. I would opt for this idea myself, but I think the privacy stuff concerning the cameras at home is a concern in my opinion.

Additional question: Hub or AI?

If you value privacy, then I would say the hub. But for convenience, I would say cameras because this can be done at home.

Respondent 2

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	This is what the whole hub is about, in my view. So it seems logical to me that this is there.
Guideline for movements	This also seems good for getting the whole picture of movements.
Different sizes of suits	This seems pretty logical to me. You cannot exclude people.
Avatar Creation Section	I would rather make my avatar in an online environment.
For use on social media (Snapchat and Whatsapp, for example)	I would rather make my avatar in an online environment.
Convert captured movements to an avatar	This seems good to me then that you can directly convert your movements to your avatar.
Avatar Webshop Section	As I said, this seems like a good addition.
Buy assets (NFTs) for avatars for personalization	This seems to be a good addition so the hub can also monetize it or generate sponsors.
Health Analysis Section	Here I can see the point of going to a hub for health-related things. Also, for getting insight into sports movements and converting movements to sports games.
Gain insights into health-related problems	(See above)
Gain insights on how users perform a sport	(See above)
Capture movements for a sports game	(See above)
Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	I do not like this since I would only go to a hub once for my movements. I do not think I

	would go there again if I already had my movements.
Hub gets more efficient when being used more	This would be useful to gain insight if something goes wrong somewhere. But I have a feeling you do not need machine learning for this.
The Motion Capture Hub	I envision the hub to capture my movements. Other than that, I do not know if I will use the other additions. Besides, I am willing to go there if it is physically nearby. Also, this would be great to have, for example, at a convention with Metaverse enthusiasts. I also like the shop-in-shop principle, so a Metaverse hub is in a big store somewhere.

Prototype 2: Aspects	
AI to Capture Movements	
More cameras for better results (more expensive)	I do not see the point of multiple cameras if you have to capture it more than once.
Fewer cameras for lower quality but cheaper + better processing time	If you only need to capture once, I would say only one camera.
Additional Features (1/2)	
Creating a motion password as login (pass-motion)	I like this since facial recognition already exists.
Integrating captured movements into sports games such as NBA/FIFA	This is a cool idea, though, as I mentioned with the hub concept.
Upload captured movements to a library so others can use it	It might work but not so sure what to make of this. I do not think myself that I would upload my movements either.

Creating an AI model of yourself if you are not there in the Metaverse	This seems a little scary to me. I am then afraid that the AI or someone does something that I get a bad reputation.
Additional Features (2/2)	
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	I also think this is cool if you earn an incentive in return.
Receive ergonomic feedback on, for example, how the user is sitting and moving	I think it would be useful to put this in the office, for example, to see if people are sitting correctly. Also, for home use, I think this would be handy. This would be another reason for me to purchase multiple cameras.
Capturing Movements with AI and cameras	I see the added value of this concept, however, mainly for the feedback on health.

Additional question: Hub or AI?

I would say the cameras since I see the hub as more of a one-time thing, so I do not know if the hub adds value.

Respondent 3

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	I am in favour of this entire section as it is really the essence of the hub.
Guideline for movements	It is a good aspect since you already need some space, and it is good to know which moves you have to perform.
Different sizes of suits	It is good to have different sizes since not everyone has the same build.
Avatar Creation Section	I see this as a good addition to the hub enabling you to then do other things.
For use on social media (Snapchat and Whatsapp, for example)	As an addition, it could. But I do not think it is used much on social media. However, it is an addition for the hub.
Convert captured movements to an avatar	This is a good addition if you want the most realistic image of yourself as an entire avatar.
Avatar Webshop Section	I do see the webshop section as a good addition. Especially that you can monetize this further.
Buy assets (NFTs) for avatars for personalization	I have my doubts here since it could be that some people can afford the assets, but some cannot. This would then create a difference between users.
Health Analysis Section	I do see the health section as a good use case for the hub and can also be an encouragement for people to exercise more.
Gain insights into health-related problems	I think this is a good aspect as it allows people to gain insight into their health problems.
Gain insights on how users perform a sport	On its own, it is good, but I think for some sports you need a lot of space. This then relates more to danger in the hub.

Capture movements for a sports game	This is something I am in favour of since it is kind of cool when you can put yourself in FIFA. Also, for the personalization.
Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	I personally like earning tokens because it gives you a reason to interact with the hub.
Hub gets more efficient when being used more	I think this is always good if this can be done.
The Motion Capture Hub	I really like the whole idea concept. It is that it might be a barrier for people since they do have to physically go somewhere.

Extra Notes Hub:

- Free NFTs as assets for users.
- Earning tokens in the health-section to stimulate users to gain insights in health.
- A shop in shop principle with a dedicated physio included. Or the hub is established at the physio.

Prototype 2: Aspects	**Summary Answers Respondents**
AI to Capture Movements	
More cameras for better results (more expensive)	It is good to have a choice between better quality, and lesser quality with better processing time.
Fewer cameras for lower quality but cheaper + better processing time	It is good to have a choice between better quality, and lesser quality with better processing time.
Additional Features (1/2)	
Creating a motion password as login (pass-motion)	I do not see this myself because of safety concerns that someone might be able to imitate it. Also if you have had an accident or are injured, you cannot get in.

Integrating captured movements into sports games such as NBA/FIFA	Integrating movements in a video game I do favour that, just as I indicated at the hub.
Upload captured movements to a library so others can use it	I do not really see the point of buying this from others. Maybe if it's aimed at famous people, then it might.
Creating an AI model of yourself if you are not there in the Metaverse	This is a good idea. I can see this happening in the Metaverse.
Additional Features (2/2)	
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	This has too many privacy issues in my view. Health insurance companies could buy this and charge you more money per month if they knew you were sick often, for example.
Receive ergonomic feedback on, for example, how the user is sitting and moving	This seems like a good idea that people can get certain feedback on how they sit, for example.
Capturing Movements with AI and cameras	I really like this concept. It seems a little more approachable than the hub, but then again, the hub seems more serious to me.

Additional question: Hub or AI?

I would say the hub because of the aspect that you can do health-related things there.

Respondent 4

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	If you are interested in the Metaverse and want to capture your movements, I think it would be a good addition that you can capture your movements in a hub.
Guideline for movements	I do think it would be helpful if there were a guideline with movements to perform so you do everything right at once. Guess the people who come here do not know about it in terms of motion capture. Also, if there is someone there, for example, who can help, I think that would be helpful.
Different sizes of suits	This does seem convenient when you have a larger size. You can hardly exclude people. Otherwise, people will get embarrassed if they cannot get in.
Avatar Creation Section	I think it is a good section to see the movements with your avatar right away. But I think most people already have an avatar if you are interested in the Metaverse. On the other hand, suppose someone takes me, who is a fan of the Metaverse, then it might be tempting to make an avatar there.
For use on social media (Snapchat and Whatsapp, for example)	I personally think most people already have an avatar. On the other hand, it is a good addition if you do not have it, especially since you can integrate your movements immediately.
Convert captured movements to an avatar	As I said, this is a good addition. I think it would be good to see your movements directly with your avatar.

Avatar Webshop Section	As I said, this is a good addition as it can provide a full experience in the hub.
Buy assets (NFTs) for avatars for personalization	For the full experience, this is a good addition. Also, as a newcomer, you might get drawn into it more.
Health Analysis Section	As I said, this does not appeal to me. For example, I would rather go to a physio than a Metaverse hub for insight into my health. Should it become a thing, someone with expertise should be there.
Gain insights into health-related problems	I personally would not necessarily want to get insights into health-related issues. Maybe for people who would, it could be an option. But this is too distant for me.
Gain insights on how users perform a sport	I think you would only use this if you were a top athlete. But if you are a top athlete, then your data of how you move is already analyzed, I think. As an amateur athlete, I would not go to this.
Capture movements for a sports game	I do think this addition is very cool. I would do this to have myself in terms of movements, for example, in a sports game.
Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	While you are there, I think it would be good to earn tokens as an extra incentive. Also, for newcomers, if, for example, they can use those tokens in the Metaverse to get assets or something else, this can be stimulating for them to visit the Metaverse more.
Hub gets more efficient when being used more	If this is possible, this seems like a good addition to me.

The Motion Capture Hub	I see the hub as a good idea to capture movements. Also, mainly to introduce people to the Metaverse.

Prototype 2: Aspects	**Summary Answers Respondents**
AI to Capture Movements	
More cameras for better results (more expensive)	I do think it is important to have the option for multiple cameras or fewer cameras. For someone with Metaverse experience, I believe multiple cameras are a good option.
Fewer cameras for lower quality but cheaper + better processing time	I do think it is important to have the option for multiple cameras or fewer cameras. I think it is important for someone just starting with the Metaverse to have an entry-level model.
Additional Features (1/2)	
Creating a motion password as login (pass-motion)	I would not use that myself. I think the passwords might be too easy to guess or mimic. Rather have a password with characters, letters, and numbers.
Integrating captured movements into sports games such as NBA/FIFA	As indicated at the hub, capturing movements for a sports game, I think, is very cool. I will definitely do this if it is accessible.
Upload captured movements to a library so others can use it	I think there are plenty of people who think this is cool. On TikTok, these dances are already totally a trend. So maybe if you personally cannot dance because you are not a dancer, you can still perform it because you bought it then. Also, I do see people doing this to generate extra income. Good to think about the copyright aspect, though.
Creating an AI model of yourself if you are not there in the Metaverse	I do not have a strong yes or no for this. It does seem like a good addition. So, if it is

	there, it is not out of place. But I do not think people will necessarily miss it if it is not there. But for the experience of the Metaverse, it is a good one.
Additional Features (2/2)	
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	I see this as a good addition for people who are not privacy-conscious. Or for people who do not care about privacy. If so, I can see these people doing it to earn extra tokens.
Receive ergonomic feedback on, for example, how the user is sitting and moving	I already see a lot around me that people are talking to physios online instead of having to go there. I kind of see this as the same idea. I think this is a good addition because it gives you a very accessible way to go to the physio, for example.
Capturing Movements with AI and cameras	All in all, I see this as a good concept for capturing movements. Only the pass-motion I have my doubts about.

Additional question: Hub or AI?

If someone were to start with the Metaverse, I would say that the AI solution with the cheaper cameras is a good option to capture the movements of your Metaverse avatars. On the other hand, if you are slightly more engaged with the Metaverse, then the hub is cool to go to with some friends who are not really engaged with the Metaverse yet. The hub might get them excited. I just would not want to travel too far for it. If I had to choose one, I would choose the AI solution.

Respondent 5

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	If you put this down well with a hub, I think it would be a good concept to get people familiar with the Metaverse.
Guideline for movements	This does seem difficult to me because everyone moves differently.
Different sizes of suits	The different sizes do seem like a must.
Avatar Creation Section	I see this section as a good addition to the hub so you can then put together your entire avatar right away.
For use on social media (Snapchat and Whatsapp, for example)	This seems like a good idea to be able to make this in the hub since you can then express yourself directly with your avatars. Expressing yourself on social media.
Convert captured movements to an avatar	This is a good addition as you then immediately have your avatar with your movements captured.
Avatar Webshop Section	I see this section as a good addition to the hub so you can then put together your entire avatar right away.
Buy assets (NFTs) for avatars for personalization	I think this is a good idea as people can then directly buy assets for their avatars. In addition, people then also learn about use cases of NFTs.
Health Analysis Section	This section would be a good addition of the hub to attract additional audiences.
Gain insights into health-related problems	This also seems like a good idea to me, only I have my doubts about how the data will be analysed.

Gain insights on how users perform a sport	Gaining insight into sports movements seems like a good way to attract an additional audience to the hub.
Capture movements for a sports game	This also seems like a good idea to me, only I have my doubts about how the data will be analyzed.
Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	Same as with NFTs, good to introduce people to blockchain. Also, nice that you can earn something if you go to the hub.
Hub gets more efficient when being used more	If this is possible, I think this would be helpful.
The Motion Capture Hub	The hub itself seems like a good idea. Also, you can apply everything extra section well. I think especially the health section, that seems like a good addition.

Prototype 2: Aspects	**Summary Answers Respondents**
AI to Capture Movements	
More cameras for better results (more expensive)	I can see cheaper cameras working better than more expensive cameras since it would make it more accessible to Metaverse users.
Fewer cameras for lower quality but cheaper + better processing time	I can see cheaper cameras working better than more expensive cameras since it would make it more accessible to Metaverse users.
Additional Features (1/2)	I can see all four ideas working as you then have additional reasons to purchase cameras.
Creating a motion password as login (pass-motion)	
Integrating captured movements into sports games such as NBA/FIFA	

Upload captured movements to a library so others can use it	
Creating an AI model of yourself if you are not there in the Metaverse	
Additional Features (2/2)	The same goes for these two ideas, I see this working well since additional applications for acquiring cameras is a must in my opinion.
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	
Receive ergonomic feedback on, for example, how the user is sitting and moving	
Capturing Movements with AI and cameras	In general, this is a good idea. Just have my doubts about very expensive cameras as the threshold may be too high. You would have to find this out further.

Additional question: Hub or AI?

I would rather go to the hub since it is more accessible to users since otherwise they would have to purchase cameras etc.

Overall Summary All Aspects of Prototypes

Prototype 1: Aspects	**Summary Answers Respondents**
Motion Capture Section	The motion capture section is considered a section that is necessary for the hub. The reason is that the hub naturally revolves around capturing movements. But one respondent did indicate that he sees the physical aspect of the hub as an obstacle.
Guideline for movements	For the hub, this is an essential aspect. Respondents indicated they felt it was necessary to have a guideline since, from their perspective, they would not know what moves to perform. Only one respondent did not see the essence of it, as he thought it could not be done because everyone moves differently.
Different sizes of suits	This aspect of the motion capture section is a must. Respondents indicated that you could not exclude people because of their build. This could then cause people to feel embarrassed if they cannot get into a suit.
Avatar Creation Section	A section is viewed positively for creating and managing an avatar in the hub. Some prefer an online environment, while others see the section as enabling them to do other things. The section is seen as a good tool for viewing avatar movements and putting together an avatar. Some believe it may attract fans of the Metaverse, while others think most people already have an avatar.
For use on social media (Snapchat and Whatsapp, for example)	Respondents had different opinions on this aspect of the hub. Some respondents indicated that they would like to be able to

	create avatars directly in the hub so that they could immediately see their captured movements. In addition, it was indicated that they see the use case of the avatar not only for social media but also for outside social media use. One respondent specifically indicated that they prefer to create the avatar in an online environment.
Convert captured movements to an avatar	It was unanimously stated that it was a good thing to be able to see your movements that you captured into your avatar directly. This gives you a complete picture of your avatar, including captured movements.
Avatar Webshop Section	A webshop section in the hub is viewed positively as a good addition to creating a complete experience and monetizing the hub. The section is seen as helpful in putting together the entire avatar.
Buy assets (NFTs) for avatars for personalization	The addition of a shop section in the hub for buying NFTs to personalize avatars is viewed positively as a complete experience, but with concern about unequal access to assets for different users. The shop is seen as a good opportunity for generating revenue and learning about NFT use cases.
Health Analysis Section	The five respondents have mixed views on the Health Analysis Section. Some see it as a valuable addition to the hub for gaining insight into health problems, while others think it's unnecessary and would prefer to see

	a professional instead. Some respondents believe the section could appeal to a broader audience, while others are sceptical about the data analysis.
Gain insights into health-related problems	A section in the hub for gaining insights into health-related problems is viewed positively by some as a valuable tool for targeting a new audience and gaining insight into health problems. Others have doubts about personal interest and the analysis of data.
Gain insights on how users perform a sport	The respondents had mixed opinions on gaining insights into users' sports performance in a physical hub. Some saw the benefit of attracting an additional audience, while others didn't see a need for it or thought it would only appeal to top athletes. One respondent raised concerns about safety in the hub for specific sports that require more space.
Capture movements for a sports game	The respondents express support for capturing movements for a sports game in a hub. The respondents see this addition as cool, interesting and a good way to personalize the experience. One respondent expressed doubts about data analysis, but the idea is favoured overall.
Other Aspects Hub	
Earn tokens (via blockchain) while interacting with the hub	The respondents' answers on earning tokens while interacting with the hub are generally positive, with a few exceptions. A few respondents see it as a good addition to the hub to get something in return, while others see it as an extra incentive to interact with

	the hub. A few respondents also see earning tokens as a good way to introduce people to blockchain and a reason to visit the Metaverse more. However, one respondent does not like the idea of earning tokens as they believe they would only go to the hub once.
Hub gets more efficient when being used more	The respondents suggest that the idea of the hub becoming more efficient when being used more due to machine learning is generally seen as a positive aspect. Respondents believe that this would be useful for gaining insight and could help resolve any issues. However, one respondent questions whether machine learning is necessary for this to happen.
The Motion Capture Hub	The interview answers about "The Motion Capture Hub" seem to have mixed opinions. Some people like the idea but question the practicality of physically going somewhere. Some are willing to go if it's nearby and to capture movements. Others are unsure about the other additions but think it could be good for introducing people to the Metaverse. Some see the hub as a good idea, with one person highlighting the health section as a particularly good addition. One person likes the shop-in-shop principle focused on the hub and envisions the hub located within a big store.

Prototype 2: Aspects	**Summary Answers Respondents**

AI to Capture Movements	
More cameras for better results (more expensive)	The respondents' answers suggest a divided opinion on using more cameras for better results (at a higher cost). Some see the benefit of choosing between more or fewer cameras, while others question the necessity of multiple cameras. Some believe better quality comes at a higher cost, while others think cheaper cameras could work better for accessibility in the Metaverse. The opinions vary on whether or not multiple cameras are a good option for getting the Metaverse experience.
Fewer cameras for lower quality but cheaper + better processing time	The respondents suggest a preference for fewer cameras for lower quality but cheaper and better processing time. Some believe it is essential to have the option for fewer cameras for cost and processing reasons, with one stating that a single camera may be sufficient if capture only needs to be done once. Others believe that having an entry-level model is vital for people just starting in the Metaverse and that cheaper cameras make it more accessible to users. There is also the idea that choosing between better quality and lower quality with better processing time is a good addition, especially for those with varying budgets.
Additional Features (1/2)	
Creating a motion password as login (pass-motion)	The respondents show a mixed reaction to the idea of creating a motion password as a login method (pass-motion). Some prefer traditional passwords with two-factor

	authentication, while others find it appealing due to the existence of facial recognition. Concerns about safety and the possibility of imitating or guessing the motion password were also raised. Some believe the traditional password with characters, letters, and numbers is a more secure option. One interviewee views the pass-motion as a good addition because it provides an additional reason to buy cameras.
Integrating captured movements into sports games such as NBA/FIFA	All respondents indicate positive opinions towards integrating captured movements into sports games such as NBA/FIFA. They believe it is a good idea. They see it as a reason to purchase cameras if it is accessible.
Upload captured movements to a library so others can use it	The respondents expressed mixed opinions about uploading captured movements to a library for others. Some see the potential if famous people sell their movements, while others are unsure and don't see the point in buying movements from others. However, some believe it could become popular, especially with the trend of dances on TikTok. One respondent also had questions about the copyright aspect.
Creating an AI model of yourself if you are not there in the Metaverse	The respondents expressed mixed feelings about creating an AI model of oneself in the Metaverse. Some find it intriguing but are unsure, while others view it as a good idea and see it happening in the Metaverse. However, others are concerned about the potential for a bad reputation due to the AI model and have no strong opinion. Overall, the presence of AI models may enhance the

	Metaverse experience, but it is not considered a necessary aspect.
Additional Features (2/2)	
Share captured movements with the health market and earn tokens/assets (blockchain/NFTs)	The respondents expressed mixed opinions about sharing captured movements with the health market and earning tokens/assets through blockchain/NFTs. Some view it as a privacy issue and would not do it, while others see it as a good opportunity to earn incentives if one is not concerned about privacy. There are concerns about health insurance companies potentially using the data for negative purposes. However, some see it as a reason to purchase cameras for those who are not privacy-conscious or don't care about privacy.
Receive ergonomic feedback on, for example, how the user is sitting and moving	The respondents express support for receiving ergonomic feedback. They see it as a valuable tool for improving posture and addressing physical complaints, especially in office and home settings. Some also view it as a convenient alternative to visiting a physiotherapist and as another reason to purchase cameras.
Capturing Movements with AI and cameras	The respondents generally see capturing movements with AI and cameras as a good idea, but some express concerns about privacy and the cost of cameras in the scenario of multiple cameras. They see added value mainly in the feedback on health and find the concept approachable but have doubts about the pass-motion and

	camera cost in the case of the multiple cameras.

Additional question: Hub or AI?

The respondents in the interview expressed mixed opinions on the choice between the hub and AI solution for capturing movements. Some preferred the hub for privacy, while others preferred the AI solution for convenience. One participant believed that the hub is more suitable for health-related purposes. When considering the Metaverse, some participants indicated that the AI solution with cheaper cameras would be a good starting point for capturing avatars' movements. In contrast, others felt the hub would be a better option for those already more engaged with the Metaverse. The hub was seen as a cool place to go with friends who are not yet engaged with the Metaverse, with the potential to excite them about it. However, the idea of travelling too far to get to the hub was seen as a drawback. One participant preferred the hub over the AI solution due to its accessibility, as users would not have to purchase cameras.