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EFFECTS OF IMMERSIVE VIRTUAL REALITY SOLUTIONS ON USER LEARNING: VALUE CO-CREATION AND CO-DESTRUCTION

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Virtuaalitodellisuuden (VR) käyttö organisaatioissa on kasvanut osana liiketoimintaa ja opetusta. Tämän on mahdollistanut teknologian kehitys, mikä on puolestaan laskenut VR ratkaisuiden hintoja ja tehnyt niistä vakuuttavampia sekä käytännön läheisempiä. Tämän tutkielman tarkoitus on syvemmin ymmärtää VR oppimista käyttäjän arvon muodostumisen avulla. Tutkielman päätutkimuskysymykset ovat ”Mitkä ovat vaikuttavimmat arvon yhteisluonti ja yhteistuho rakennelmat virtuaalitodellisuuden oppimiskokemuksessa?” ja ”Kuinka koetut arvot hyödyttävät tai haittaavat VR alustalla tapahtuvaa kokemuksellista oppimista?”.

Tutkimuksen tavoitetta lähestytään palvelulähtöisen ajattelun (Service-dominant logic) kautta. Tutkielman aihetta pohjustetaan kirjallisuuskatsauksessa, mikä koostuu kolmesta kokonaisuudesta: VR ominaisuudet, VR oppimisteemat, ja palvelulähtöinen ajattelu. Tutkielman empiirinen osuus suoritettiin teemahaastatteluiden kautta, minkä osallistujat olivat paikallisen koulutuskuntayhtymän opiskelijoita. Tutkimukseen osallistuneet 8 opiskelijaa testasivat Oculus Quest 2 virtuaalitodellisuusalustalle toteutettua 360-videoon perustuvaa opettavaista kierrosta metallin jalostuksesta. Haastatteluiden litteroinnit analysoitiin käyttämällä laadullista sisältöanalyysiä.

Tutkimuksen tuloksena todettiin 37 arvon yhteisluonti rakennelmaa liittyen virtuaalitodellisuuden teemoihin kiinnostus, sosiaalisuus, tila ymmärrys, fyysinen tuntemus, interaktiivisuus, kognitiivinen kuormitus, ja paikka illuusio. Myös 24 arvon yhteistuho rakennelmaa tunnistettiin liittyen samoihin teemoihin. Rakennelmat sisältävät yksityiskohtaista tietoa arvon muodostumisesta liittyen koettuun arvoon, sen lähteeseen, sekä oppimisteemoihin mihin ne vaikuttavat. VR oppimisteemat todettiin liittyvän kokemuksesta oppimiseen 24:llä arvon yhteisluonti rakennelmalla ja 11:sta arvon yhteistuhon rakennelmalla.

Tutkimuksen perusteella voidaan päätellä, että palvelulähtöisen ajattelun mukaista arvon muodostumista voidaan käyttää tehokkaasti arvioimaan oppimista virtuaalitodellisuudessa. Tämän lisäksi todettiin, että arvon muodostumisesta saavutettua ymmärrystä voidaan käyttää kokemuksellisen oppimisen teorian tarkentamiseksi tässä kontekstissa ja sen avulla voidaan paremmin ymmärtää kokemuksellisen oppimisen muodostumista VR käytön aikana.

Asiasanat: virtuaalitodellisuus, oppiminen, palvelulähtöinen ajattelu, laadullinen tutkimus, teemahaastattelu, laadullinen sisältöanalyysi

ABSTRACT

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Use of virtual reality (VR) as part of business and education has been gaining momentum because of developments in VR technology. The cost of the devices and solutions have been decreasing while fidelity and tracking accuracy have been increasing resulting in more convincing virtual environments with more concrete use cases. This study's goal is to understand VR learning more in-depth from user value perspective. Thus, the main research questions of this study are "What are the prevalent value co-creation and co-destruction constructs emerging from virtual reality learning experience?" and "How the perceived user values affect experiential learning during VR use?".

The research goal is approached from point of view of Service-Dominant (S-D) logic. Theoretical foundation for this study is formed from a literature review regarding VR characteristics, prevalent VR learning themes, and S-D logic literature. The empirical section of this study uses qualitative methods. This study's participants were 8 active students recruited from a local educational consortium. The participants tested a VR solution on Oculus Quest 2 VR platform. The tested solution was an educational 360-degree video tour of a metal refining plant. The data was gathered using focused interviews and analyzed using thematic content analysis.

The main findings of this study were 37 value co-creation constructs regarding VR learning themes engagement, sociability, spatial information, physical sensation, interactivity, cognitive load, and presence. Also 24 value co-destruction constructs regarding these themes were recognized. The constructs contain detailed information about value co-production during learning use of VR including user perceived values, VR feature affecting them, and VR learning affordances. The VR learning themes were found to directly connect to experiential learning by 24 value co-creation constructs and 11 value co-destruction constructs.

The results of this study show that value formation as presented in S-D logic can be used to effectively understand VR learning. In addition to this, value co-creation and co-destruction was found to give insight into experiential learning in VR context. The findings were used to connect perceived VR learning benefits to facets of experiential learning, thus expanding understanding of experiential learning process in context of VR.

Keywords: virtual reality, learning, service-dominant logic, qualitative research, focused interview, thematic content analysis

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INTRODUCTION

Virtual Reality (VR) solutions have become more affordable and accessible not only for the large companies or universities at the cutting edge of technological advancement, but also for small and medium size enterprises as well as consumers. VR technology has taken leaps forward in many facets such as fidelity of virtual environments, display technology, usability, portability, and the number of applications the VR has. Comparing to a decade back, powerful VR devices can be now used without need for outside tracking of the device or even separate computer to run the device which shows how far the VR technology has come. The main goal of VR technology is to immerse its users into virtual environments as if they did travel in an instant from a physical space to the virtual environments such as surface of Mars or deep under sea. Thus, VR makes impossible or impractical experiences possible. The most accessible and highly immersive VR solutions revolve around head mounted display (HMD) technology, which covers user's field of view and tracks their movements.

VR has again become a more popular subject of research as the popularity and accessibility of the technology has increased. Initially VR was comparatively popular subject of research, but lack of advancements few decades ago in the VR technology did thwart the interest of scholars. The educational benefits of VR have been explored in many fields. One of the highlights is in the medical field where realistic virtual experiences enabled by VR during training can save future patient lives. Despite the variety of educational contexts, research of immersive VR solutions has been lacking in number of meaningful empirical studies (Atsikpasi & Fokides, 2021).

Fully immersive VR solutions are especially powerful for improving users' immersion, learning motivation, engagement, and enjoyment (Atsikpasi & Fokides, 2021). Furthermore, the benefit of immersive VR solutions for learning is that they allow virtual experiences that are comparable to real ones (Kwon, 2018; Fromm et al., 2021). Arguably this is also the reason why immersive VR solutions are widely used in training and learning where experience is key to success. VR learning is especially powerful because it enables experiential learning (Kwon, 2018; Fromm et a., 2021). Experiential learning theory by Kolb (1984) focuses on learning from experience and it has been extremely influential in understanding the process. Previous studies have shown that experiential learning does happen during VR use and is prevalent in VR learning (Kwon, 2018; Fromm et al., 2021).

The effect of immersive VR solutions on users' learning and skills is considered multi-dimensional and complex (Atsikpasi & Fokides, 2021). This study aims to contribute to the understanding of VR's educational uses by exploring value co-creation and co-destruction emerging during use of VR solutions. This is done by using service-dominant logic (Vargo & Lusch, 2004; Vargo et al., 2008; Vargo et al., 2020) as a lens. Understanding the value co-creation and co-destruction process allows better understanding user behavior and experience (Ranjan & Read, 2016). Thus, S-D logic provides insight into how different facets of VR experience affect the learning experience.

Only few previous studies have used S-D logic as a lens to explore immersive VR solutions (eg. Mei et al., 2021; Tom Dieck & Han, 2022; Charron, 2017), while none of these studies specifically focus on the context of learning. Previous information system studies have used S-D logic as a lens to understand value formation in digital services with great results. Closer to VR context, S-D logic has also been used for exploring augmented reality, delivering fruitful results, and demonstrating the use of S-D logic to better understand where and how user values emerged in that context (Elo, et al., 2021). As presented, in context of VR for education or training, the S-D logic metatheoretical framework has not been fully utilized to explore the VR learning service value formation.

These factors present that there is a dire need for more VR research in the context of education, but especially it highlights the possibility for better understanding how perceived user value in VR forms during experiential learning. This can provide significant contribution to VR service design, education, as well as for research, opening new avenues for knowledge as well as for better VR user experiences.

1.1 Research questions

As primed in the previous chapter, the low number of studies regarding VR from value perspective and the fruitfulness of such an approach makes for a great research opportunity. Furthermore, previous studies have greatly benefitted practice and literature by using S-D logic to examine user experience which makes it especially intriguing perspective. Therefore, the aim of this study is to examine VR learning from user value perspective. According to Kwon (2018) and Fromm et al. (2021) VR's characteristics enable experiential learning, and the users recognize virtual experiences as direct ones. Therefore, VR learning is considered experiential learning. Thus, more accurately the research goal of this master's thesis is to define the obstacles and benefits for experiential learning in the immersive VR use context. Furthermore, the intention is not to just name the emerging values, but rather understand how the values are connected to the VR experience by co-creative and co-destructive processes of S-D logic framework (Vargo & Lusch, 2004; Vargo & Lusch 2020). These will form value constructs in the context of this study.

Because the previous literature is a void of a comprehensive study on VR value formation in learning context, this study needs to take three main steps to answer the call for such a significant undertaking. Firstly, the prevalent benefits and hinderances regarding VR learning need to be recognized from the previous literature, which will form the theoretical foundation of this study. Secondly, the user values emerging from the recognized VR learning processes need to be understood. Thirdly and finally, the connection between emerging user value and value co-creative and co-destructive VR learning experience to experiential learning needs to be formed. These steps form three distinct questions, thus the research questions for this master's study are:

1. *(Assisting research question) What are the prevalent VR learning hinderances and benefits according to previous studies?*
2. *What are the prevalent value co-creation and co-destruction constructs emerging from virtual reality learning experience themes?*
3. *How the perceived user values affect experiential learning during VR use?*

1.2 Research methods

This master's thesis has two main parts: theoretical background study, and empirical study. Theoretical background study is done as a literature review. The theoretical section introduces key VR characteristics, VR learning effects, and S-D logic. The first goal of theoretical background is to create basis for the empirical section's interviews, where understanding the main themes of VR learning is crucial. The second goal is to introduce how user value forms according to S-D logic. This means exploring themes of value co-creation, value co-destruction, and value-in-use. Thus, providing basis this study to explore user value formation during VR learning.

The empirical section of this study is done using qualitative methods. The empirical study was conducted in three main sections: VR testing events, focused interviews, and thematic content analysis of the interview transcripts. Participants of the study were recruited from a local educational consortium and were active students at upper secondary or higher level. The participants tested VR solution for twenty to twenty-five minutes so they would all have similar VR experiences, since all participants had little to no previous VR experience. The data for this study was collected using focused interview method following Hirsijärvi and Hurme (2008) methodology. Eight in-depth semi-structured focused interviews were completed to collect the data, where the focused interview portion lasted average of 38 minutes 55 seconds each. Thematic content analysis method (Anderson, 2007) was chosen to generalize the individual interview data into themes which describe the user experiences. The emerging themes were then subdivided to value co-creation, value co-destruction, and nuances. These categories were then discussed and applied to learning and value formation themes recognized in the theoretical background section of.

1.3 Findings and contribution

The main findings of this study regard value co-creation and co-destruction in VR learning context. First, this study recognized 37 prevalent value co-creation and 24 co-destruction constructs which describe connections with perceived user value, VR learning themes, and VR features. The constructs were categorized under the VR learning themes to highlight their relevance for VR learning.

Each of the recognized VR learning themes had value co-creation constructs relating to them: *engagement* (16 observations), *sociability* (4 observations), *spatial information* (4 observations), *physical sensation* (1 observation), *interactivity* (5 observations), *cognitive load* (1 observation), and *presence* (6 observations). In the context of this study, *engagement* was found to emerge mostly from emotional engagement regarding interest, fun, and excitement. Also, utility values such as environmental values and career planning highlighted. Intrinsic interest in VR technology was also determined important for engagement. *Sociability* did highlight sharing for enjoyment, mutual understanding, and improved learning value constructs. *Spatial information* was important factor for remembering objects, locations, and actions, building knowledge alike to from visiting a location. *Physical sensation* was recognized to excite the users because of involuntarily reactions resulting from perception of being at high places. *Interactivity* connected to increased interest, increased spatial understanding, and learning by trying things. *Cognitive load* was reduced by use of VR device because visual isolation did lessen distractions from surroundings and VR increased user's focus in the subject. *Presence* was especially affected by value constructs revolving around the degrees of freedom VR user experienced, seeing own body in a virtual representation, and positively perceived physical sensations.

Value co-destruction constructs recognized for each VR learning theme were: *engagement* (5 observations), *sociability* (4 observations), *spatial information* (1 observation), *physical sensation* (3 observations), *interactivity* (3 observations), *cognitive load* (2 observations), *presence* (6 observations). Value co-destruction in *engagement* was mostly because of annoyance from device's physical or usability properties, fear of falling, and familiar learning methods becoming less effective. *Sociability* related negative values were recognized as anxiety, judgment, and distraction. *Spatial information* related co-destruction was because of reduced attention to other sources of information. *Physical sensation* was negatively experienced as simulator sickness such as vertigo and eye strain, or possible simulator sickness caused worry about VR's physical effects. *Interactivity* value co-destruction was found to be because of software not allowing enough control or having issues with usability. *Cognitive load* affected user experiences because of perceived too much information at once, and lack of control of information flow. Finally, *presence* value co-destruction was mainly related to lack of fidelity or features tying VR into real world such as play area borders, physical discomfort, or lacking freedom of movement.

The recognized variety of value co-creation and co-destruction constructs for same VR use cases shows that for future studies approach of understanding VR services or VR learning from S-D logic's value-in-use standpoint is effective method for determining how specific service components affect perceived value of the service. This approach can as well be used in VR service design to better understand how to develop VR services especially in learning context. Educators can use the findings of this study to better understand how to engage learners as well as understand which VR learning solutions fit their education goals the best.

The second main finding of this study shows that experiential learning was found to be directly affected by value co-creation constructs of *engagement* (13), *sociability* (2), *spatial information* (4), *interactivity* (1), *cognitive load* (1), *and presence* (3). Contrarily, number of affecting value co-destruction constructs were 3, 2, 1, 1, 2, and 2 respectively. The number of value constructs directly affecting experiential learning differs from the total number of recognized value co-creation constructs because not all of the constructs were recognized to affect experiential learning directly. Only VR learning theme included in this study which was not found to affect experiential learning directly was physical sensation, but it affected engagement and presence, thus indirectly affecting experiential learning according to findings of this study.

The second finding stems from the theoretical framework built based on the previous studies and the relationships recognized from those studies between VR learning themes and experiential learning. This contributes to the literature by clarifying the relationships between VR learning themes and experiential learning during VR use. VR service designers can use the recognized value constructs to affect VR learning themes so that they emphasize experiential learning and reduce hinderances for it by design choices deriving from the value constructs.

The third main finding of this study is proposed clarified connections between experiential learning model's (Kolb, 1984) facets to learning results and perceived value. This study takes advantage of the recognized value constructs while examining experiential learning facets. This approach is aligned with the goals of this study because learning from experience is crucial part of what makes VR learning especially useful for training and opens new methods for learning. The findings regarding concrete experience facet did show that the value constructs described sources of concrete experience in line with the previous studies, thus the other facets of experiential learning were examined. Especially interesting finding is proposed connection between abstract conceptualization process and which knowledge users do generalize. It was shown to depend mostly on engagement value constructs in VR learning situations when the users have multiple stimuli to choose from. Furthermore, VR characteristics seem to also affect preference for spatial information over narration or traditional video for what information to internalize.

Contribution of the third finding for literature is an addition to understanding experiential learning from the user perspective in VR. Examining experiential learning from the user value perspective allows for understanding the perceived value outcomes and thus evaluate how the different VR phenomena affect the experiential learning. This approach also allows researchers better possibility to understand VR learning issues. For a concrete example, high engagement but low learning effects can be better understood because the users are engaged in learning about the concrete VR experience rather than the subject because of their personal interest is focused on VR. In education context this could be taken advantage of by ensuring the learners are either already familiar with VR platform enough so that they focus on the learning subject instead or they are motivated to the subject appropriately. Thus, the finding contributes to education context practice as well.

1.4 Thesis structure

This study is organized into theoretical background, empirical section, findings, and conclusion. The theoretical background is arranged as follows: First, the characteristics of VR are presented. Second, the VR learning themes are explored starting from the characteristics of VR, then prevalent specific learning effects recognized from previous literature, and finally experiential learning. Third, value from perspective of S-D logic is examined as well as use of it in VR context.

The empirical section is arranged chronologically where first the two qualitative methods are introduced: the focused interview (Hirsijärvi & Hurme, 2008) and thematic content analysis method (Anderson, 2007). Next, the implementation of the methods is presented where recruitment of participants, VR solution testing event, focused interview event, as well as thematic content analysis method implementation is presented.

Findings of this study present relevant background information of the participants, value co-creation and co-destruction constructs which were recognized going by the VR learning themes, and relationship between value constructs and experiential learning theory.

In the discussions chapter, the findings are discussed to answer research questions, compare their relation to previous studies, as well as implications for research and practice are explored.

Finally, the conclusion of this study is presented and limitations of this study as well as suggestions for future research given.

2 THEORETICAL BACKGROUND

This chapter explores the scientific background of this study. The theoretical background of this study focuses on creating basis for focused interviews by forming theoretical framework that can be used to construct themes that the interviews will follow. The themes emerge from the literature review process which focused on characteristics of VR, nuances of VR learning, and S-D logic value literature. Theoretical background also establishes basis on how value forms from S-D logic point of view, which will be utilized to reinforce the theoretical framework, and understand VR value formation process in the latter parts of this study.

While scientific literature regarding VR from value perspective is scarce, the theoretical background of this study is complemented by the number of studies that focus on VR learning perspective. Using combination of value and learning perspectives, the theoretical background forms a rich and saturated view of themes that affect VR learning. In the latter chapters the emerging value constructs can then be evaluated against the theoretical background.

Theoretical background chapter is arranged as follows. First, the virtual reality characteristics and its key terms are defined to create basis for VR learning effects. Second, the views of previous literature on the most prevalent VR learning phenomenon are explored. Third, the perspective of value co-creation and co-destruction, value-in-use, and views of previous literature on value in VR context are investigated. Finally, the theoretical background is concluded by presenting theoretical framework.

2.1 Virtual Reality

Virtual reality (VR) is a surprisingly old concept. The first modern solution was developed by Sutherland in 1968 where stereoscopic image and tracking user's head motion was utilized for presentation of virtual objects (Sutherland, 1968). What makes VR different from other forms of media is its ability give the users a sensation of being transported into a virtual environment. The virtual environments allow completion of actions that would not be possible in physical world, or alternatively they mimic physical world. The early solutions had multitude of issues relating to fidelity of the virtual environment, resolution of the used liquid crystal displays, and responsiveness which all caused low immersion and more simulator sickness. Hence, the more effective early solutions were expensive. Furthermore, the negative response to the VR solutions in early 1990 did result in decrease in research interest towards VR. The recent decades have brought major improvements in the VR technology as well as heavily reduced the costs related to VR solutions, which further has invigorated the subject as a matter of research because of the increasing popularity of VR hardware and available software designed for VR use.

VR as a term has been used broadly in literature to describe systems such as 360-degree video, CAVE virtual environments, technology stimulating multiple senses such as haptic stimulus with visual, or head mounted display (HMD) technology. The common theme in VR solutions is the goal to make the users feel like they are transported into a virtual environment and can act in it. This enables the sensation of being in the virtual environment, or as called in previous studies sensation of presence or place illusion. Arguably, the key characteristics of VR that facilitate presence are immersion and interactivity. Hence, the main characteristics of VR can be compiled to presence, immersion, and interactivity. (Freina & Ott, 2015; Mütterlein & Hess, 2017). For this study, the main characteristics of VR are used to understand what makes VR unique compared to other forms of media, and how these unique characteristics affect learning.

The combination of a software to present virtual environment and a hardware, such as HMD solution, can be considered an immersive VR platform (Pallot & Richir, 2016). The hardware enables immersive presentation of the software. While the virtual environment is important, the responsiveness and the fidelity of the stimulus solution can be even more impactful to the user experience. This has been observed with old solutions which had low field of view, inaccurate position-tracking, slow responsiveness, and low-quality displays more often resulting to low immersion and negative effects such as simulator sickness or frustration.

Despite hardware being major factor in the immersiveness and usability of the VR experience, the software is central to the case specific user experience. The software can put the hardware's immersive and interactivity features to use, taking the users into a specific context with means to interact with the virtual environment. This context can be learning, entertainment, culture, social and many more, only limited by the software. Therefore, VR platform as a whole has an impact on the benefits and hinderances experienced by the user, as well as experienced usability.

2.1.1 Immersion

For this study, understanding different sources of immersion is important to evaluate value formation in immersive VR. This is due to immersion being central characteristic of VR and it is crucial in causing users sensation of presence (Figure 1). Presence is important for benefits of VR to occur such as learning benefits (Kye & Kim, 2008), co-creation (eg. Wang & Sun, 2021) and acceptance (Mütterlein & Hess, 2017). Furthermore, understanding which features of VR platforms affect users' presence allows better understanding of how value co-creation in the context of a VR platform might happen.

The VR platforms are designed to overtake the stimulus coming from real world and replace it with virtual. This results in immersion into the VR, which the users perceive as sensation of being transported into another place as depicted by the virtual environment. This is also described as place illusion or presence (Slater, 2009; Parong et al., 2020).

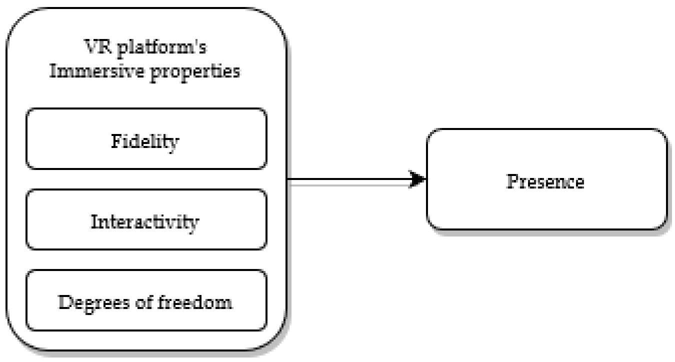

Figure 1 Immersive VR platform features lead to user presence, adapted from Kwon (2018) and Nilsson et al. (2016).

The immersion can be defined as a property of a VR platform such as quality of the screen or solution's ability to track a user's movement, while presence is subjective to a user's response to a specific VR platform (Slater, 2003; Nilsson, Nordahl, & Serafin, 2016). Another way of defining immersion in the scientific VR literature is that the term "immersion" refers to a user's experience rather than a property of a system (Björk & Holopainen, 2005; Pallot & Richir, 2016; Nilsson, Nordahl, & Serafin, 2016). This means that the literal dictionary definition of the word immersion as in a state of being completely engaged or absorbed into a subject, is used. In the context of this study, immersion is considered a property of a VR platform while presence is reserved for the immersion experienced by a user.

Considering immersion as a property of a VR platform is truer to the original meaning as stated by Slater (2003) in context of VR and it allows separately discussing immersive properties of a VR platform that give users subjective experiences in virtual environments. The immersive properties of a VR platform can be measured, and the VR solution classified accordingly. Measurable properties can be the field of view, degrees of freedom, resolution, stereo, interactivity, or haptic feedback as presented for an example in Figure 1. (Slater, 2018). When discussing immersive VR platforms, the immersive properties of the platform are considered high compared to other types of virtual environment presenting solutions. In general, higher the immersive qualities of a VR platform, the higher the level of presence user experiences (Parong et al., 2020).

According to the reviewed literature, presence comes from properties of the VR hardware, virtual environment presented by the software, and people participating to the user's experience (Nilsson et al., 2016; Pallot et la., 2017). VR hardware affects presence by fidelity of sensory representation, responsiveness, and allowing means of interaction such as controllers or movement tracking (Figure 1). Virtual environment is the cause of most narrative and challenge based immersive effects. (Nilsson et al., 2016). Finally, the social immersion during VR use is the result of interaction with other people or representation of them in virtual environment (Pallot et la., 2017). Separating VR platform's immersive properties from user experience better allows for examining sources of experienced presence.

2.1.2 Presence

Presence is the second main characteristic of VR and continues the discussion which was started in previous chapter about facets of presence but from a more human standpoint. Presence can be defined as a human cognitive reaction to immersion and hence the same immersive system can cause varying levels of presence for different users (Slater, 2003; Slater & Sanches-Vives, 2016; Nilsson, Nordahl, & Serafin, 2016). This creates interesting setting for research as users' institutions can create very different reactions to a specific VR solution. Thus, S-D logic's value-in-use thinking can be well utilized to understand how perceived value of the same service can differ depending on a person.

Presence manifests as a sensation of really being in a virtual environment, although it does not mean that the user really believes to be in the virtual environment but rather their body reacts to stimuli as if it was in there (Slater, 2018). For example, a football flying towards the user's face in the virtual environment can cause reflexive reaction to dodge it before the user's mind catches up that it is not a real football.

According to previous literature, presence is a subjective experience which emerges from a wide range of immersive qualities affecting user experience. Nilsson, Nordahl, and Serafin (2016) divide stimuli of the subjective presence into categories of narrative and challenge-based presence, while Pallot et al. (2017) add a social category (Figure 2). According to Nilsson et al. (2016) the categories of narratives and challenges are both largely product of the mediated content. This means that the virtual environment is mostly responsible for the presence by use of challenges, narratives, and characters. The immersive properties of VR hardware are also contributing to presence in narrative and challenge categories although less (Nilsson et al., 2016). The social dimension considers co-creational aspects of interacting with others during use of VR and how it affects the users.

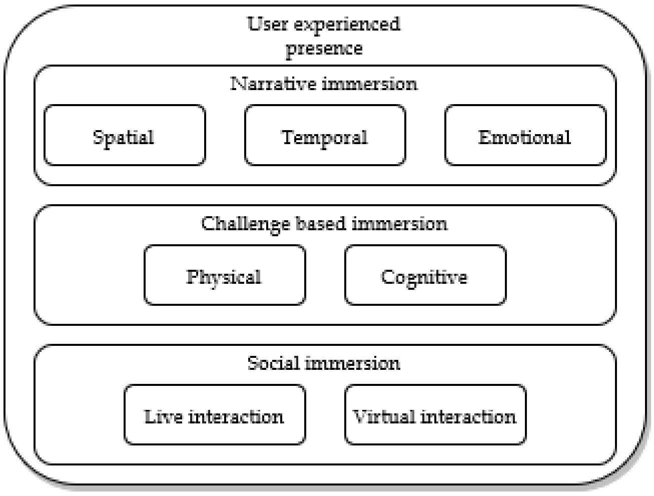

Figure 2 User experienced presence and categories of immersion combined from Nilsson et al. (2016), Pallot et al. (2017), Hudson et al. (2019), and Davis et al. (2009).

Narrative based presence's subcategories are spatial, temporal, and emotional (Nilsson et al., 2016). In context of VR, immersion is usually referring to the spatial immersion which gives the user a sensation of presence, where the user feels like being transported into the virtual environment due to the sensory stimulation that imitates real (Freina & Ott, 2015; Parong et al., 2020). This type of immersive effect can be especially strong when the spatial immersive properties of a VR platform are high, but presence experienced by a user is still subjective. Furthermore, Björk and Holopainen (2005) argue that spatial immersion results of extensive maneuvering in a virtual environment and doing so from the point of view of an avatar. To navigate in a virtual environment, a user must be able to interact with it. Temporal immersion captures user's attention by progression of a narrative (Nilsson et al., 2016). The user wants to know what happens next in the story, which could happen in form of captivating narrative or presented continuous process. This type of presence is common in television or film medium. Finally, emotional immersion is due to emotional investment to the characters depicted in the media (Nilsson, Nordahl, & Serafin, 2016).

Challenge based immersion's subcategories are divided into physical and cognitive according to Nilsson et al. (2016). Physical challenge can be a task requiring intense coordination of eyes and hand working together to solve a mechanical problem or a quick reaction to stimulus. On the other hand, solving a problem is seen as a cognitive challenge. (Pallot & Richir, 2016). Cognitive tasks are common in all forms of media, but for physical tasks interactive VR can be especially effective because of variety of control methods and freedom of movement enabled by many VR solutions.

Social immersion is a result of interaction with other participants of VR or observers (Hudson et al., 2019; Pallot et al., 2017). Users do not all need to be using VR but rather one can be wearing HMD while rest of the participants are watching the same virtual environment from a display and discussing with the user and group (Pallot et al., 2017; Holopainen et al., 2019). This would be considered presence from live interaction. User's experience of social immersion can also be because of co-presence, where having other people in the virtual environment increases the user's sensation of "being there" (Davis et al., 2009). This would be considered presence from virtual interaction.

Slater and Sanches-Vives (2016) present the possibility to increase the presence by meeting user exceptions. This means that what is happening in the virtual environment should behave as expected by the user to effectively uphold the illusion of being in the virtual environment. For example, the physics of an apple falling or how one can interact with it should behave as expect. This highlights the importance of immersive qualities needing to enable illusion of the VR user being actually in another place.

Level of presence VR platform user experiences is challenging to accurately measure as it is subjective. For this study, the presence is considered an important intermediary between VR platform features leading to user experience and then learning effects.

2.1.3 Interactivity

In the case of this study, it is important to define difference between interactivity and interaction. Here interactivity refers to actions that allow user to control VR platform and the virtual environment. Contrarily interaction is used to describe interplay between two actors, when referring to S-D logic's value co-creation or co-destruction. Interactivity as a main characteristic of VR and co-creation are both key themes of this study, and as such the difference between the definitions needed to be clarified.

Interactivity in its essence allows user to manipulate virtual reality. Interactivity can vary greatly depending on the VR platform. HMDs often include tracking at least 3 degrees of freedom, while many solutions allow 6 degrees. Respectively, this means that the user can look to direction they want or look and move in the real space to control the point of view. In addition to the movement, many solutions include handheld controllers which enable manipulation of virtual objects or user interface. Recent solutions such as Oculus Quest 2 can track the user's hands while the hands are in the view of the frontal cameras, making the controllers unnecessary for some use cases.

Interactivity contributes to presence experienced by a user. As shown in previous chapter, interactivity is recognized by multiple studies to contribute to users' VR experience (eg. Slater, 2003; Nilsson, Nordahl, & Serafin, 2016; Slater, 2018; Kwon, 2018). Interactivity especially contributes to how real the experience feels (Kwon, 2018). This comes evident in virtual environments where user can interact with the environment by picking up items, like in real world. The effect could be enhanced if the objects behave like they should in physical world when placed, dropped, or thrown like previously mentioned. Haptic feedback during interaction would further enhance the sensation of presence and it has been recent subject of development in form of haptic feedback gloves.

Effectiveness of interactivity on presence and plausibility of VR depends on the type of interactivity. Nilsson et al. (2016) state that moving around in real space to move in virtual environment is better than pressing a button on controller to move. This could extend to different types of control solutions, such as difference between using traditional handheld controllers, haptic controllers, or just bare hands.

2.1.4 Head mounted displays

As presented in chapter 2.1, the head mounted displays (HMD) are often associated with term VR and especially immersive VR. For the empirical part of this study, VR testing events were organized where participants were able to test an application using HMD solution Oculus Quest 2. The HMDs are the most accessible and popular form of immersive VR with constant development of the technology and new applications. The choice of this VR platform was done because of its availability as well as high immersive characteristics. Solutions with high immersive characteristics enable exploring effects of VR on the users more clearly (Freina & Ott, 2015). Thus, focusing on devices with high immersive characteristics should give more clear results. This is stated because a study by Parong et al. (2020) where they compared spatial learning effects. In it they noticed solutions inducing medium and low presence in users had no difference in learning effects while high presence inducing solution led to better performance (Parong et al., 2020). Therefore, focusing on Oculus Quest 2 with its high immersive characteristics should be preferable for this study's goals.

HMD devices consists of screens, lenses, head mounts, and variety of components to track movement and surroundings. High resolution and high dots per inch displays are commonly used to reduce visible pixels from the close distance to users' eyes the displays are mounted on. The lenses enable the displays to be viewed from close distance as if the displays were further away but still covering substantial portion of the user's field of view. The head mount is often in a form of straps and cushioning to adjust the device in place and keep it steadily on the user's face. Depending on the solution it can contain cameras and accelerometers to track movement. In addition to accelerometers, VR devices like Oculus Quest 2, use cameras to track movement and surroundings. Alternatively, tracking stations placed in the physical space can track the HMD's movement using laser-based scanning. Since the device mounts on the user's face, it simultaneously tracks the user position. In addition to the main components, stereo audio stimulus can be provided by earphones or built-in speakers, and interactivity with the virtual environment can be enabled by hand-held controllers or hand tracking.

The HMD solutions allow users to experience vastly varying levels of freedom, depending on the configuration and application. HMDs with 3 degrees of freedom limit a user to a static position allowing the user to freely look around. On the other hand, HMDs with 6 degrees of freedom allow full movement of the user in physical space to change the virtual position accordingly in a virtual environment. The higher degrees of freedom increase immersion experienced by users (Atsikpasi & Fokides, 2021). In this study, the tested solution was Oculus Quest 2, which can do 6 degrees of freedom, but the software solution limited it to 3 degrees of freedom.

Most of the recent developments in VR solutions have been focused on HMD technology allowing 6 Degrees of Freedom. There are efforts in developing VR technology that stimulates more of the human senses than just the visual and auditory. These include hand-held controller solutions with tension feedback for simulating gripping items or harnesses with electric motors to simulate touch, but the solutions are still in early production or proofs of concept.

2.2 Prevalent effects of VR on learning

Learning as a process of creating knowledge is in many cases very subjective, depending on variety of factors such as personal interest and previous institutions. The personal nature of learning and variety of situations it is done in makes the subject diverse. Furthermore, the views on how learning happens and all the factors that can affect it has been explored extensively by previous literature which makes for a rich background for the purpose of this study. Therefore, the challenge for this study regarding learning is to include all relevant views. The most relevant for this study is learning in the context of VR. Therefore, the previous literature on VR's learning affordances and the main directions has been explored in a literature review. The intention is to build a set of themes for the focused interviews, which would regard all emerging main aspects of VR learning as presented by previous literature. These aspects then can be explored on a personal level using value perspective.

Many preceding studies discuss learning outcomes deriving from VR characteristics immersion, presence, and interactivity (eg. Madathil et al., 2017; Rupp et al., 2019). While some focus on the flow as an important mediator of learning experience (Kye & Kim, 2008; Choi & Baek, 2011; Bodzin et al., 2020). On top of this, using a novel technology, emotions (Bodzin et al., 2020; Atsikpasi & Fokides, 2021) or sociability (Holopainen et al., 2019; Mei et al., 2021) are also seen as important antecedents for learning outcomes. While majority of preceding studies focus on the positive learning outcomes, there are few commonly recognized negative learning effects such as simulator sickness and cognitive load (Wong et al., 2012; Makransky et al., 2019; Madathil et al., 2017; Rupp et al., 2019). Overall, the intention of VR is to enable lifelike virtual experiences, enabling learning comparable to authentic hands-on experience. Therefore, VR is often used in training exercise with applications ranging from military use to health care. The virtual lifelike experience is unique to VR technology (Kwon, 2018), hence experiential learning theory has been prominent part of deciphering VR learning (Kwon, 2018; Fromm et al., 2021).

The next chapters discuss relationship of recognized important themes of VR learning. The themes are organized so that user centric view is central, hence presence, flow, sociability, cognitive load, simulator sickness, engagement, and emotions emerge from the previous literature. Finally, experiential learning (Kolb, 1984) in context of VR is reviewed as lifelike experience enabled by presence is crucial part of what makes VR learning so different from other media.

2.2.1 How presence affects learning?

As previously established, VR's spatially immersive features are especially pronounced, hence the effects of presence are important for learning outcomes. Dalgarno and Lee (2010) divide effects of presence in two main categories: presence and co-presence. The main learning benefits deriving from these according to Dalgarno and Lee (2010) are spatial knowledge, engagement, learning in context, by experimenting, and by collaboration. The benefits for learning recognized by their study give presence a wide sweeping effect, but it seems their findings are aligned with the general view of VR learning studies.

Presence is a sensation of "being there" which gives VR users possibility of realizing spatial features such as size, position, and context of the presented subject much better than when using traditional media (Dalgarno & Lee, 2010). This of course creates richer context for a subject and enables knowledge that other forms of media cannot offer to the same degree. The rich context as previously presented is important part of the virtual experience. It allows turning virtual experience into a concrete one, which is especially crucial when considering learning from experience (Kwon, 2018; Howard-Morris, 2020).

According to Rupp et al. (2019) sensation of being in a virtual environment improved interest towards the subject of study, although they recognize the real reason could as well be novelty of the tested VR solutions. Prolonged use of VR over several months use has not been explored in the context of education (Atsikpasi & Fokides, 2021). Therefore, it is hard to say if the improved interest is due to experienced presence or novelty of the technology.

Despite the benefits of presence for learning, it does not mean that learning solutions with high immersion are more effective. For example, Makransky et al. (2019) found that a VR learning solution did give increased sensation of presence but negatively affected learning due to other factors. They recognized cognitive load had strained the users' abilities to learn, but they also noted it could have been due to presence not assisting notably with all learning tasks which is especially interesting notion. This view of presence's effects depending on the learning task is further validated by Parong et al. (2020) study. Their research found that the effectiveness of VR for learning seems to change depending on the type of the learning task. Tasks depending on understanding the surroundings such as surveying items in the virtual environment and remembering the items were more successful in VR than other in media, while other types of tasks did show no significant difference between low, medium, and high immersion solutions (Parong et al., 2020).

In cases when presence is important, immersive qualities of VR platform are crucial. Parong et al. (2020) noted that high immersion solutions did have significant difference in effectiveness compared to the other low and medium immersion solutions. The latter two did not show significant difference between them (Parong et al., 2020). The difference in effectiveness becoming apparent only in high immersion solutions can be because medium to low immersion solutions not presenting spatial information enough effectively which results in poor spatial knowledge related performance. The observed learning effects could also be because of highly immersive VR is better able to focus the user's attention to the subject.

Because presence is recognized consequential for VR learning experience, the following chapters further explore how it forms learning benefits, and how it affects engagement, collaboration, and learning from a concrete experience in VR context.

2.2.2 Flow as a mediator of VR learning

In Kye and Kim's (2008) study regarding augmented reality, they formulated from preceding VR literature a theoretical model representing how characteristics of a VR solution affect learning via presence and flow as seen in figure 3. Although it has been over a decade since, they present interesting connection between media characteristics and how the learning effects formulate. Their recognition of flow's importance in VR context is aligned with view of more recent studies, for example Kwon (2018) presents similar connection between media characteristics leading to presence, which leads to flow which then brings learning effects.

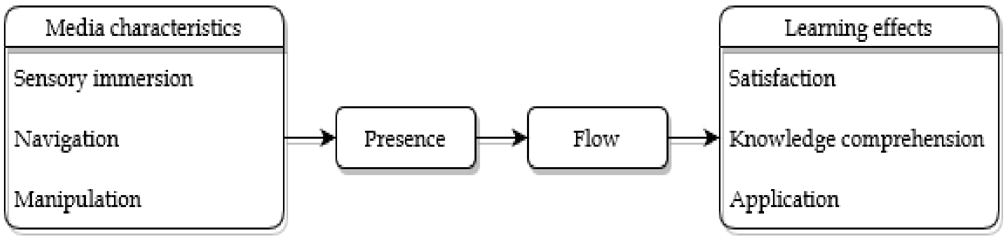

Figure 3 Relationship of media characteristics and learning effects (Kye and Kim, 2008, page 7).

In the figure 3, navigation and manipulation are both occurrences of interactivity enabled by a VR platform, while sensory immersion is analogous to spatial immersion. The VR features enable users to experience presence, but especially interesting in this model is how presence causes flow, then resulting in learning effects. The study by Kim and Kye (2008) did presented a significant relationship between presence and flow. The relationship between experienced flow and VR learning was also recently recognized by Bodzin et al. (2020) and Kwon (2018).

Interestingly, the model does not consider temporal, emotional, social, physical, or cognitive challenge -based immersion. It is likely because these forms of immersion are more subjective and often in VR literature only spatial immersion is directly considered as it is the standout feature of VR. Despite this, as previously argued, it would be valuable to consider the complete picture in the context of complex VR platform where presence can come from various stimuli and sources of interactivity. More inclusive approach enables consideration of more human aspects affecting presence such as personal institutions.

The flow state is extremely common in immersive VR where engagement, learning, immersion, and presence are high (Bodzin et al., 2020). Flow is an individual state of complete focus resulting to a full absorption in an activity and a subjective optimal experience (Csikszentmihalyi, 1975; Csikszentmihalyi, 1990). The flow state is a result of clear goals, immediate feedback, and adequate challenge (Csikszentmihalyi 1997). According to Csikszentmihalyi (1997) dimensions of flow are full concentration on the subject, action and awareness merging, no worry about failure, losing self-consciousness and sense of time, and the experience becomes the reward. For example, flow experience can appear as lost sense of passing time while user is focused on a puzzle or presented environment. The user's own skill and personality as well as VR platform can affect the flow state conditions. Clear goals and immediate feedback depend heavily on the VR platform's software, for example a prompt if the task is completed successfully or not. For the rest the divide is not as clear. For example, balance of challenge and skill depends on the software but also the ability of the user. Another example is concentration on the task can be increased by HMD hardware as the virtual environment encompasses user's visual sense, while the software focuses on the subject, and the user's own mind is interested on the presented subject resulting in complete focus on the task at hand enabled by all sides.

In study by Choi and Baek (2011) the media characteristics that influence flow were examined and found to be interactivity, representational fidelity, immediacy of communication, consistency, and persistence. The interactivity and representational fidelity were considered directly influencing flow while the latter three had connection but could not be used to predict learner's engagement. Representational fidelity consists of realistic display of the virtual environment, objects within it and consistency of them, as well as spatial audio, force feedback, and user representation. Interactivity causing flow is due to embodied view control, object manipulation, navigation, embodied communication, control of environment and objects. (Choi & Baek, 2011).

What is especially interesting about the flow state and its enablers is that it seems to be directly result of presence caused by interactivity and immersive characteristics in the context of virtual learning environments. Comparing to the VR's main characteristics previously explored in this study, interactivity is present in Choi and Baek (2011) study as it has been discussed before, but immersion is divided to some of its causes: fidelity, communication, consistency, and persistency. In Kye and Kim (2008) study the similar causes of flow deriving from presence were confirmed.

The importance of flow for the user's optimal learning experience is clear in preceding studies. In the context of VR solutions, the VR characteristics are defining the source of flow. Therefore, the immersive and interactivity enabling features of the VR platform should be considered as part of possible mediators of user learning via presence and furthermore the flow state.

2.2.3 Sociability learning effects

The sociability learning outcomes derive from sharing a VR experience, which can happen either virtually or in real space. The nature of VR technology enables more broad, intricate, and personal social interactions for its users (Mei et al., 2021). The VR experience can also enable other social effects that manifest in social situations, such as initiating discussion or increasing willingness to share ideas (Holopainen et al., 2019).

Sensation of being in the same space virtually, or co-presence, is quite common in multiplayer video games where users' avatars remind of co-existence in the virtual environment (Davis et al, 2009). VR's immersive characteristics enable more realistic experience of co-presence compared to traditional virtual environments. This can have benefits such as sharing experiences in VR to improve understanding of a subject or creating mutual understanding between two actors (Holopainen et al., 2019; Mei et al., 2021). Concrete example of social benefits because of co-presence would be working together in virtual environment to solve a problem or something as simple as a customer virtually designing a cake with a chef as seen in the study by Mei et al. (2021).

Social situations which are empowered by VR experience can improve motivation as well as improve discussion in person (Holopainen et al., 2019). Holopainen et al. (2019) shows that in group use, individuals are compelled to indulge further into the VR experience because others suggest them to try new things in the VR. This seems to be similar to cooperative learning where individuals participate to form a more complete understanding of a subject by adding information others did not notice. In context of information systems, collaborative learning has positive impact on use of system and overall satisfaction (Junglas et al., 2013; Salam & Farooq, 2020).

From value perspective, exploring social situations is a fruitful source for understanding value co-creation. Collaboration is one of the more prevalent themes arising from previous literature regarding value formation in the context of VR. Thus, connection of sociability to learning should be considered as it emerges from actor-to-actor interaction resulting in abundant possibilities for value co-creation.

2.2.4 Cognitive load learning effects

Resulting from use of VR platform and intensity of its characteristics as well as novelty of the technology, cognitive load is recognized as a concern in several studies (eg. Wong et al., 2012; Makransky et al., 2017; Rupp et al., 2019). Cognitive load is a result of stimuli being too taxing on the user's working memory and hence causing inefficient information acquisition.

The causes of cognitive load are such as VR platform being challenging to use (Makransky et al., 2017; Rupp et al., 2019), information being too densely presented (Wong et al., 2012; Albus et al., 2021), and challenges in concentrating on the subject-matter while using VR (Makransky et al., 2017).

If a user is not confident with a VR platform, the user's efforts will be focused on navigating and using the VR solution, hence not enough cognitive capability is available to focus on actual subject-matter. Cognitive load can be mitigated by VR platform in ways such as ease of use features or attention guiding features (Rupp et al., 2019; Albus et al., 2021). Thus, novelty of VR technology appears to be a benefit as well as hinderance, depending on user institutions.

The challenge of information density is present in all learning. Especially new media formats can deliver large amounts of information in a short time span. For example, comparing traditional blackboard class setting where the teacher writes and talks freely to a video format that is no longer dependent on writing speed or fluency of the talking. In this example, the video format can be much more information dense. In practice, understanding sources of cognitive load such as information density while designing a learning service is important. For example. using shorter automatic sections or videos provides better learning results in modern learning media (Wong et al., 2012).

New technology can be a distraction from learning as the user might find themselves enjoying the novelty of the technology during the experience, while learning is left as a secondary objective. Makransky et al. (2017) found that despite higher level of experienced presence, the users were still having worse results on learning. They suspected that VR platform itself can act as a distraction and cause cognitive load, which caused the observed results.

2.2.5 Physical sensation learning effects

In this study, physical sensations regard the involuntary reactions that a users' body experiences during VR use. These sensations are generally considered as simulator sickness in previous literature, but simulator sickness has supposition of being purely undesirable and negative for user experience although this is not true in all cases. Therefore, in this study physical sensation is used to describe in more neutral supposition what previous studies refer to only as simulator sickness. Simulator sickness is still used as a descriptive term for consistency with the previous studies.

VR can cause simulator sickness which can be seen as a negative aspect of VR (eg. Moss and Muth, 2011; Dziuda et al., 2014; Kim et al. 2018), and thus it affects user experience negatively. According to Kim et al. (2018) simulator sickness happens because of what the user sees and feels does not match. They also state that especially erratic movement causes simulator sickness, which is in line with results from study by Dziuda et al. (2014). Dziuda et al. (2014) observed that adding movement to the simulator platform increases simulator sickness. Simulator sickness manifests as nausea, eye strain, and disorientation (Kim et al., 2018).

It would be challenging to argue, that simulator sickness has anything but negative effects on user experience, but Kwon (2018) present simulator sickness as one of the causes for presence. According to Kim et al. (2018), one of the simulator sickness symptoms is vertigo. While in general this would be uncomfortable, some users might find the sensation of vertigo exciting. In lesser amounts, the sensation might be even desirable. Kwon (2018) suggests that the physical sensation does intensify the experience and shows concretely how authentic virtual experience can be. Are there other similar effects that briefly give VR users a rush like in a real situation because of how their body involuntarily reacts to it? If there are, it could provide interesting knowledge about how to improve VR experience. Therefore, there is an interesting possibility for both negative and positive value to be explored by questioning the users about their physical sensations, situations that cause it, and how it affects the user experience.

2.2.6 Engagement and emotions learning effects

Literature review by Atsikpasi and Fokides (2021) shows that engagement and emotions are a major contributor to positive learning outcomes in context of VR. Their finding is also in line with the literature included in this study. The users can become more engaged in the learning because they are either interested in the novelty of VR technology, or they find variety in learning methodology intriguing (Madathil, 2017; Rupp et al., 2019; Bodzin et al., 2020). It is also interesting to consider if learning effects stemming from novelty would retain over longer period of a time, but there is no empirical evidence for or against it, as VR research with longer interventions have not been conducted (Atsikpasi & Fokides, 2021). Comparing VR learning to other media such as computer classes, it could be said that experienced presence and isolation from real world is much higher in VR use case, so it might better retain user engagement after the novelty wears off.

Engagement in VR context can arise from variety of reasons. Bodzin et al. (2020) presents it to be caused by interest, gaming features, and VR experience. They state that users' interest depends on the institutions where relevancy and authenticity are crucial. Gaming features as Bodzin et al. (2020) call them are a mix of immersive and flow inducing features such as challenges, narratives, immediate feedback, and intrinsically rewarding experiences. Definition of interest by Bodzin et al. (2020) is extremely board, thus engagement in school education context is used to expand upon it.

In the context of school education, engagement is defined by three categories according to Fredricks et al. (2004). (1) Behavioral engagement manifests in social, academic, or extracurricular activities which engage student involvement. (2) Emotional engagement regards positive or negative emotions towards people, subjects, or education institutions. (3) Cognitive engagement emerges as being invested and willing to learn new skills and concepts. (Fredricks et al., 2004). Therefore, Fredricks et al. (2004) state that engagement is a fusion of behavior, emotion, and cognition.

Behavioral engagement with its social side could appear as learners' involvement in asking questions and contributing to discussion in social learning situations. VR has been recognized to be effective for sociability and initiating discussion among people participating in the experience (Holopainen et al., 2019). Therefore, behavior or values that would be considered improving social learning could affect VR user engagement. Also, previous experience or interest in VR video games could extend user interest to VR in learning context, thus behaviorally engage the user.

Emotional engagement as presented by Fredricks et al. (2004) comprises of value components which are especially interesting from the point of view of this study. The value components are interest, attainment value, utility value, and cost (Fredricks et al., 2004; Blumenfeld, Kempler & Krajcik, 2006). The interest is related to enjoyment of the activity. The attainment value refers to confirming self-schema by doing well in a learning task. The utility value regards future goals and how important the learning task at hand is for them. Lastly, the cost is the negative aspects of engaging in the learning. (Fredricks et al. 2004; Blumenfeld, Kempler & Krajcik, 2006). In VR context, the costs could be effort, simulator sickness, and time spent. Use of VR sparks emotions towards the technology, subjects, and activities which are modified by the VR experience, hence evaluating the value components presented by Fredricks et al. (2004) for emotional engagement could provide insight into engagement in VR context as well.

Cognitive engagement stems from self-regulated and strategic investment in learning coming from learner's inner qualities (Fredricks et al., 2004). In other words, the process of learning is engaging to the learner, initiating state of focus on acquiring new skills or understanding concepts. Fredricks et al. (2004) present that cognitive engagement can differ for one person depending on the context and situation. They state that a person can be strategically invested in learning when it is necessary for them or when they have the skills to do so. Hence role of VR in cognitive engagement could be providing alternate means of learning, which for some could allow strategic learning, especially if find themselves to better learn from an experience. Alternatively, VR learning provides possibilities for acquiring skills that depend on a place and time, which the learner is otherwise not able to acquire.

Thus, being engaged in a subject means that you are focused, motivated, and interested in the subject. Hence, it would be likely that a benefit of engagement is retained attention as presented by Dalgarno and Lee (2010), willingness to further explore the subject (Rupp et al., 2019), and memorability of the experience. Although this type of benefits could be expected, it does not necessarily mean that they result in a statistical difference between VR learning performance and other medium as seen in study by Madathil et al. (2017).

No measurable learning benefits of engagement and emotions were recognized by the empirical studies included in this study's literature review. Despite this, positive emotions and behavior induced by VR can have indirect learning benefits such as helping to retaining interest towards learning over longer time, or personal and hedonistic benefits which lead to attention.

2.2.7 Learning from experience: Experiential learning in virtual reality

As evident in previous chapters, the role of presence is vitally important for learning outcomes of VR. Compelling argument that could be made is that the sensation of presence allows for virtual experiences that have the benefits of real experiences. But how does this tie into context of learning? This has caused interest in theories that focus on learning from experience, of which experiential learning theory by Kolb (1984) has been one of the most influential ones. Kwon's (2018) and Fromm et al. (2021) studies present that VR platforms can indeed enable experiential learning. Experiential learning is only a single theoretical perspective on learning, but during VR use it is arguably the most present form of learning and distinguishing factor of VR compared to other forms of media. Therefore, this study considers the recognized learning effects to influence users' experiential learning process.

The experiential learning theory according to Kolb et al. (2014) is a holistic model of the learning process where, as the name highlights, the role of experience is central in the learning process. Kolb's (1984) Lewinian experiential learning model (Figure 4) shows the role of the model's four central themes: active experimentation, concrete experience, reflective observation, and abstract conceptualization.

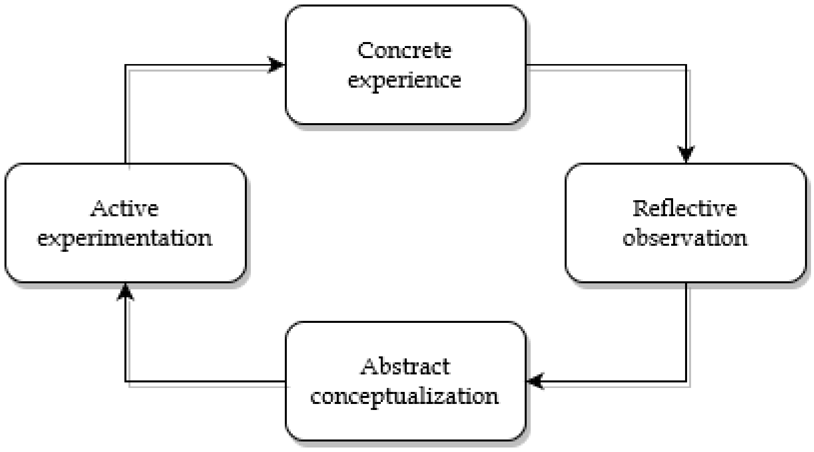

Figure 4 Kolb's (1984) Lewinian Experiential Learning Model.

The experiential learning model consists of two modes of grasping experience (concrete experience and abstract conceptualization) as well as of two modes of transforming experience (reflective observation and active experimentation) (Kolb et al, 2014). As presented by the Kolb's model the four different stages of learning interact in a learning cycle as presented in the figure 4. The concrete experience allows for reflective observations to be made about the subject which can then be used to form abstract conceptualizations about it. The cyclic nature comes from using the newly formed implications as basis for exploring new experiences. (Kolb et al., 2014).

The experiential learning theory presented by Kolb (1984) has been extremely influential and central to explaining learning process alongside cognitive and behavioral learning theories. Kolb's (1984) intention was not to present an alternative learning theory to the previously mentioned, but instead together with cognitive and behavioral learning theories create more complete understanding about learning. Despite this it does have its issues, mainly because of being a high-level theory where some of the concepts of the central themes are rather open to scholar's interpretation.

Kolb (1984) described the concrete experience as "here-and-now concrete experience". He highlights the importance of collecting subjective personal meanings to abstract concepts as part of this step. Howard-Morris (2020) in his literature review on use of "concrete experience" in experiential learning context defines it as "hands on participation" where the learners are involved and active participants in real-world uncontrived experience. Furthermore, he presents that the concrete experience includes rich contextual information. From VR standpoint, this is extremely interesting because one of the main characteristics of VR is presence as discussed in the previous chapter. Presence is a sensation of "being there" which is partially caused by the VR's fidelity and interactivity with. Therefore, rich, lifelike, spatially immersive experiences filled with contextual information are possible. This view is aligned with studies of Kwon (2018) and Fromm et al. (2021).

The reflective observation is more of a passive learning form where the learner is forming observations about a subject because of what is happening due to someone else's or their own actions in the concrete experience. Less interactive VR experiences induce spectator type learning (Kwon, 2018).

The abstract conceptualization according to Kolb et al. (2014) is an act of distilling reflections about a subject into abstract concept which can then be used to explain multiple situations. They use an example of analyzing driver's manual to understand a car's functions. In other words, abstract conceptualization focuses on creating a personal understanding of how a phenomenon happens or functions.

The active experimentation is an active learning form where personal understanding is put into use by testing the formed understanding or theories to solve the phenomenon. VR experiences with high interactivity, such as being able to pick up and play with items found in virtual environment, enable active experimentation (Kwon, 2018).

The possibility of VR presenting contextually rich and interactive experiences allows experiential learning. Kwon (2018) in his study suggests that because of the fidelity, interactivity, and presence of VR experiences, the users recognize these virtual experiences as direct experiences, and thus the learning effect is enhanced. Oddly, he also presents simulator sickness as something that makes the virtual experience feel more like an actual experience. This might be because the stimuli being enough real for visual senses that it tricks the brain to perceive the virtual environment and its movement as real as it does in physical environments. The high interactivity is important for enabling active experiential learning that is more comparable to learning from real experiences (Kwon, 2018). Although experiential learning VR literature often focuses on lifelikeness of the presented virtual environment, also the role of engaging and complex tasks that immerse learners in tasks should be as well considered as it can be important (Herrington, 2007). Completeness of the experience should hence be considered, not just the visual fidelity and interactivity of the experience.

The difference between real experience and VR mediated experience is that in many cases the users need to learn to use the VR platform before they can focus on the subject. Stevens and Jouny-Rivier (2020) argued that experiential learning would be an antecedent of technology acceptance model's perceived usability and perceived usefulness of an information system. These qualities are also important for VR as seen by previous studies where usability has hindered learning outcomes (Makransky et al., 2017; Holopainen et al., 2019; Rupp et al., 2019). This suggests that experiential learning could have two-fold meaning for evaluating antecedents of VR benefits and hinderances. The users are going through the experiential learning process to determine ease of use of the VR platform and its usefulness, but also they are using the experiential learning process to learn about the subject.

Overall, the experiential learning theory is meaningful for the goals of this study for several reasons. First, the VR was presented to enable learning from experience, thus the experiential learning theory by Kolb (1984) is important to unravel the learning process. Second, the experiential learning could explain both learning to use VR as well as perceived VR learning outcomes. Third, the previous studies did show that at least presence, physical sensation, interactivity, and fidelity of the VR platform affect experiential learning, but this study presented multitude of other prevalent VR learning effects and their relationship to experiential learning is unclear and should be better clarified. Furthermore, the value perspective this study employs can be used to clarify the relationships from user perspective. Therefore, the empirical section of this study considers the themes of experiential learning as presented by Kolb's (1984) model, the role of virtual experience compared to real, how VR learning use leads to perceived value outcomes, as well as relationship of the VR learning themes and the experiential learning.

2.3 Value in service-dominant logic

Integral part of any business is delivering customers services that fulfill their needs. To improve the business, it is crucial to understand what the customer needs are and those are met by the produced services. In other words, the question is how the business creates value as it delivers its services to fulfill customer needs. To quote Grönroos and Voima (2013, page 2) "On a general level, value creation entails a process that increases the customer's well-being, such that the user becomes better off in some respect". Previous literature also recognizes negative value creation, where the user of a service becomes worse off, called value destruction.

For nearly two decades in the field of marketing, a prominent view of value creation has been service-dominant (S-D) logic as proposed by Vargo and Lusch (2004). Redefining when the value creation happens was a major focus of S-D logic as well as seeing the value created as co-production (Ranjan & Read, 2016). Previously, value was understood as something created in the provider sphere and delivered when the customer acquired a product (Grönroos & Voima, 2013). The figure 5 presents service life cycle from production to use, provider and customer sphere. For value creation as seen by S-D logic, the customer sphere is central for where the value creation happens.

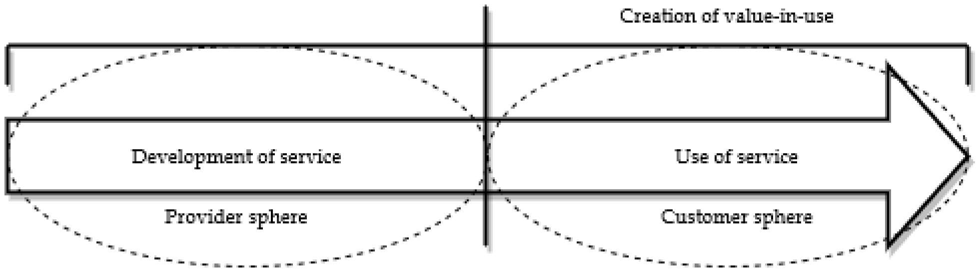

Figure 5 Value creation scope, adapted from Grönroos and Voima (2013).

In the S-D logic value is understood to form during the use of the product in the customer sphere, hence called value-in-use (Vargo & Lusch, 2004). This means that value outcomes happen during the consumption, and depends on the customer's experiences, abilities, and logic to extract value out of the product (Grönroos & Voima, 2013; Ranjan & Read, 2016). Therefore, value is perceived individually and personally, and affected by experience, personalization, and relationships (Ranjan & Read, 2016).

For the goals of this study, understanding when value forms is crucial. Value-in-use view allows exploring how use of a VR solution can produce benefits as well as hinderances in learning context. Furthermore, differing benefits and hinderances for person to person can be understood due to individual nature of the S-D logic's value formation process. However, it also shows how much of a challenge the value perspective is from generalization standpoint because every change in a system that is being examined can result in a drastic change in the value and learning outcomes. Therefore, it is important to examine the value formation process and not only the value outcomes. Next chapter focuses on the value co-creation and co-destruction to better understand value formation process.

2.3.1 Value co-creation and co-destruction

The S-D logic examines interaction between actors relating to a service, hence the S-D logic's value creation refers to creation of value-in-use where co-creation is the purpose of the interaction (Grönroos & Voima, 2013). The value emerges from collaboration which means the value is co-created by the actors (Lusch & Vargo, 2006; Vargo, et al., 2008). In further detail, combination of resources owned by the collaborating actors is what generates value (Vargo et al., 2020). This highlights that the customer participates to the value co-creation process instead of receiving value as is. Ranjan and Read (2016) state that co-production as an important antecedent to value co-creation, forming from shared knowledge, equity, and interaction between actors. The combined resources in context of learning while using VR can be knowledge of the software developer on the subject matter, product of the HMD producer, and time and effort of the user learning to use the VR platform and studying the subject.

Despite the co-creative nature of value in S-D logic view, the experienced value can also have negative outcomes for all the actors. These outcomes depend on the actor and the context (Vargo, Akaka, & Vaughan, 2017) which means that the same process can create positive value in one situation for one person while for another the experienced value is negative (Plé & Cáceres, 2010; Echeverri & Skålén, 2021). Value co-destruction is as well an outcome of the resource integration process. The value co-destruction can be considered decline in value or well-being experienced by any actor (Plé & Cáceres, 2010; Echeverri & Skålén, 2021).

Value co-creation and co-destruction have been studied from a variety of perspectives: Cultural context such as practices, meanings, norms, and resources which influence value co-creation (Akaka, Schau, & Vargo, 2017). Social forces and structures, and their effect on value creation and service systems (Edvardsson, Tronvoll & Gruber, 2011). Even co-operation can be seen as a form of value co-creation (Haukkamaa, Yliräisänen-Seppänen & Timonen, 2012; Charron, 2017). Haukkamaa et al. (2012) presented so in educational context, where the students are co-operating with the educational institute to form value-in-use. Whereas Charron (2017) present the co-operation in entertainment context where concert goers themselves are a part of the value co-creation because they participate in creation of meanings, experiences, and services. It seems that the possibilities for new perspectives on value co-creation are found from all situations where there is possibility for resource integration during use of a service. This also creates fruitful opportunity to explore VR learning from the S-D logic perspective to improve understanding of value co-creation in this context. Furthermore, the value perspective can clarify relationships of the actors in VR learning process and how the different themes of VR learning affect it.

Both the value co-creation and co-destruction are crucial for understanding user experiences. The key takeaway is that value does not form in an isolation, but rather it is a product of co-production and value-in-use (Ranjan & Read, 2016). Understanding the value formation and outcomes allows one to predict the effects of a service to its users. To quote Ranjan and Read (2016, page 292), "Value co-creation also describes the way actors behave, interact, interpret, experience, use, and evaluate propositions based on social construction of which they are a part.". Being able to reason where and why an observed learning outcome comes from is a powerful tool for evaluating and improving VR learning tools, which is why value perspective was chosen for this study.

2.3.2 Service systems

Service in the context of S-D logic means using resources of one actor to benefit another and the exchange can be considered as a service-for-service exchange. This forms the core of the value-in-use in S-D logic. (Vargo et al., 2008; Vargo et al., 2020).

Service systems are two or more actors that are connected by value propositions. These can include information, technology, or people. Service systems can also interact with other service systems. Vargo et al. (2008). Vargo et al. (2008) give basic example of a service system which includes a firm's crucial business partners together forming a service system while customer side with their value proposition connections forms a second service system. Then the firm can deliver a service to the customer, where in use of the delivered service a resource integration from customer side happens to form the value of the delivered service (Vargo et al., 2008). This also means that the customer side gave something back to the firm, which in many cases is money but also can be direct interaction with the resources of the firm, such as interacting with the firm through use of social media.

The interaction between the customer and the service provider can hence be direct or indirect (Grönroos & Voima, 2013). According to Grönroos and Voima (2013) direct interaction requires both sides to interact directly and continuously with each other's resource to form value. They state that indirect interaction means the firm would deliver a product and the customer would use or consume it without directly interacting with the firm's resources. Furthermore, indirect interaction can also take place before direct interaction, like reading an advertisement before buying a service (Grönroos & Voima, 2013).

The key points here are that S-D logic focuses on actors delivering services to other actors. Service systems can be seen as contributors to the service that an actor delivers to another, which shows that there can be multiple actors contributing to a single service. In context of a VR user, this means that people who interact with the VR user can co-creating or co-destroy value. Furthermore, direct and indirect interactions can take place, which means that exploring value co-creation and co-destruction experienced by a VR user does not always require constant interaction between the actors' resources, but rather can also happen when the user consumes a firms' VR product (Grönroos & Voima, 2013).

2.3.3 Service-dominant logic view of virtual reality

VR experience is a complex combination of actors, hardware, software, and environment all interacting to create experience depending on the benefactor's personal institutions (Atsikpasi & Fokides, 2021). This makes the study of value outcomes benefit from the S-D logic framework which considers the value formation in use. Furthermore, the different sides of the service system of immersive VR can be considered taking a part to the process directly or indirectly, where the resource integration results in value co-creation or co-destruction.

For this study, the S-D logic is essential in enabling interviews to explore value formation perspectives. Furthermore, the S-D logic will be used to explore value outcomes and processes from which they emerge. Therefore, views of preceding literature on VR value formation need to be explored because they provide further insight on how VR value formation can happen as well as can be used to discuss and compare the findings of this study.

The literature review on VR value co-creation did reveal that there is only a handful of studies that consider value formation in VR context presented in table 1. Four articles were discovered that used the S-D logic in meaningful manner to examine VR value formation (Mei et al., 2021; Tom Dieck & Han, 2022; Holopainen et al., 2019; Charron, 2017). While similar value perspective was used in a study by Nussipova, Nordin, and Sörhammar (2020).

	Value co-creation	Value co-destruction	Reference
1	Improved communication		Mei et al., 2021
2	Improved understanding		Tom Dieck & Han, 2022
3		Exhaustion and simulator sickness	Nussipova et al., 2020
4	Improved communication, improved sense making, safety, trust, innovation, value co-creation	Usability	Holopainen et al., 2019
5	Improved mediated experience		Charron, 2017

Table 1 Value co-creation and co-destruction in previous studies which consider the value point of view in VR context.

Preceding studies reveal important features that should be considered when exploring the S-D logic value formation in the VR context. Reflecting these preceding views of value formation to VR learning affordances creates preliminary connection between value and VR learning effects. This connection is crucial for this study's main research questions of how VR affects user learning.

According to preceding studies included in this review, the value of VR platforms revolves around collaboration, communication, and sense making as seen in the table 1. VR platforms are seen as an advanced means of communication and collaboration with advantage of presenting more spatially accurate information to the users. The spatial information and the ability of the users to communicate via various means such as interacting with the environment, speech, and gestures gives unique value to VR solutions compared to other forms of distance communication.

Social value of VR has been recognized by multiple studies (eg. Hudson et al., 2019; Holopainen, 2019; Mei et al., 2021). Social values comprise of various benefits and hinderances which all relate to people interaction. In this literature review the common values relating to social interactions were shared understanding (Dupont, Morel & Pallot, 2016; Pallot, et al. 2017; Lammi et al., 2018; Holopainen, 2019; Tom Dieck & Han, 2022; Mei et al., 2021), communication (Lammi et al., 2018; Holopainen, 2019; Mei et al., 2021), trust (Pallot, et al. 2017), improved learning (Mei et al., 2021; Wang & Sun, 2021; Brown et al. 2016), satisfaction, and loyalty (Hudson et al., 2019). Furthermore, distinct values such as improved user experience (Razek et al., 2019), in context learning and spatial learning (Brown et al., 2016) were also recognized.

The shared understanding refers to VR solution's ability to enable its users to experience, describe, and demonstrate information because of representation of physical objects, space, and user avatars to form a mutual understanding. The intuitive sensation of space, shapes and sizes enabled by VR gives more realistic depiction of products and configurations, which in turn create mutual understanding between actors (Mei et al., 2021) as well as improves general understanding of the products (Nussipova et al. (2020). Immersive presentations of prototype products or facilities in VR makes it possible for different project stakeholders to better understand and discuss the prototypes (Lammi et al., 2018;

Nussipova et al., 2020). Understanding other actor's point of view leads to the improved shared understanding and enables co-creation, which then on leading to more innovation (Dupont, Morel, & Pallot, 2016; Holopainen, 2019).

While communication is required to have shared understanding, communication in VR context does also exhibit distinct values. The benefits of VR in communication are not only related to interactions in the VR over distance but also in the immediate physical space where the technology acts as a facilitator for discussion, thus enabling co-creation (Holopainen, 2019). Although VR solutions can initiate social interactions in the physical space, the HMD solutions also have an isolating effect which will hinder user's ability to discuss and interact with people in the physical space (Brown et al., 2016). Generally, social benefits of VR solutions are considered to outweigh the hinderances.

It also should be noted that there are differences in importance of roles the spectators have depending on the technology and intention. Role of the spectator as a guide affects the value perceived by the user. It seems to be even more important in immersive VR solutions for less experienced users and less impactful for the users with prior experience (Nussipova et al., 2020).

In this literature review, the learning affordances were present because VR affects engagement (Mei et al., 2021; Wang & Sun, 2021), attention allocation (Mei et al., 2021), as well as enhances spatial and contextual clues (Brown et al., 2016). The engagement was seen to be because of the novelty of the VR solution and user interest in it (Wang & Sun, 2021), as well as the unique way how social VR enables knowledge communication (Mei et al., 2021). The knowledge communication also has been highlighted as a feature of virtual environments (Müller, 2011). How VR can present virtual environments and objects allows life-like situations and means of communicating spatial and object related information, as suggested previously.

Nussipova et al. (2020) took an activity perspective on value formation in immersive VR solutions and presented that it emerges from combination of physical and cognitive activities. This view is aligned with how spatial immersion forms from ability to move and interact with the environment in a natural manner, and how it affects the level of presence the user cognitively experiences. Importantly, this was one of the very few studies to directly considering value formation from user point of view in VR, although similar values have been indirectly discussed in the other included scholarly articles. Nussipova et al. (2020) found that the negative values resulting from physical and cognitive activities to be exhaustion and simulator sickness, which were also recognized in context of service prototyping in VR by Razek et al. (2019).

2.3.4 Value formation in VR use conclusions

The main methods recognized in the studies how value is created were positive impacts on learning, communication, understanding, knowledge sharing, trust, and safety. Overall, most of the studies did consider the better or unique possibilities for cooperation and interaction between actors to be the reason for the seen benefits.

Value destruction seems to happen because of exhaustion, simulator sickness, issues with usability, and visual isolation. As discussed previously, intensity, novelty, and shortcomings of the VR technology cause many of these issues, which were also recognized by the preceding literature exploring VR learning.

The literature review regarding value in VR did complete its objective of ensuring previous literature related to the goals of this study were thoroughly investigated for formulating comprehensive themes for the empirical section. The themes that emerged from value VR literature review are importance of social aspects, knowledge sharing and cooperation. The interviews will also benefit from the generated understanding of value formation in VR context as the interviewer will be more qualified to inquire about value related aspects of subjects' experiences. Furthermore, the VR value formation literature review as well as VR learning outcomes will enable evaluation of the emerging results and richer discussion regarding the results. Lastly, the value centered VR literature review alone presents fruitful results for the future studies regarding current view of VR value formation and actors.

2.4 Concluding theoretical framework

This chapter concludes the theoretical background section by presenting two main findings that the theoretical background section presents. First, according to the literature review there is several connections between the discussed VR themes affecting learning experience, as well as between the presented themes and the experiential learning, which are presented in figure 6. Second, the previous studies recognized cases where the learning themes affected VR learning experience negatively or positively. There were only few studies where these effects were considered from value creation standpoint, but here all the recognized negative and positive effects are proposed to be plausible occurrences of value co-creation and co-destruction as shown in figure 7.

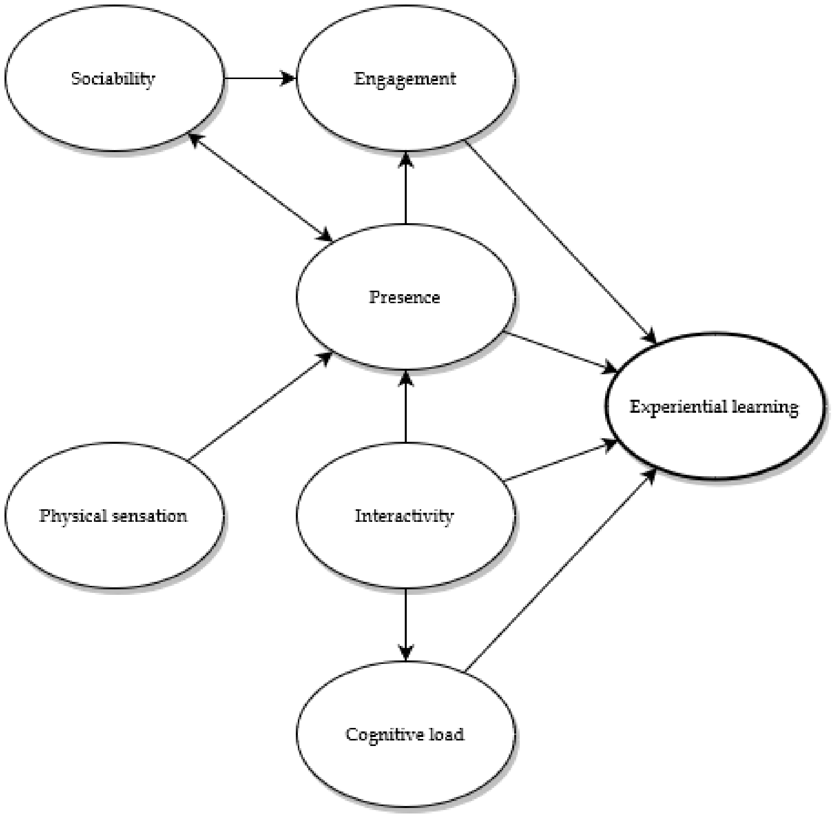

Figure 6 VR learning theme connections leading to experiential learning, combined from the literature review.

The figure 6 presents the recognize important themes for learning as discussed in the previous chapters as well as their relationships in form of arrows which present the direction of effect. According to the previous studies engagement (Madathil, 2017; Rupp et al., 2019; Bodzin et al., 2020; Atsikpasi & Fokides, 2021), presence (Dalgarno & Lee, 2010; Kwon, 2018; Howard-Morris, 2020), interactivity (Kwon, 2018), and cognitive load (Wong et al., 2012; Makransky et al., 2017; Rupp et al., 2019; Albus et al., 2021) were considered to affect experiential learning directly, whereas sociability affected engagement and presence while physical sensation affected mainly presence.

Presence is affected by physical sensation (Kwon 2018), sociability (Pallot et la., 2017; Hudson et al., 2019), and interactivity (Slater, 2018). Presence as well affects sociability because of co-presence (Davis et al., 2009; Dalgarno & Lee, 2010) and engagement (Rupp et al., 2019).

Cognitive load while using VR is partially because of interactivity as the users are focused on interacting with the virtual environment by using the device which is apparent especially in new VR users (Makransky et al., 2017).

Sociability was argued to affect engagement following taxonomy of Fredricks et al. (2004) where behavioral engagement includes social side. Thus, results of Holopainen et al. (2019) study where sociability was shown to increase discussion and participation to VR experience was argued as a possible example of behavioral engagement.

The theoretical framework regarding connections between the central VR learning affecting themes and their relationship to experiential learning is used as basis to explore VR learning. The empirical section will test and further evaluate the connections presented in Figure 6. The goal is to understand relationship between VR platform, user experienced value, and learning outcomes. Thus, the main research goal of this study can be answered. Next, the point of view of value co-creation and co-destruction in VR learning themes discussed previously is considered from theoretical framework point of view.

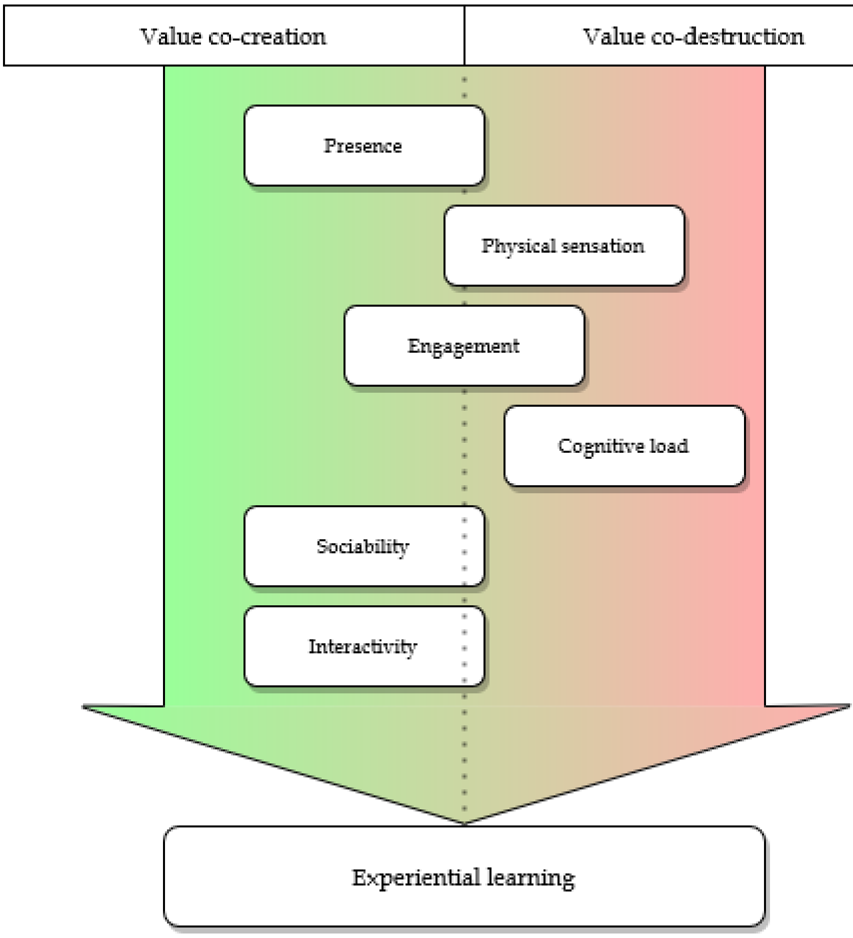

Figure 7 VR learning themes weighted according to potential value co-creation and co-destruction, combined from the literature review.

Both the negative and the positive effects relating to each individual VR learning theme are often not considered by previous studies. Presence is mostly recognized having positive effects on learning such as better understanding spatial features (Dalgarno & Lee, 2010), or making virtual experience a concrete one (Kwon, 2018; Howard-Morris, 2020). Makransky et al. (2019) did present possibility for a negative effect on learning where presence might not contribute to all learning tasks.

Physical sensation is mostly seen having negative effects on learning because of simulator sickness but Kwon (2018) did present that it can have positive effect such as improving sensation of presence by giving physical sensations in VR like in real situations.

Engagement here is presented to have clearly both negative and positive effects. Engagement was found to be result of many different facets relating to individual's interests, goals, and personality (Fredricks et al., 2004; Bodzin et al., 2020). Thus, it is arguable that similar VR features or content can have positive or negative effects on engagement depending on the personal institutions, therefore it can positively or negatively affect experiential learning.

Cognitive load was considered from negative perspective by previous studies (Wong et al., 2012; Markansky et al., 2017; Rupp et al., 2019), thus it is presented in the potential value co-destruction side.

Effects of sociability for VR learning experience were heavily weighted on positive side. The previous studies did show co-presence (Davis et al., 2009) and forming mutual understanding (Holopainen et al., 2019; Mei et al., 2021) to be the main contributors to this during VR use in virtual and real spaces. Learning from collaboration or improved interaction have also been major point of VR value co-creation literature as discussed in chapter 2.3.3. Only case of negative effects from sociability was reduced interaction between HMD user and people in the real space, which would then reduce learning potential (Brown et al., 2016).

Interactivity as presented in Figure 7 is also seen by previous studies as something positively affecting learning experience. Interactivity regarded interacting with virtual environment using the VR features such as 3 or 6 degrees of freedom and some type of controllers. Only case of negative learning effects from interactivity was suggested because could cause cognitive load in specific case when the user is not comfortable with using VR (Makransky et al., 2017).

Possibility for value co-creation and co-destruction occurrences and their effects on experiential learning experience is thus proposed by the theoretical background of this study. The empirical section aims to further evaluate the possible value co-creation and co-destruction in VR learning use and their true relationship with experiential learning.

This chapter concluded the theoretical background section of this study by presenting theoretical framework in form of connections between VR learning themes and their connections to experiential learning (Figure 6) as well as preliminary evaluation of value co-creation and co-destruction that contributes to the prevalent VR learning themes as is present in the literature reviewed for this study. The recognized themes and their nuances form basis for the interviews, which are discussed in the following chapters regarding data collection and analysis. The empirical section will test and evaluate the proposed theoretical frameworks.

3 DATA COLLECTION AND DATA ANALYSIS

The goal of the empirical part of this study is test the theoretical framework formed in the previous chapters. This chapter describes the methods as well as reasoning for the empirical methodology choices. Overall, the design of the empirical study follows qualitative research methodology, where one-on-one interviews with the recruited participants were completed and themes emerging from theoretical background were used as basis the interviews. The interviews were completed after the participants had tested a VR solution. Data from the interviews was then analyzed using thematic content analysis method (Anderson, 2007).

The empirical section forms from methodology and implementation chapters. Firstly, the chosen methods for this study are discussed in detail which are focused interview method (Hirsijärvi & Hurme, 2008), and thematic content analysis (Anderson, 2007). Secondly, the empirical section focuses on the implementation of these methods for the data collection and analysis. Detailed description of recruitment of the participants, from it emerging discretionary sample, VR testing event, as well as implementation of the analysis method and the choices made during it are presented and justified.

3.1 Empirical study methods

The following subchapters go in depth about the methods used for empirical section of this study. First the choice of qualitative methods is briefly explained, then thorough description of focused interview method, its choice and chosen themes is presented. Finally thematic content analysis method is explained as well as its reasoning for the use of this study.

3.1.1 Qualitative research

Since the focus of this study is on personal value co-creation and co-destruction as well as the nature of the study is rather explorative, qualitative methods were chosen for this study. Qualitative methods focus on descriptive data such as observations or interviews (Myers, 1997). This study takes advantage of semi-structured focused interviews to collect data, which is further discussed in the following chapter.

The intention of qualitative research is to allow the participants perspectives on subjective meanings, actions they take, and their context to form the basis for results of the study (Myers, 1997; Fossey et al., 2002). This means that for this study it is important that the perspectives of the participants are represented as true to their meaning and context as possible. This is important for data analysis, as it should aim to objectively form generalizations from the data without interpretation of the researcher affecting the results.

3.1.2 Focused interview method

The focused interview (teemahaastattelu) method was chosen for this study because its semi-structured form allows freedom for the interviewee's own notions to surface during the interviews and guide the interview to things that are important for the interviewee. This means that the interview does not follow strict set of questions but rather follows several themes that are discussed with each participant (Hirsijärvi & Hurme (2008). According to Saaranen-Kauppinen and Puusniekka (2006) focused interview method is especially useful for understanding less known phenomena because it allows important points from interviewee's perspective to surface during the interview, which is especially fitting for this study. The focused interview method following the pre-established themes rather than strict set of questions, allows it to explore the VR phenomenon from different perspectives than the one beforehand established by the researcher (Hirsijärvi & Hurme, 2008). Therefore, this method should have the potential to expose interesting aspects of the VR value creation and furthermore it's benefits and hinderances to a user's learning processes. To plan and guide the interview, an interview framework was created as suggested in Hirsijärvi & Hurme (2008) method literature. The framework included formalities, background questions, themes, opening questions, and themed questions (See appendix 1: Interview framework).

The focused interview method is especially fitting for this study firstly because the understanding of VR's learning effects based on empirical studies is still lacking (Atsikpasi & Fokides, 2021). Secondly, the literature review conducted for this study found that there is extremely scarce scientific background regarding the user value perspective in context of VR. Forming strong hypotheses based on the previous literature could limit the discovery of possible new value processes. Therefore, the semi-structured interview method was expected to give less researcher biased results compared to more structured interview models because it promotes open discussion under the set themes. The focused interview is also an effective method for understanding user value formation because it allows important themes for the interviewee to be discussed in depth, therefore value perspective can be explored where relevant. On the other-hand, due to the unexpectedly low number of voluntary participants it was preferred to use focused interviews to ensure the collected data would be richer, thus representing the discretionary sample better.

Semi-structured interview methods which promote open discussion are especially dependent on the skill of the interviewer. Hirsijärvi and Hurme (2008) emphasize that the focused interview method takes into account and focuses on the different interpretations and meanings which people have on a phenomenon. Also, they note that these meanings form in interplay between the interviewer and the interviewee. Hence the interviewer should be well prepared, knowledgeable about the subject, but still neutral while encouraging an open attitude (Hirsijärvi & Hurme, 2008). To prepare for the interviews, thorough research on the previous literature and themes surrounding the subject was completed (see theoretical background chapter). This included a literature review and general in-depth orientation in aspects of VR, VR's educational uses, and value creation. This ensured that the interviewer was knowledgeable about the subject. Furthermore, two test interviews were completed before the data gathering. Thest interviews were suggested important by Hirsijärvi and Hurme (2008). The test interviews resulted in a few changes in the language and the content of the opening questions. During the data gathering it was noticed that it would have been beneficial to complete more test interviews, because after several first interviews the interviewer was more able to inquire about the interviewee's thoughts on the subject matter. It is not expected that this had significant effect on the data collected from the first interviews, but it is worth to note the recognized importance of the test interviews to not only test the framework but also to train the interviewer. According to the experiences from this study, it would be suggested to have at least four test interviews. It was also clear that the willigness to share personal ideas did heavily depend on the interviewee's attitude, institutions, and how they perceived the interviewer as even if the interviewer's demeanor did not change over the course of the data gathering.

The focused interview method is not without challenges. Firstly, Hirsijärvi and Hurme (2008) highlight that depending on the person, language has different meanings. For this study, the test interviews, background questions, and opening questions were used to establish baseline on the technical level of the interviewee as well as used to ensure the language used during the interviews was understood in the intended manner. Also, if there were misunderstandings the interviewer did adjust the question fittingly. Secondly, in semi-structured interview methods challenge is that interviewees answers extend beyond what is the study's subject (Hirsijärvi & Hurme, 2008). If this is the case, the interviewer should be able to courteously guide the interview towards the subject or break off from the subject transcending direction. Thirdly, Hirsijärvi and Hurme (2008) note that it is easy to discuss phenomena at its surface level, but the intention of the focused interview would rather be to get to the most essential points. To try and overcome this challenge, the interviewer would have to inquire further towards personal level of the interviewee which can cause defensive reactions from the interviewee. A polite, interested, but neutral demeanor should improve the interviewee's openness but also the interviewer should be inquisitive enough to ask more when necessary. The in-depth review of the theoretical background did also assist with understanding when the discussion is at the surface level and when the personal values were reached.

The focused interview themes were chosen according to the findings of the literature review and the synthesis conducted for this master's thesis as suggested by the focused interview method literature (Hirsijärvi and Hurme, 2008). Hirsijärvi and Hurme (2008) suggest that the focused interview themes are chosen to represent the important themes recognized from the previous literature that seem to be significant for the subject of the study. Thus, the chosen themes guide the direction of the interview towards the recognized subjects without restricting the conversation too heavily. Hirsijärvi and Hurme (2008) urge to present easy opening questions for each theme that are open and promote initial discussion, this should help discussion and make the interviewee feel like they can answer the following questions as well. The added questions were found to be helpful during two test interviews that were conducted, as well as during the main interviews because the VR subject was very new for most of the participants. The added questions also helped to diversify the discussion and indulge in areas recognized during construction of the theoretical background. The opening questions are presented in the appendix 1.

The interview themes were formed from the themes emerging from previous scientific literature as presented in the theoretical background chapter of this study. The goal of this study is to explore how VR affects learning using value co-creation and co-destruction perspective. Thus, the themes of focused interviews follow the VR learning themes as shown in the theoretical framework of this study (Figure 6 and Figure 7). The empirical section aims to test and evaluate the theoretical framework of this study. The main emerging VR experiential learning affecting themes were summarized in the chapter 2.4 and their content was adapted to focused interview themes: (1) using the device, (2) focus and application content, (3) immersion and freedom, (4) experiential learning, and (5) communication and sociability. Appendix 1 shows the assisting questions contained by these interview themes. Next, the content of the themes and their connection to the theoretical background is presented.

The first theme regards the effects of VR characteristics to user's well-being, usability, safety, and interests. The first theme also explores motivations and general feelings towards VR. This was chosen because of apparent impact of usability recognized in chapters regarding cognitive load (chapter 2.2.4), experiential learning (chapter 2.2.7) and VR value formation (chapter 2.3.3). Safety and well-being was recognized important in value formation chapter as a generic benefit of VR training where the user does not need to get into a dangerous situation to train. VR's effects on well-being were especially prevalent because of possible simulator sickness presented in the chapter 2.2.5. Interests were considered important to discuss to understand motivations and initial feelings as well as institutions towards VR. These were found important because of the chapters regarding presence (chapters 2.1.2 and 2.2.1), engagement and emotions (chapter 2.2.6), and value (chapter 2.3).

The second theme « focus and application content » considers effects of VR taking over user's visual sense and its effect on the user's focus on the content and possible issues that this brings aside from the previously explored safety issues. The previous studies also suggested that the takeover of visual and auditory senses could negatively affect the learning experience (VR value formation, chapter 2.3.3). With the focus subject, it was also relevant to discuss the effect of VR to the participants interest in learning about the subject itself. Previous literature presents the novelty of VR a possible cause for increased interest in learning about subjects, hence improving the learning process (engagement and emotions, chapter 2.2.6).

The third theme « immersion and freedom » emerged mainly from the immersive characteristic of VR (chapter 2.1.1, 2.1.2, and 2.2.1). Freedom is considered to increase immersion as well as allow the VR users to choose more about how they want to learn. Immersion and freedom are also key features that are considered to improve sensation of flow in VR by Kye and Kim (2008) and Bodzin et al. (2020) as explored in chapter 2.2.2. Thus, the effects of immersion and freedom experienced by the participants are important for the goal of this study.

The fourth theme is closely related to the theme of learning, especially from the experiential learning point of view. The experiential learning has been major interest in research exploring educational use of VR as presented in the chapter 2.2.7. The experiential learning theme inquires the participant about experiencing, reflecting, generalizing, and applying what they have learned from the VR experience. This approach follows the Kolb's (1984) experiential learning model's facets. In addition to this, the usability of the system or frustration experienced because of it could be because the VR platform does not enable experiential learning effectively. Also, it is of great interest how the participants would perceive the benefits and hinderances of VR for their own learning use and how they feel about using VR in learning. This was found to be important because in chapter 2.2.1 regarding VR use cases in learning, it was found that VR does not seem to benefit all learning tasks, hence the personal value perspective of the interviewees could provide insight into what affects the usefulness of VR.

The fifth and final theme « communication and sociability » was chosen because the literature review conducted for this study revealed that major reason for value co-creation is because of improved communication and cooperation enabled by the VR as explored in chapters 2.2.3, 2.3.2, and 2.3.3. The sociability also explores the interaction between actors where presence of other people might cause discomfort or encourage sharing information which also could hinder or benefit the learning in various of ways. Effects of sociability as seen by the previous studies were explored in chapters regarding social learning (chapter 2.2.3) and value in VR context (chapter 2.3.3).

3.1.3 Thematic content analysis method

Thematic content analysis (laadullinen sisältöanalyysi) is a descriptive presentation of qualitative data such as interview transcriptions (Anderson, 2007). The intention of this data analysis method is to bring out the information that the interviewees were relaying. Anderson (2007) emphasizes that the TCA method distills and groups data to recognize common themes from the individual interviews. She also states that the themes formed in this manner, or in other words coded in this manner, should be named according to the wordings used in the data, as well as grouped so that the theme reflects well the whole text.

Important for this type of qualitative data analysis method is that the researcher has to be able to detach their own feelings and thoughts from what the themes are or what the themes may signify (Anderson, 2007). Because of this study being master's thesis with single person completing background research, design of the interview framework, and data analysis, it is extremely important and rather challenging to remain neutral about what the transcribed interview data presents. As an attempt to ensure better objectivity, after the transcription process which was done mostly during the interviews a distancing from the data was done lasting two weeks. After this the first coding process was completed followed by another few days long distancing from the data as per suggested by Anderson (2007). The shorter distancing from data was completed few times between coding sessions to ensure the themes that arose from the data were as unambiguous as possible. The intention here was to be as objective as possible about what the actual data was saying and to ensure the formed themes were loyal to the data, rather than go into it with biases or form themes and groups according to only the first evaluation. The process is discussed more in detail with the following implementation chapter.

Thematic content analysis was done using text manipulation program Microsoft Word. This choice was done because of familiarity with the program and confidence that using Microsoft Word would reach the same level of fidelity in the case of the data set used for this study because it was manageable size of 23743 words. Also, the important tool functions for the TCA method are highlighting information, copying, and pasting which Microsoft Word supports. These functions are required for arranging information into groups and themes.

For the goals of this study, TCA method has several advantages. Firstly, the data can be interpreted as it is. This means that even though the themes of the data are based on previous literature, the data is analyzed for meanings and themes without relying on previous assumptions. As Anderson (2007) describes, the epistemological stance of the researcher is objective. Therefore, for the goals of this study, TCA is excellent for discovering new views or truths according to how the data presents them. Secondly, as discovered during the background research for this study, the previous studies regarding value formation in VR are scarce and do not explore learning. The scientific background is rich in VR learning context, but the value processes seem to be largely undiscovered, hence making heavy assumptions before the data analysis could have hindered the discovery and objectivity of this research. In addition to this, after the TCA is completed the S-D logic can be used as a lens to evaluate and further assess the results.

3.2 Empirical study implementation

This chapter presents the implementation of empirical study. First, the recruitment, choice of participants, and emerging discretionary sample is discussed. Second, the VR solution testing event as well as the content of VR solution is presented. Third, the TCA implementation is described as it was used to form data presented in the following findings section.

3.2.1 Recruitment of participants

To facilitate the recruitment of the participants a local educational consortium Gradia was chosen because of the large pool of possible participants it would have from the desired active student background. The local educational consortium overall has around twenty-one thousand students in a variety of upper secondary schools, and vocational institutions. Therefore, a research permit was applied for. Research permit required application form and research plan. As an addition to the required documents, information privacy statement and informed consent document was presented with the application.

Once the research permit was granted, the recruitment for participants started. In collaboration with Gradia's Director of Development, a plan to recruit participants by email was formed. The invitation to participate in the research was sent only to students of the final year of their upper secondary level studies by email. The intention was to recruit students who were adults or near adults, having interest towards either the field or VR, and of the similar VR use background. Invitation gave overview of the study, what type of VR solution they would be able to test, and presented a link to a short contact form they would need to fill to participate. In the contact form information privacy statement and informed consent document were available for download.

Despite the vast number of students receiving the invitation to join the study, the number of students interested in participating in the research was only four. Thus, the target group of the invitation was extended to all adult students of the educational consortium. This did open up the background of the participants to more variety than only upper secondary school, but in the same time it did bring more participants as well as possibility of new point of views on the subject matter that would have otherwise been left uncovered by this study. This still ensured the participants would be studying actively, as well as hold the interest towards either the field or VR. Furthermore, the number of participants increased to eight which was desirable increase, although it is worth to mention that it is lower than what was expected. Due to the timeframe of this study, it was not feasible to recruit participants from another educational consortium. Despite the lower number of participants that was expected, the saturation of the data collection was adequate. This conclusion was reached because in the format of this study, the latter interviews resulted in similar findings as earlier. Although, it should be noted that increasing the number of interviews could have resulted in further new findings.

Hirsijärvi and Hurme (2008) emphasize that with the focused interview method the participants form a discretionary sample, rather than a random sample. The intention here is to understand a specific phenomenon, in this case VR value creation in experiential learning context. Therefore, the background of the participants being active students was seen as an especially important stipulation to participation as they would have an educational perspective from a learner's standpoint.

The initial restriction of the invitation being sent only to the students in final year of upper secondary school was done with intention of ensuring the content of the VR application would be fitting for the age. The age of the participants and similar background also improved the planning for the interviews for the language and content of the questions, as well as the context.

The most importantly, the setup of the VR testing session into an interview ensured each participant of the study would have exactly same VR experience. Although some of the participants had some slight previous experiences with VR, the main VR experience each had was obtained in controlled manner during this study. The previous VR experiences of the participants were taken into account during the interviews. It was expected to allow comparisons between the experiences and discussion about possibilities of VR for learning that were not present in the tested VR application, hence enriching the data.

Table 5 presents the demographic information of the participants which for this study were age, gender, and education in the form of the highest or current degree they were studying. Also, their previous experiences with VR solutions were collected including type of the solution, use case, and time spent with them previously. The identifier for each participant which is used from now on is also present in the table 5.

id	Gender	Age	Education	Previous VR use experience
P1	Male	47	Tertiary	One-time: Video game
P2	Female	18	Upper secondary	One-time: Video game
P3	Female	18	Upper secondary	Two-time: Video games
P4	Other	19	Upper secondary	One-time: Google cardboard
P5	Male	19	Upper secondary	One-time: Video game
P6	Female	29	Vocational edu.	None
P7	Female	18	Upper secondary	None
P8	Male	19	Upper secondary	Few times: Video games

Table 2 Participant demographics and previous VR experiences.

All the participants were recruited through the local education consortium. 75 percent of the participants were upper secondary students while 25 percent were from adult education side of the consortium. This does diversify the discretionary sample which could be seen as a benefit and disadvantage. The benefit of this is that the focused interview data includes slightly better demographic background variety, while disadvantage is lesser consistency.

The average age of the participants was 23 years and median 20 years old. The difference between average and median age is because of relatively small sample and one large divergence in age.

Genders in the discretionary sample were representative of all genders (Figure 7). Four of the participants identified as female, three as male, and one as other.

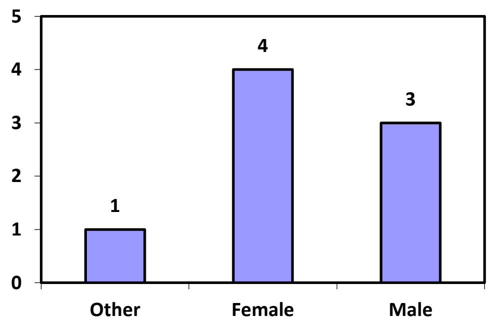

Figure 8 Participant genders.

3.2.2 VR solution testing

To facilitate the VR solution testing, each participant was contacted individually and a time fitting for them were arranged. Then private spaces according to participants' availability were reserved in Gradia's facilities by contacting the Gradia's Director of Development. This resulted in four separate days for the testing events. The epidemic restrictions were still in place during the VR solution testing which affected the testing events. The safety of the participants was considered by spacing the VR testing, cleaning the headset between tests, and distancing appropriately. Because of the epidemic restrictions, the interviews were better arranged for separate dates as discussed further in the next chapter.

The VR testing events lasted approximately thirty minutes per participant. Firstly, the participant was given brief introductions on how to use the device and the application they would be testing. This ensured that the participant would be prepared to focus on the use of the VR solution and the contents of the application, instead of needing to ask for instructions during the testing. Next, the participant did complete the VR application and finally a brief first impressions discussion was had with the participant about their immediate experience, well-being during the VR experience, and how it felt to use the device. Finally, a date, time and application was settled for the interview. Each participant did go through this process.

Time spent by each participant in VR was twenty to twenty-five minutes. The difference in time spent in VR was due to varied amount of interaction each participant had with the application. Exploring all optional routes in the application or taking their time with choosing options increased their time spent with the VR solution. All the participants completed the VR experience.

The VR application which was used during this study was provided by Metso Outotec. The application is a part of « Social innovation for sustainable treatment of European metals » project in which a copper refining process of Metso Outotec's corporate partner Atlantic Copper S.L.U is presented. The goal of the application is to educate and inspire students by enabling a virtual visit into a copper processing facility and explaining key steps in the process. The application is a tour from inside the facility moving automatically from one step of the copper refining process to next with a 360-degree video recorded from inside the factory. At each step users can choose to view informative short video about the step of the process they are currently viewing. The videos detail the process, product, by-products, and how any waste is recycled. In the end of the VR tour, the users are presented with four multiple choice questions about the contents of the VR tour they just experienced, including immediate feedback on how they perform in the questionnaire, and which would have been the correct answer.

The VR device used for the testing was Oculus Quest 2, which at the time of writing this study rebranded to Meta Quest 2. At the time of writing, Oculus Quest 2 is the most popular VR HMD solution in personal computer video games by large margin, taking fourty-six percent of user share of a popular video game platform Steam by Valve Corporation (Statista.com, 2022). Advantages of this device for the VR testing were no need for computer connection, wires or outside tracking devices, as well as good tracking and video quality, enabling highly immersive experience in extremely mobile form factor. Especially interesting was that for this application there were no need for physical handheld controllers because of Oculus Quest 2's hand tracking feature which enabled users to control the application with their bare hands and see accurate digital representation of them in the VR application.

3.2.3 The focused interviews implementation

The in-depth focused interviews were conducted one-on-one with the participants by use of remote conference software Microsoft Teams or Zoom, according to the preferences of interviewee. It would have been preferred to complete the interviews directly after the VR testing so that the feelings and impressions would have been still fresh, but it was not feasible because of the circumstances. Despite this, the remote interview option was mainly chosen because of three reasons. Firstly, during the completion of this study epidemic restrictions were still in place, meaning it was safer for the participants to complete the interviews remotely. Secondly, the VR testing premises were facilitated by an education organization Gradia and only limited amount of time was available for the facilities. Thirdly, the participants being able to attend to the interview from comfortable environment of their own choice without the interviewer entering their private premises should also reduce stress of the interview situation. To alleviate the increased time between VR testing and the interview, the first impressions were collected during the VR testing event.

The interview process was completed using the interview framework. The interviews were one-on-one session with expected duration of 30 to 60 minutes.

The interviews started by ensuring both parties were able to hear each other clearly and then proceeded with small talk and formalities to ensure that there was relaxed, open, but still professional atmosphere. The participants were told that there are no right or wrong answers, and their perspectives, attitudes and feelings towards the discussed themes would be most interesting for the goals of this study. The interviews were recorded with permission of the participant. All but one interview were completed in Finnish and the final one was, as per request of the participant, completed in English.

The focused interview section did always start with same or similar opening questions and proceeded according to the answers of the interviewee to follow-up questions. The interviewer used understanding of value formation, VR, and VR learning as established by the theoretical background of this study to inquire about points that the participant did bring forth. This was done using neutral terms and without pushing the discussion towards a direction that the participant did not initiate. What guided the interview was interviewees' own notions as well as the established themes and opening questions.

The focused interviews done in this study did draw some practice from laddering interview method (Reynolds & Gutman, 1988) where forming chains from the attributes of a system to user values is key. The interviewer often inquired why the participant did find a VR feature beneficial or hindering, or why the benefit or the hinderance was especially important for the participant. This line of inquires also went to other direction where reasoning for experienced value was inquired. This would make the interview data more beneficial for the goals of this study.

Finally, the participant was asked if they had some of their own themes that were not discussed yet regarding their VR experience or if they wanted to highlight something specific about their experience which was already discussed. This was done to ensure that anything crucial to the experience of the participants in their own opinion was not left unnoticed.

3.2.4 Thematic content analysis implementation

The TCA was used to analyze transcripts resulting from the focused interviews. The transcriptions resulted in a data set containing total of 23743 words, where seven interview transcripts were in Finnish and one in English. Each transcript was written into its own document and was a word for word accurate to the interview recordings.

The data analysis for this study was done following Anderson's (2007) description of the steps to take for TCA. The stages one to nine were completed for each individual interview transcription. The stages are as follows: (1) The interview transcriptions and post VR testing notes were made multiple copies of to ensure that any manipulation to the texts can be traced back if needed. (2) All relevant data was marked as stated by this chapter to include the focused interview transcriptions for all themes discussed, mainly on the interviewees' side. (3) Changes of meanings were marked into separate units from all the highlighted data. In this stage, it was ensured that the units were long enough to include all the relevant data for their meanings so the relevant information will not be disconnected from the source (Anderson, 2007). (4) Similar units were then combined into a separate Word document and coded « interview number-page », for example 7-5 would mean interview number 7, page 5. (5) Each Word document containing initial categories were labeled by keywords or phrases which were found in the transcription data. This was done to best describe the meanings by which they were combined into the document. (6) If any obvious information missing from the texts was noticed, then categories for such were identified. (7) After the initial thematic grouping, the transcripts were then re-read thoroughly, units identified again, grouping redone, additional categories added or removed where needed, as well as the theme labels reconsidered. Intention here was to ensure that the emerging categories follow the data and to avoid researchers own interpretation as much as possible. (8) After the transcription units were grouped into separate Word documents, the focus shifted to the categories and the units contained in them. At this stage, units were redistributed as needed and category labels reconsidered. (9) Two-day distancing from the analysis was taken after which the first pass on the units, categories, and their sizes were reconsidered. (10) Once all interview transcripts were separately analyzed, the resulting categories were combined where appropriate, and again considered for re-labeling. Anderson (2007) states that it is better to have too many categories and retain labels that are accurate to the transcripts, which was followed for this process. (11) Finally, another distancing from the TCA process was taken and the categories reconsidered again to ensure they make overall sense of the interviews. The categories formed in the TCA method are the emerging central themes regarding personal and subjective views on the conceptualization of the benefits and hinderances regarding VR learning, which were the goals of this study.

Next the reasonings behind the thematic coding is described. The goal of this study is to understand from value perspective how VR affects learning. Therefore, it was important to recognize from the previous studies the themes important for VR learning and their relationships, which guided the focused interviews. The interview transcripts were first examined to recognize important themes of discussion emerging from the original themes, these formed the main categories. Because of the objective approach from the value perspective, not all of the categories were directly related to learning benefits or hinderances, but rather to the experience as a whole. After the thematic coding the initial five focused interview themes did expand into twenty recognized categories regarding common themes in the transcript data such as institutions, real world disassociation, interactivity, ease of use and more. These categories also included learning effects recognized in the literature review of the study: presence, flow, social, cognitive load, physical sensation, engagement, emotions, and experiential learning related themes. Each of these categories were individually divided further to contain subcategories regarding nuances, and negative and positive value outcomes. This approach did mean that in some cases one statement from a participant did appear in several categories. For example, « It felt like I was really in a high place (**presence**), like I was about to fall and lose balance (**simulator**

sickness), but I knew I was actually safe so it was mostly exciting (**emotion**). », would appear in categories considering presence, simulator sickness, and emotions.

The thematic coding was done in this manner for three reasons: Firstly, to see if the emerging themes corresponded to the VR learning themes and related characteristics recognized in the theoretical background section. This would be expected because the focused interview themes were based on the previous literature. Secondly, to understand the value formation within these learning affordances. And thirdly, the approach to have statements appear in multiple categories where applicable allows examining connections between different features, VR learning themes, and then on the value formation process such as hedonic values emerging from immersive VR's characteristics. This approach allows forming generalizations and relations from the data, and thus the observations are based on the data.

4 FINDINGS

This chapter presents the findings emerging from the TCA. First, the participant backgrounds and interviews are briefly discussed. Second, value co-creation and co-destruction in VR learning is presented. Third, the findings regarding experiential learning are presented.

4.1 Participant backgrounds and interviews

As stated previously, the most important for this study was the similarity of the previous VR experiences. The participants all had either no previous VR experience or very little. Mainly previous experiences were testing VR video games in conventions, school or at leisure. The time spent with VR solutions were uniformly under an hour and in all but one case (P8) less than fifteen minutes. Two of the participants recognized that they were more informed about VR without having experienced it themselves, because it was something they were following on social media at their leisure. Furthermore, for all participants the main VR experience was induced by the VR testing event conducted as part of this study.

The background questions also included previous knowledge about the metal refining process depicted in the VR experience. Overall, participants had little to no previous knowledge about the VR experience's content. One participant (P4) recognized previous knowledge about other types of factory manufacturing settings, which gave them abstract understanding of the depicted metal refining process. Three participants (P5, P7 & P8) stated having slight high-level knowledge, because of chemistry and physics education.

Duration of the focused interviews averaged 38 minutes and 55 seconds per interview while median focused interview duration was 37 minutes and 4 seconds. Duration of the interviews is shown in table 3 below.

id	Interview duration
P1	26 min 21 sec

P2	32 min 35 sec
P3	31 min 06 sec
P4	40 min 42 sec
P5	62 min 30 sec
P6	35 min 41 sec
P7	47 min 00 sec
P8	35 min 21 sec

Table 3 Duration of the focused interviews.

4.2 Value co-creation and co-destruction in VR learning

The focused interview recordings once transcribed resulted in eight transcription Word documents forming data set including 23743 words. These transcriptions were then coded according to the TCA method and thematic coding procedures as presented in chapters 3.1.3 and 3.2.4 resulted in total of twenty main categories, each containing subcategories for nuances and value outcomes. Some of the categories are much more saturated than others. For example, category regarding sociability contains four value co-creation aspects and three value co-destruction aspects with other nuances, while category regarding cognitive load only contains one recognized value co-creation aspect and two co-destruction aspects. Emerging themes were categorized as presented in table 4.

	Theme		Theme
1	Institutions	11	VR vs traditional learning
2	Visual isolation	12	Sociability
3	Presence	13	Spatial information
4	Safety	14	Personal values
5	Software	15	Flow
6	Information	16	Concrete experience
7	Physical sensation	17	Ease of use
8	Interactivity	18	Applying concepts
9	Emotions	19	Freedom of movement
10	Communication between actors	20	Cognitive load

Table 4 Themes emerging from thematic content analysis.

The themes emerging from the TCA did concern participants previous institutions, learning effects, and VR experience. The focused interview themes were likely to emerge because the questions were designed to focus on the aspects recognized in the theoretical background, which were presence, physical sensation, interactivity, emotions, communication between actors, sociability, spatial information, personal values, flow, concrete experience, applying concepts, and cognitive load. In addition to these, participants institutions emerged from the background questions and the questions regarding previous experiences and interests. Visual isolation was part of several other themes (presence, safety, emotions, sociability, concrete experience, and cognitive load) so it was highlighted as its own theme as well although its contents were a part of the other themes. Freedom of movement was closely related to theme interactivity in the theoretical background, but interactivity emerged as interacting with virtual objects and virtual environment while freedom of movement had participant desires to move around and explore. Still, these both are considered occurrences of interactivity for consistency because both require the user to interact with the VR platform.

The themes without an exception seem to have blurred lines or connections between multiple other themes. For example, themes such as safety, emotions, information, presence, and interactivity attempt to generalize subjective experiences as they emerge from the statements of the participants. The use of subcategories and including the participant statements from which the themes and subcategories emerged ensured that there were no over generalization, and connections between the themes were preserved for analysis in the following chapters.

Although twenty themes were recognized using TCA method, it was recognized that institutions, safety, software, emotions, VR vs traditional learning, flow, ease of use, and freedom of movement would not be included as separate chapters. This was done because the content of these themes was already represented by the included VR learning themes, or the findings of these themes were fully focused on VR experience rather than regarded learning. Despite this, the contribution of all emerging themes to this study's results were considered thoroughly, resulting in rich value co-creation and co-destruction findings regarding experiential learning in VR context as presented in next chapters.

This study discusses of value co-creation and co-destruction constructs, because as presented in the following findings, they contain perceived user value, relation to VR platform or source, and relation to learning themes. Therefore, the term value construct is used.

Tables in the following chapters present value co-creation and co-destruction constructs that were recognized for each main theme emerging from the focused interview data. Example of the used table formatting is presented in table 5. The percentage presented with the value co-creation and co-destruction titles summarizes frequency for the experienced VR learning theme out of the discretionary sample which participants formed. Thus, 100% frequency would state that all the participants experienced some of the value co-creation in the category. The number associated with each individual value construct is the number of participants that experienced the specific value construct, thus eight would be all participants.

Value co-creation	100%	Value co-destruction	25%
Positive value 1	8	Negative value 1	2
Positive value 2	8	Negative value 2	2

Table 5 Example value co-creation and co-destruction table.

The main contributors recognized in this study to user's VR learning experience were engagement, sociability, spatial information, physical sensation, interactivity, cognitive load, and presence as presented in table 6. The table presents number of value co-creation constructs (VCC), number of value co-destruction constructs (VCD) and frequency which is the percentage of the participants that experienced the value constructs in that category.

VR learning contributor	VCC (n)	frequency (%)	VCD (n)	frequency(%)
Engagement	16	100.0	5	75.0
Sociability	4	62.5	4	62.5
Spatial information	4	87.5	1	25.0
Physical sensation	1	37.5	3	50.0
Interactivity	5	100.0	3	50.0
Cognitive load	1	25.0	2	62.5
Presence	6	87.5	6	62.5

Table 6 Value co-creation and co-destruction constructs by theme.

These main contributors had a total of 37 value co-creation constructs and 24 value co-destruction constructs. Where the highest number of different value co-creation constructs was recognized for engagement (16). The highest value co-creation frequency of experience was for engagement (100%) and interactivity (100%) where all participants experienced some value constructs in these categories. The highest number of value co-destructions constructs was found in presence category, but the highest value co-destruction experience frequency was in engagement (75%).

4.2.1 Engagement value constructs

Engagement according to the data of this study is affected by a combination of emotional values, social values, cognitive values, and personal institutions which affect interpretation of the VR experience. This was present as co-creation and co-destruction of value in various value constructs (Table 7). Because of the variety of recognized engagement value constructs, it was natural to follow the classification presented by Fredricks et al. (2004), where emotional, behavioral, and cognitive sides build into engagement. The benefit is presentation of different value facets of engagement in uniform manner and enabling comparison to the theoretical background. The emerging value constructs which were not representative of Fredricks et al. (2004) engagement taxonomy are separately presented. Depending on the emerging value constructs of engagement, the construct did either emerge from the learning experience or VR experience, which then on forms the total engagement value of the VR learning experience as perceived by the user.

Value co-creation	100.0%	Value co-destruction	75.0%
Emotional engagement:		**Emotional engagement costs of VR:**	
Interest	5	Annoyance	4
Fun	2	Forced experience	1

Excitement	3	Fear of falling	3
Impressed by technology	1		
Attainment value	1		
Improve work life	2		
Improve well-being	1		
Improve financial decisions	1		
Improve society	2		
Improve personal goals	1		
Environmental values	3		
Improved career planning	2		
Behavioral engagement:		**Behavioral engagement cost of VR:**	
Social interaction	1	Reduced social interaction	1
Cognitive engagement:		**Cognitive engagement cost of VR:**	
Learning is rewarding	4	Tried learning methods less effective	3
VR provides new learning method	2		
Other:		**Other:**	
Intrinsic interest in VR technology	5		

Table 7 Engagement user value constructs.

Emotional engagement value co-creation emerged from combination of interest, attainment, and utility values. **Interest value** is combination of emotions of *interest*, *fun*, *excitement*, and *impress* experienced by the users during VR learning experience.

Interest emotion emerged from interactivity with VR, meaningful information, pacing of the experience, or experience of virtual environment (P1, P2, P4, P5 & P7):

> It was an interesting experience. I rather do it like that [in VR] than from PowerPoint slides. It was more interesting learning experience than following some other's PowerPoint presentation. (P1)

> I mean VR environment like that is always fancy. I mean it is nice to follow it even if the subject isn't interesting. – I mean I guess it was kind of interesting, maybe. But maybe more interesting was being there, on site, and being able to look around and see what is going in in there. (P2)

> Of course it [interactivity] is good, if I could change volume, and how fast it progresses or information that is available. In my opinion it would be good. It helps to customize the experience for different people. -- I want to emphasize that everything begins from my interest, and it is taken into consideration in the experience. Every step of it isn't as important for me, but if I'm interested then I want to learn about the subject. (P4)

> Maybe in subjects which are less motivating for me, like high school mandatory courses, it [VR] would help to internalize those subjects when the interest in the subject

> is not the motivator. It would help to be able to study those subjects in a interesting environment, comparing to gray book and gray class room. – I was really excited to learn about the subject [metal refining] even though it is not initially interesting because I did get to see it all from so close. (P7)

Fun led to engagement. The participants presented features of VR to affect their enjoyment of the VR experience. The features referred to especially give sensation of fun were presence and no need for controllers to control the experience (P2, P7):

> --I had the glasses [HMD], and then I could move and see everywhere and turn around. It was pretty fun! And I didn't know that I could without controller press things, it was pretty fun as well. It was more fun than with controllers, I think. – The high places were fun as well and seeing environment and there were the people, it felt like... Like I was in some place and able to look around. (P2)

Excitement or fear of falling was a pronounced emotion encountering virtual high places or danger. High places and danger divided reactions between negative and positive. In positive cases the sensation of excitement was present, resulting from experienced strong presence that VR platform could induce in its users (P2, P5 & P7). Similar negative value construct resulted in fear of height when the user did not perceive the physical reaction positively (P3, P5 & P8). Interestingly, Participant 5 did perceive the experience positively as well as negatively, while Participant 3 had a negative experience:

> I vividly remember when I was taken high up into the air, I mentioned it before, on one hand it was a little nerve wracking on the other hand it was very interesting feeling. That was one of the highlights. Then other highlights were showing certain processes which have an element of danger to them, I remember specifically when molten mixture was poured into a furnace or taken out of furnace. Obviously, those are things that would be done in a safe manner in a factory but in an uncontrolled context outside of the factory would spark bit of a nerve wracking feeling around to the regular person, being so close to this molten mixture. These are some good highlights I would say. (P5)

> But the implementation [of VR experience] was bad in a sense that it maybe isn't the best idea to put the view seven meters high, so that it gives vertigo. -- But when you moved left or right, or forwards you could see a cage [play space borders] how much you can move in place. It was good because in scenes where there was a railing eight meters high, you could still see the cage, so it reduced vertigo effect, in my opinion. (P3)

Impressing the user did as well enable value co-creation. Participant 5 expressed they were impressed by the VR technology. This caused positive change in preconceptions about VR and caused sensation of increased presence in the virtual environment.

> I think another preconception I had was that I wasn't sure whether it [VR] would be very refined or it would be proof of concept technology with a lot of bugs. – The simple fact that I could see my hands without any joysticks was a good example of how

> refined the technology has become. As of now it is a lot more refined than I remember from other times I have tried it. As far as I remember, as it has been a long time. Yeah, it does seem like a lot more finished product than I initially thought. – It is an impressive technology. Maybe feeling impressed by the level of immersion. Immersion... Yeah, feeling very immersed in this virtual world as is the point of the technology. And that does impress me at least. (P5)

Value co-destruction in the context of interest value was recognized in situations where the VR experience was *annoying*, *forcing*, or causing *fear of falling*. *Annoyance* emerged from HMD's physical properties, where the device over time would feel heavy and cause physical discomfort (P2) or low-resolution cause eye strain (P4), and how limiting the VR solution running on the device was regarding movement in virtual environment or controls (P5):

> After I had used the device for longer, it started to press my forehead. So much so that towards the end it was annoying because it was so heavy. (P2)

> It was a little finnicky to control. The hand controls weren't as responsive that I would have wanted, clicking buttons and so. – I think the experience that I had was too short to develop a hardline opinion about the matter, but I had a feeling that for a longer period of a time it could get quite frustrating – or maybe just slightly annoyed when your actions are not recognized by the software for example, it's a little annoying. (P5)

> I was in a big warehouse with the machinery and there was a long walkway leading from one end to another and I remember specifically wanting to take a stroll along that walkway and obviously the real-world location would not have allowed hundreds of meters of walkway so that can feel a little limiting in terms of simply having a headset and not being able to move around. -- now that I think of it, it could and it in the matter of the fact did spark a bit of annoyance that I couldn't move around freely in terms of stepping, taking actual steps, but at the same time it could spark a bit of curiosity towards different areas, being able to see something but not being able to walk to it. (P5)

Feeling of being *forced* affected VR engagement. According to Participant 8, it came from need to look at certain things to get relevant information and having to watch videos that interrupted the experience:

> It felt a little forcing, when you had to watch certain things to understand what is going on. – Maybe it was those popup windows which did show a video, so you had to watch that before you could proceed. (P8)

Attainment value in learning context would be something where the learner is motivated to do well in a learning task, so it serves their self-schema (Fredricks et al., 2004). Attainment value emerged only in one case where information about questionnaire in the end of the VR experience did motivate a participant to pay more attention to the contents of the VR experience:

> [Interviewer: What did help you to focus on the contents of the VR experience?] Well, I think the questionnaire and the fact that I knew about it beforehand. (P2)

Utility value emerged from the VR experience, stimulating the users mind about how they could utilize what they learned from the experience in their own life to meet personal goals or how they could benefit from the information acquired. This did manifest two separate value co-creation constructs: Utilizing knowledge about VR and utilizing knowledge about the presented content. Engagement from understanding more about VR enabled personal goals such as how one could use VR to improve work (P1 & P6), well-being (P4), financial decisions (P7), society (P3 & P6), personal goals (P7). Utilizing knowledge about the presented content enabled the participants to think about importance of environmentally friendly products (P3), shared environmental values (P3, P6 & P7) and career options (P2 & P6), which led to engagement.

> My interested was sparked in use of VR and its possible benefits. I'm interested in understanding how VR could be used better in supporting business, and could it bring something new into my profession. I don't know, I'm interested to understand better. (P1)

> There is the personal side where I can use this understanding in the future if I'm interested in taking a part in other VR things. I now know how it affects my well-being or do I need to take medication before the experience. (P4)

> Now I know if VR works for me, so I don't get sick or so. It was really good to get to test it for free before I'd buy my own headset. Now I have some background on knowing what I would invest into, and the money would not go wasted. (P7)

> --For example, in healthcare some dangerous situations or what you have to do when a person goes into epileptic shock, even though it is described in a book or shown from video, it is a shock when the situation is in front of you. VR learning could increase potential to act in real life situations. (P3)

> This [VR] could be beneficial for considering some workplaces, if I can see in VR reality the places it can give an idea how it would be. – And I thought about how it would be to build VR environments like that. [Interviewer: What does these thoughts relate to?] I think my career options. (P2)

Behavioral engagement only emerged as a social value co-creation in a single instance. As discussed previously, other social value co-creation and co-destruction constructs emerged in various other contexts. Specifically social engagement was present in a statement by Participant 8, where co-presence in VR with a friend could make it more memorable experience:

> If we could both first see it [VR experience] or share into a screen what friend sees when they are using VR. -- In my opinion it would be even better, like in some scenes friend does something like fools around with their avatar or something else it could create memories. But it could also help with studying the subject. (P8)

Contrarily, as presented with social values in the next subchapter, VR can reduce ability of the user to interact with the people in the same room, because of visual isolation caused by HMD solution, which was expressed by Participant 3. Thus, negatively affecting behavioral engagement.

Cognitive engagement emerged in form of the participants *enjoying learning something new* and it being rewarding as in itself, hence positively affecting engagement (P4, P5, P6 & P7):

> Hmm. Well because I'm not in the industry, it is a bit hard for me to apply this specific set of information in different context but hmm… There is always benefit in learning something new. (P5)

> I think that knowledge is its own gift. It is a bit similar when orienting to things because learning is fun, and learning is its own gift. (P4)

Unlike many of other recognized value constructs, this was solely dependent on user's institutions rather than a product of VR device, application, subject, or situation. Therefore, it should be noted that despite engagement from learning something new clearly affects learning engagement, it is not directly related to VR platform but rather users' personal values.

Secondly, cognitive engagement emerged from *VR providing new learning method*. Here the role of VR is in creating variety from the traditional learning methods and enabling more concrete experience for the user to learn from, focusing on spatial information (P1 & P7):

> I'm much more willing to learn about copper manufacturing, than normally from school desk. It sounds much more boring than getting to see yourself all of it and more in such a semi-realistic manner. (P7)

In other cases, cognitive engagement of a user can be worse off because of the new learning method required for effective knowledge comprehension using VR, thus resulting in value co-destruction in form of *tried learning methods being less effective*. This is represented by Participants 5, 7 and 8, where their tried-and-true learning methods would not be effective in some VR learning cases:

> I think it [preference for learning method] is very very situational and subjective. Because I've studied my whole life with these conventional methods so having a book, so I also went through my high school studies using paper and pen much more than computer. So, I would say, I think that as I am now if I had to choose, I would stick to more conventional ways of learning. (P5)

> Writing by hand is a completely different type of learning because of brain-hand motoric connection, if I have for example do a vocabulary exercise which requires completely different learning style [from VR learning]. And I prefer to write if I study some language's vocabulary. But if it was some game which was in VR world, it would be a different experience and form different neural connections, but somehow, I prefer for it the traditional way. (P7)

> [Interviewer: Then when you prefer those traditional methods over VR?] In subjects like health education or biology, where I need to have more things on paper, so I understand what I'm reading. (P8)

Final engagement value co-creation construct emerging from the collected data of this study is *intrinsic interest in VR technology*, which arises from user's intrinsic interest towards VR technology (P1, P5, P6, P7 & P8). This value construct is separate from interest that rises from VR use, but interest from VR use or acquired information in other means about VR can lead to changes in user's intrinsic interest. Thus, making a VR experience important for the future occurrences of intrinsic interest in VR technology. As Participant 6 and 7 said:

> Use of VR overall in games and otherwise, was interest to me because it is modern and new technology. (P6)

> I've seen a lot of [VR] games and such, and I'd really like to try them out and how real it looks and feels, compared to the real world. (P7)

4.2.2 Sociability value constructs

Sociability values emerge from a variety of social situations and social features. For this study, the tested VR solution did not have social features which were built in but the conducted VR testing, previous experiences with multiplayer video games, and social situations allowed discussion of social sides and in VR and during VR use.

In this study, four distinct value co-creation constructs were recognized and four co-destructive constructs (Table 8). Social value co-creation emerged from enjoyment of sharing experience, learning from sharing and discussing, safety, and utility value. Value co-destruction happen because of social anxiety, social judgment, distraction, and reduced interaction. Overall, social side and its effects on the value constructs depended heavily on participant's social institutions and status they would have with people they would be interacting with.

Value co-creation	62.5%	Value co-destruction	62.5%
Sharing experience:		**Live sociability while using VR:**	
Enjoyment from sharing experience	3	Social anxiety	3
Safety from sociability	1	Social judgment	2
Cooperative learning:		**Cooperative learning:**	
Learning from sharing and discussing	3	Sociability distracts from subject	2
		Using VR reduces real interaction	1
Other:			
Utility value from sociability	1		

Table 8 Sociability value constructs.

Enjoyment from sharing experience regards situations where the participants found interaction with friends or people they are in good terms with entertaining, stimulating, memorable, or fun (P2, P7 & P8).

> It would be fun with a friend if they were besides me in VR world as some funny avatar. So in a way we could share experiences together. (P7)

> If we could both first see it [VR experience] or share into a screen what friend sees when they are using VR. -- In my opinion it would be even better, like in some scenes friend does something like fools around with their avatar or something else it could create memories. But it could also help with studying the subject. (P8)

Learning from sharing and discussing, as said by Participant 8, was also highlighted in the study. Mainly the sharing regarded information to improve knowledge gathering, where one participant would see things the other did not, and afterwards share the knowledge, thus improving learning and socially engaging the participants into a learning experience (P4, P6 & P7).

> Somehow I feel that the experience I experience during VR, is focused on what I see and hear. But on the other hand, it could be that sharing the experience would enhance the experience. Everyone sees the experience differently and someone could have realized something more that I did not pay attention to because I was focused on something else during the video. (P6)

> Of course [VR experience] would have to be so that first I could with a friend focus on listening the speech and then through it discuss with the friend like « aah, I did not know that there was this and that behind it », like about the information we had gathered. (P7)

Alternatively, if the participant is in VR with a trainer or a guide, they could inquire about things they did not understand or wanted more information about (P4).

> Maybe I would ask questions more actively. When you are alone [in VR], when questions come, they come and go. But if there was a guide I could stop [VR experience] and say « hey, I have a question » or « something is unclear to me, could you tell what is going on? – It would be beneficial because learning starts from my own will, so I learn better. (P4)

Safety from sociability emerged from presence of people being in the same physical room where the participant would be using VR. In the case of VR testing sessions which were conducted, there was only single person in the testing room with the participant. Because the VR user is visually isolated from the surroundings, they must rely on the software to warn them if they are about to collide with items or furniture in the physical room. With new technology, from the users' point of view, they might not fully trust the software presentation of the play space so they want confirmation from the people in the room that they are not walking out of the safe area.

> At the start I was maybe like « help, am I going to hit a wall! », but when you [guide] were there, it wasn't too worrying and there was decent amount of space in the meeting room. (P7)

Utility value from sociability emerged from social situation having some intrinsic value that meets the user's future goals or how important the task at hand is for them. This categorization is similar to Fredricks et al. (2004) emotional engagement's utility value since the meaning here aligns well with their taxonomy. As stated by Participant 7, the sociability would enable them to improve their language skills and meet people from around the world. Of course, this could not be demonstrated by the VR solution which was tested for this study, but it was something the participant found especially interesting in social aspects.

> It would want to test more [VR experiences]. Or it would be really nice to try VRChats or similar to meet people around the world and talk with them, because I like to study languages and I could improve language skills with it. (P7)

Social anxiety value construct emerged from three participants (P4, P6 & P7) and in all the cases it was because of the visual isolation that wearing HMD causes. The user is not able to see what is going on in the room, because they are viewing the virtual environment, and thus they feel like they are being observed or watched while they are unable to see:

> Probably it [other people in same room where I'm using VR] would have distracted me. Yeah. I would have felt a little anxiety about the situation then. --- Maybe it is just the fact that there are other people who would see what I'm doing. I'm swinging my arms around while I'm wearing VR device on my head and that is uncomfortable thought. (P4)

> I think maybe that [using VR while other people are in same room] would be a little more stressful for me, maybe. Just because… Yeah, I wouldn't be able to explain, maybe I would feel like I'm being observed or looked at from different angles without me being able to see the observers, maybe that would be a bit stressful, maybe. (P5)

> I have to say that it would make me nervous. You are completely closed into your own world where you are in VR. Maybe that is why I would think that it is embarrassing, when other people are around observing when you are all focused into it. Your own eyes are tied, so you can't use your visual sense to which in your life you are relying on. --- Of course the setting would be different, if there were strangers -- I would feel nervous, but with familiar people it would not matter. (P6)

Social judgment refers to pressure of behaving or appearing in a way that serves person's self-schema. In this study, it emerged from two participants (P2 & P3) where they would not want to act in an embarrassing way or thought about how they would look with the device on in other's eyes. Again, as with the previous value co-destruction occurrence, the emergence of this depended on the setting, where familiarity with the observer or VR activity type would change the outcome:

> It depends a little on what kind of VR it is. If you have to do some odd dance moves and there is some person who you don't dare to act stupidly with then I wouldn't do so big dance moves, but in this case, it did not matter too much. (P2)

Sociability distracts from subject value construct comes from interaction between actors during a VR learning experience, distracting them from learning. Here, it was recognized only as something which happens when both users are in VR, and they are represented by avatars to one another:

> -- like I wouldn't focus on the narrative if I couldn't control it myself. I would just start talking with a friend like « oh look what is there and here is this », and the narrative on the background I wouldn't be able to focus on. (P7)

> Well in the long term, I think it [sharing VR environment with someone] wouldn't have too much of an effect on the experience but in short term there would be a lot of fooling around, obviously depending on the people. (P5)

Using VR reduces interaction emerged from Participant 3, because they considered group learning or social learning as an important part of their learning process and felt like that use of VR reduces the ability to benefit from it:

> Even though in virtual reality seeing things is beneficial, another thing boosting learning is groups and group memory, and some guiding person increasing the learning potential. I mean in theory and group reasoning requiring things would be better to handle in real human contact. (P3)

4.2.3 Spatial information value constructs

The VR platforms allow its users to benefit from provided concrete experience of virtually being in a location. The user is surrounded by the virtual learning environment and can use stereoscopic vision to perceive distances and sizes as they would in real life. HMD solutions enable use of stereoscopic vision and multiple degrees of freedom. Because the users are so used to collecting spatial information by looking around, they can naturally collect the spatial information from VR as its goal is to imitate the real-life stimuli, hence the spatial learning value constructs emerge. The vast amount of experience in collecting spatial information in real world does seem to impact user willingness to put in cognitive effort in collecting information from other sources while using immersive VR. This finding suggests that in VR solutions the preferred method of learning is by collecting spatial information and concrete visual experiences, rather than traditional means if both are present at once. The recognized value constructs relating to spatial information are presented in table 9.

Value co-creation	87.5%	Value co-destruction	25.0%
Remembering locations	6	Reduced focus on other information	2
Remembering objects	5		
Remembering actions	5		
Forming connections	2		

Table 9 Spatial information value constructs.

The spatial information aspects that came especially clear from this study's data analysis were: *Remembering locations* (P2, P3, P4, P6, P7 & P8), *remembering objects* (P2, P3, P4, P5 & P7) and *remembering actions* (P4, P3, P5, P7 & P8). The locations were spaces like factory halls and surrounding environments. The objects were mostly machines and devices. The actions were machines or people doing something in the scene. The value co-creation emerges as use of the VR devices immersive properties enable realistic representation of the surroundings enough so that the user can look around, perceive objects in three dimensions, and distances which improve the VR learning experience:

> Well, there was quite a lot of all kinds of stairs and devices and machines and things you could look at. People working and such. I started thinking how it would be to work in a place like this because I should go to work now after upper secondary school. (P2)

> There was some manufacturing plant, manufacturing copper or so. A factory scenery in a sunny place X. (P3)

> Massive halls and challenging work conditions. Like I said then, I'm glad that my work is a clean indoors job. (P6)

> When something was smelted you could hear a sound and it did glow. And of course, I haven't seen molten metal like that or lava or anything, so I remember that. And random memories are those sheets and I remember about them that something was dripping down from them somewhere down and they recovered it or something. And I remember how that factory looked from outside when I was in a tower, and then there was sea or something close by. (P7)

Forming connections refers to a value construct where visually realistic information improved forming connections in the information which VR software presented. The connections formed from concrete information between presented stages acquired from spatial immersion (P4) and spatial information filling in the gaps in narration (P3), in both cases leading to more complete understanding of the subject at hand.

> Because I focused so much on what was going on around me, I remember how I moved from place A to place B and from which stage I moved to which and how those roughly looked like. Those were the main things that I remember. (P4)

> I could see activity going on and sometimes a voice told what was going on there and then the info buttons did show a little more in detail what was really going on in the factory that you could see. (P3)

Reduced focus on other information value construct emerged from the participants feeling like their attention was divided between the visual and narrative side, so they did prefer to focus on only one. Therefore, the experience felt overwhelming, or the participants felt like they missed something crucial for their learning as they were unable to pay attention to both information sources. Thus, abundance of spatial information seems to be partial cause to cognitive load. Spatial information presented by VR experience seemed to be preferred in this case as it was easier to follow than for example narration:

> Because there was so much going on at once I couldn't focus on one thing at a time, but instead I had to switch between looking around and trying to absorb new information. – In the end I did pay much more attention to the visual process which I could see rather than to what they wanted to teach me. (P4)

> I wasn't focusing at all what the narration was talking about, because it was the kind of English vocabulary that isn't needed in daily use, like special vocabulary. So, everything didn't stick, and I focused on what I could see and how I move and act. (P7)

4.2.4 Physical sensation value constructs

The findings on physical sensation relate to the VR experience rather than strictly to learning. Despite this, it does affect the engagement of VR solutions, presence, as well as long term usability of VR in learning. The tested VR solution did not allow users to walk around or use controls to move their point of view, which according to previous studies lessens the strong physical sensation effects (Dziuda et al., 2014; Kim et al., 2018). Furthermore, the point of view did stay stationary at all times. Even in the rather minimal case of physical sensation causing features, the experienced presence did cause mild cases of simulator sickness effects. The physical sensations did stem from users' natural instincts as a fear of height, VR hardware as it did not focus properly, as well as from user preconceptions, experiences, and underlying conditions. Thus, mitigation of simulator sickness' effects on user experience is not fully mitigable by only the service design.

The value outcomes affecting participants of this study are presented in the table 10. Only mild cases of physical sensation were recognized. The participants did not report nausea or strong symptoms of simulator sickness, nor other effects that would relate to strong or lasting simulator sickness.

Value co-creation	37.5%	Value co-destruction	50.0%
Physical sensation:		**Simulator sickness:**	
Excitement from involuntary reaction	3	Vertigo	3
		Eye strain	1
		Negative perceptions:	
		Worry of physical toll	4

Table 10 Simulator sickness value constructs.

Value co-creation during VR use was only recognized to appear as excitement from involuntary reaction to presence (P2, P5, P7). This happen because of virtual situations, where they felt like they could have been in danger or in a high place, and the sensation of presence was convincing enough that their body reacted involuntarily to it. For example, high point of view caused a sensation of vertigo, or standing close to depicted molten metal was found exciting:

> It felt like or I guess I knew that I was inside a video but there were same feelings like being high up or being closer to a fence or so. I though I'm about to fall, and I was about to try and take hold of the fence, so the brain is a little tangled up there or so. – But it wasn't a bad thing but rather exciting, if you have any fear of height it was like a sensation of « woah ». (P7)

Value co-destruction was apparent in cases of negative reaction to vertigo, eye strain, or worry about the physical toll of VR use which did negatively affect the VR experience.

Vertigo did slightly hinder the experience for three participants. According to Participant 3 and 8, it was because of point of view being suddenly in a high place. Participant 8 also noted about sudden change of the scenery caused a slight loss of balance, while Participant 4 stated they felt like afterwards it took a while to rebalance to the real world due to the perceived low-resolution, which likely refers to the imaging technique used to capture the 360-degree video, hence being a software limitation rather than hardware in this specific case.

> I've had a bit vertigo before [when using VR], but this time it was not as bad. First time when I was doing that play testing, which was my first time in VR, I felt like I was about to fall, but I didn't have that this time. (P3)

> I felt a bit of swaying when the scene changed or when it was too high, so it felt a little bad but normalized once the view came back to ground level. – The suddenly changing scene and once you looked around it felt different even though my feet were stood on the ground. (P8)

Eye strain was experienced by Participant 4, affecting their experience negatively. It was according to them because of low-resolution or not being able to properly focus the HMD screens to reach a sharp image.

> As an experience, my biggest problem was that I couldn't get the picture sharp, it was varying so it was sometimes sharp and sometimes unfocused. That gave me a memory about the clearest physical experience. It caused a bit discomfort and took a while to get used to and afterwards it took a while to rebalance myself. – I mean to get used to the difference when the picture was not clear and how it feels to be again without it. (P4)

Worry of physical toll emerged from either preconceptions about the simulator sickness being a possibility (P5 & P7), worry about VR triggering underlying medical conditions such as migraine (P4) or if VR is a safe technology for the user (P3).

> I had heard that the physical toll can be quite intense, some people cannot stay with the headset on for too long. I think that was one of my assumptions that it would have affected... Or caused some type of motion sickness. (P5)

> I now decided to take a risk that I would test if it [VR] would affect my migraine because I knew it [VR experience] wouldn't be a long thing. So, it was a bit like I wanted to see if it has effects on me. (P4)

> -- how much research has been done about VR's effects on brain, like blue light and everything else, how close it is to normal screens and does it have some of its own effects or impediments. (P3)

4.2.5 Interactivity value constructs

The VR solution used in this study was based on a 360-degree video with only slight interactivity possibilities. The participants were unable to walk around or decide the pace at which the scenes would advance. The interaction that they were able to experience was mostly 3 degrees of freedom and interacting with some user interface elements for bringing up a video detailing the process of the metal refining stage they were viewing. Despite the lack of interactivity in the tested solution, it did provide basis for discussion about what VR interactivity did mean for the participants.

Interactivity in VR enables users to utilize their experiential learning skills as they would in real situation by interacting with virtual learning environment. Interactivity contributes as well to engagement by increasing user interest as it allows them to be active rather than passive learners, as well as control the pace and content of the information they are presented. The perceived value co-creation and value co-destruction stemming from interactivity are shown in table 11.

Value co-creation	100.0%	Value co-destruction	50.0%
Affecting emotional engagement:		**Affecting emotional engagement:**	
Interest	4	Frustration from usability	1
Curiosity from lack of freedom	2	Forced due to lack of control	1
Satisfaction from freedom	1		
Active learning:		**Passive learning cost:**	
Learning by trying things	2	Couldn't focus on information	2
Improved spatial understanding	2		

Table 11 Interactivity value constructs.

Value co-creation from interactivity emerged in five value constructs. *Interest* value construct builds up from interactivity either enabling control of the subject and information which in turn gave the users sensation of interest or engagement and then on leading to possible learning benefits. Especially valuable for the interest and learning was interactivity by which the pace of information could be controlled, allowing the user to choose when and what information comes (P4, P7).

> In that environment [talking of tested solution] I wouldn't see that observer could concretely take a part in how the factory works. In that environment the info panel was

enough, but in some another environment being able to be interactive with the surroundings, so that could open something and close something and so would get more information about the surroundings. [Interviewer: Would you see there is some benefit for the user?] I think it could increase interest towards the subject or surroundings when the observer can themselves explore the environment. [Interviewer: Why would that be important?] They could be more motivated to understand or internalize the subject. And remember it better, I mean it would support learning. (P1)

It is cool, somehow it [using hands to interact] felt like from a sci-fi movie. It came to my mind that interactivity is pretty fun if I could interact more with the environment. Yeah, I think that would be at least fun. Well, it could feel more like a video game so it would be more fun and increase interest towards the subject, even if it wasn't initially interesting. (P2)

Of course it [interactivity] is good, if I could change volume, and how fast it progresses or information that is available. In my opinion it would be good. It helps to customize the experience for different people. -- I want to emphasize that everything begins from my interest, and it is taken into consideration in the experience. Every step of it isn't as important for me, but if I'm interested then I want to learn about the subject. (P4)

I think It would help me to learn better if I could control what happens next and when the scene changes. Because otherwise it becomes really incoherent and can't remember things when pictures just keep changing really quickly and you haven't had time to internalize it or the narration. (P7)

Learning by trying things emerged from user desire to add concrete activity to the VR experience, which would allow users to learn by doing. The desire for concrete actions was for an example interacting with the virtual environment more than pressing buttons in the user interface and rather interacting with the presented machinery or items placed in the virtual environment:

The demo didn't have much of interaction other than pressing buttons, but then there is other VR apps and games and others, but I'm not sure about them. I guess it [interactivity] depends on the game how it works. At least in that demo it didn't lag when I did press the button with my finger. [Interviewer: Why is the interactivity important for you?] Contact to learning content connects it to yourself, I think. (P3)

Just pressing a button and closing some pages was a bit lame. I would have wanted to for example press buttons to concretely move the machines within the application, like I would get more information about how the process actually happens inside there [factory]. – When talking about demo, usually you'd want one talking about things that people like and where you can do things, because we are talking VR devices. People want to do all kinds of things with their hands especially when you have that kind of VR glasses. [Interviewer: Why would the interactivity be important for learning in your opinion?] Its that you could physically do something in there. That would for example connect things in your memory so you would remember it better in things like « when I turned this thing, something happen in there ». (P8)

Improved spatial understanding from interaction value construct emerged from the participants desires to move around to change their point of view closer or further, or to some another point in the virtual environment, which would have helped them to better understand the size of the spaces or objects. Again, the personal benefit of this would be learning and engagement. This value construct emerged from data as follows:

> The freedom was rather small. You couldn't concretely walk much; it was designed to be just look 360 around. Video taken from a certain place and shown how it happens. I would have wanted to look more closely some objects or from further away. It would have given me immersion or vision of how big some factory hall actually is. It would help to create perspective about how things are and how big they are in today's factories. (P8)

> I think it would be nice addition to be able to move around the machinery freely, to see it from different angles, of course I did see it from different angles, but they were pre-recorded angles. – [Interviewer: What you would benefit from that?] There would be the entertainment factor. It is always interesting to be able to move in a virtual world as it feels new and exciting. Depending on the context beneficially understanding how things work, how the environment around you works. Getting more in depth understanding of how it works as you can see it from different angles. (P5)

Satisfaction from freedom value construct describes situations where interactivity enabled 3 degrees freedom that the VR platform did allow user, and the participants experienced sensation of satisfaction due to it. It seems that desire for interactivity depends heavily on user-to-user, coming from their previous experiences and desires. For Participant 6, the 3 degrees of freedom were enough to satisfy their curiosity and desire to move around as it was their first VR experience:

> I didn't have desire to move during the video. Of course, I did look up and down and around at the environment a lot and curiously wherever I could get a peek at. – The view as it is was good, because I could see around so I didn't need to move for some specific reason. (P6)

Curiosity from lack of freedom was an unusual value construct emerging from the data. This value co-creation construct emerged because the VR experience heavily restricted exploring the surroundings and it did cause value co-creation in form of making the participants curious. The participants 5 and 7 felt like they wanted to explore places they did see, but since they could not interact with the environment to move where they wanted, they were left curious and thinking what was in some area where they could not see to:

> I was in a big warehouse with the machinery and there was a long walkway leading from one end to another and I remember specifically wanting to take a stroll along that walkway and obviously the real-world location would not have allowed hundreds of meters of walkway so that can feel a little limiting in terms of simply having a headset and not being able to move around. -- now that I think of it, it could and it in the matter of the fact did spark a bit of annoyance that I couldn't move around freely in terms of taking actual steps. But at the same time, it could spark a bit of curiosity towards different areas, being able to see something but not being able to walk to it. (P5)

> I would wanted to go closer to the workers and maybe closer to the hot lava, molten metal to look at it from really close, of course laws of physics would come in the way of it so the camera could not get so close to see it really clearly and so -- When I saw some worker there, I felt like it was interesting to see people there and I kept thinking that I hoped be able to go closer to look at it all. (P7)

Value co-destruction from interactivity emerged in form of three value constructs. *Frustration from usability* (P5) regards interaction with the virtual environment where usability or responsiveness of the system is lacking. Frustration from usability did occur only once. Other participants had no notable issues with controlling the experience and reported more neutral or positive experience regarding usability. Participant 5 did state that they felt frustration because their actions were not recognized by the software:

> It was a little finnicky to control. The hand controls weren't as responsive that I would have wanted, clicking buttons and so. – I think the experience that I had was too short to develop a hardline opinion about the matter, but I had a feeling that for a longer period of a time it could get quite frustrating – or maybe just slightly annoyed when your actions are not recognized by the software for example, it's a little annoying. (P5)

Couldn't focus on information (P4 & P7) relates to interactivity because lack of controls for progressing the experience does not allow the users to control their information intake, hence causing cognitive load and then on reducing comprehension of the information. Interestingly, being unable to control the experience made Participant 4 focus on spatial information such as depicted factory environment, instead of attempting to intake information from narration or video:

> I have ADHD, and when the scene kept changing and there were things moving around, I just kept looking around and my attention was focused on it so much that I did not notice if there was some text or something else. It would have to be more clear for me, like I need to be able to move at the pace I want to. – I would rather be in a situation where I could control myself when I move to next part or step. -- I did pay attention when it was really clearly pointed that « pay attention to this now » [video pop-ups], but otherwise I was just looking around what the process looked like, instead of whatever information was attempted to communicate to me. (P4)

Forced due to lack of control (P8) is the final emerging value construct from interactivity. The interface elements such as video pop-ups which could not be controlled felt forced, reducing the enjoyment of the VR experience, thus emerging as value co-destruction:

> It felt a little forcing, when you had to watch certain things to understand what is going on. – Maybe it was those popup windows which did show a video, so you had to watch that before you could proceed. (P8)

4.2.6 Cognitive load value constructs

The value constructs regarding cognitive load describe the source of the cognitive load value co-creation or value co-destruction from the participants point of view

(Table 12). The focused interviews mostly inquired about amount of information present and participant's ability to focus on the subject which were recognized in theoretical background important for cognitive load and could be easily discussed during the interviews. The findings show that VR can be used in learning situations to reduce cognitive load by ensuring focus stays on the subject no matter the surroundings, controlling amount of information, and allowing users to decide the pace of their progress.

Value co-creation	25.0%	Value co-destruction	62.5%
Controlling subject focus:		**Information density:**	
VR reduces cognitive load by focus	2	Too much information	4
		Unable to control progress	3

Table 12 Cognitive load value constructs

VR reduces cognitive load by redistributing the VR user's focus. This emerged from two reasons: Firstly, Participants 4 and 8 felt like they were focused on the VR experience because they could not do anything else while they had the HMD on them, and they could not open another application like on computer they would. Participants' lack of interest in subject or habits to divide their attention is mitigated by HMD causing visual isolation from surroundings and software not enabling multitasking. Thus, their learning experience was more focused because of the VR platform controlling information intake and distractions.

> Lets say it like this, the fact that it was « immersive » it helped [focus] ; I had to be completely in that moment. Everything I was doing did in the end relate to the experience. Usually when I'm playing something, I have some video playing on the background which takes the attention from both things I'm doing at once. But with VR I had to focus in the moment. (P4)

> I think it was the simplicity: You couldn't do much else during it [VR experience]. I mean that you have one thing loaded up in the application and you can only do that one thing which is programmed for you, so maybe that did affect the concentration. – I feel like I retained concentration easier into the subject so information I did get through VR didn't go wasted. If I compared to normal school classes, I think VR did retain my concentration better. (P8)

Value co-destruction because of cognitive load did come forth solely because of the VR software presenting too much information at once. More specifically the negative value outcome happens because of too much information simultaneously from different sources such as variety of visual information and spoken information (P2, P4, P5 & P6). This seems to be partially because of abundance of spatial information. Additionally, language barrier did affect the ability of some participants to take in information simultaneously.

> Well first I wasn't all sure what it [VR experience] tried to tell me and then that one thing popped up on the screen and I was like « hmm what is this? » [Probably talking about information panel]. But after a while I felt like I caught up with it. (P2)

> The additional reasons might have made it in that specific context harder for me to focus than easier in the content, because well you have this default direction, but then there is whole 360 degrees of digital world to explore around you. And with all the noise and small things going around you, once you realize that you can turn your head to look around you, that could have been a distraction to look around you, to turn your head to look at some worker doing in your right in your left, behind you, it could have been distractions. (P5)

Interestingly, the interview completed in English because of the participant's request did have the same effect, so it suggests that the metal refining context specific language was the issue rather than native tongue.

Relating to speed of the presented information, negative value outcome which emerged was *unable to control progress* (P4, P5 & P7). The abundant amount of information could be mitigated by pacing of the information appropriately, but in the case of the tested VR solution, the users were unable to control the pacing of the VR experience.

> The texts came with the picture, I mean they did show some process at the same time as they explained what was going on, but I would have preferred to first take my time to look and then get the sound and explanation. So like that I think I would learn better if I could control myself what happens next and when the scene changes, because otherwise it becomes really confusing and I can remember barely anything if the scene changes quickly and I haven't had time to internalize the narration. (P7)

4.2.7 Presence value constructs

Presence emerges from variety of factors affecting user experience and it is integral sensation in VR, leading to engagement (chapter 4.2.1) and learning (chapter 4.2.3). Furthermore, it has been recognized especially important for making experiences feel concrete. The findings of this study show that presence value co-creation constructs emerged from VR features, interactivity, cognitive challenges, sociability, and physical sensation. Hence the participants experienced presence. Whereas value co-destruction constructs emerged from VR features, temporal immersion, and interactivity. This chapter presents value co-creation and co-destruction constructs resulting from participants' VR learning experience regarding sensation of presence. The recognized value constructs are named after their source in the table 13.

Value co-creation	87.5%	Value co-destruction	62.5%
Spatial immersion:		**Spatial immersion costs:**	
Being able to see hands	3	Lacking freedom of movement	1
3 degrees of freedom	6		
		Temporal immersion costs:	
		Lack of narrational continuity	1
VR fidelity:		**VR fidelity costs:**	
Fidelity of virtual environment	1	Lack of fidelity	2
Live interaction:		**Software costs:**	

Social immersion	1	Play area borders	2
Physical sensation:			
Physical sensation	3		
Hardware:		**Hardware costs:**	
Visual isolation	1	Physical discomfort	1
		Haptic feedback	1

Table 13 Presence value constructs.

Value co-creation out of spatial immersion was especially strong contributor to experienced presence. The participants experienced it because of specific VR platform features and how well it matched their image of realism. The main VR platform features allowing co-creation were being able to use and see their hands (P5, P7 & P8), 3 degrees of freedom in looking around (P1, P5, P6, P7 & P8), and fidelity of the virtual environment.

Being able to see and use hands caused reaction of amazement or presence and made the virtual environment more convincing by having no controllers, but still the position of hands was accurately represented and interactivity with the environment was possible much like in real life (P5, P7 & P8). This shows that platform being able to track user's body and software creating representation of it in the virtual environment is important for value co-creation as it allows users to intuitively interact with virtual environment and feel like their body is at least partially in the virtual environment.

> I could see my hands without any joysticks was a good example of how refined the technology has become. – [How did seeing your hands make you feel?] Primary feeling would be immersion, it's a lot more immersive if you can see your hands in front of you. Yeah. (P5)

3 degrees of freedom stimulated value co-creation and co-destruction. Value co-creation was enabled by the VR platform allowing the participants to look around freely to explore the virtual environment as they wanted, resulting in strong sensation of being concretely inside the presented environment (P1, P3, P5, P6, P7 & P8). And thus, it allowed more concrete experience as well as improved spatial learning.

> It felt surprisingly real. I mean the movement, like it [point of view] moved with you when you moved. (P3)

> As is expected by virtual reality that I can move my head and feel like I'm there where the software, I'm there in this virtual world. It feels like you are in a completely different place where you were couple of seconds ago when you put the headset on. (P5)

> I thought it was really amazing experience that you are kind of inside it all, like there is the environment 360 degrees around you. It is a really fancy system. (P6)

Fidelity of the virtual environment emerged from the participants recognizing the virtual environment to be high quality and realistic enough that they perceived the experience as if visiting the actual place. The realism of the virtual environment would be high in the tested VR solution as most of it was done in 360-video recording, but because some of the participants (P7 & P8) felt like the resolution was too low and image grainy, it suggests that visual fidelity depends on the participants previous experiences and expectations on the quality.

Social immersion value co-creation was recognized from Participant 7 where having people to react with would make the experience stronger. This is a result of the participant's institutions where social habits enhance the VR experience.

> Its kind of my style to talk to myself or think out aloud when other people are around in the same room. I think my reactions that are stronger if I say them out loud. It would feel dumb to talk out loud when I'm alone. Of course I could have been quietly there, but when there's other people around in the room it feels natural to react out loud. (P7)

Physical sensation as presented in the physical sensation findings subchapter did enhance the VR experience by making the participants feel excitement as their body reacted involuntarily to the realistic stimulus (P2, P5 & P7). Overall, the perceived value of this was either positive or negative, depending on the strength or interpretation. In this case, only the value co-creation from physical sensation would be considered as it contributed to the user experienced presence directly.

Visual isolation enabled the participants to disassociate from the real world because the HMD fully, or nearly fully, covered their vision and replaced it with the virtual. This focuses users' cognitive resources to virtual environment and ensures they are only viewing VR:

> -- Kind of like I did separate somehow from the normal world, but you just have those glasses on, the real environment doesn't change but what you physically see through the glasses brings the three dimensionality around you. -- Its a bit like going into your own bubble when you put VR glasses on. (P8)

Physical discomfort distracts the user from the VR illusion and reminds them of the device that is causing it. Weight of the HMD made Participant 2 feel annoyed which reduced the presence as well as engagement especially as the experience went on.

> The headset thing was a bit, like after using it for a longer while, it started to press on my forehead. Towards the end it was annoying because it was heavy. (P2)

Perceived low resolution of the VR platform resulted in less convincing place illusion and in the case of Participant 8, it also made it challenging to see what was going on in the VR experience. Although the effect of resolution is clear on the user experience where low-resolution or unfocused image makes the virtual environment less convincing to the users, the source is still somewhat unclear. The screen resolution of the used VR device is fairly high but not perfect while the 360-video recording method results in lower pixel density, but also the position of the device fixed the unfocused or low-resolution image for Participant 7. Thus, the fidelity of experience regarding presence is affected by hardware and software as well as user expectations.

> At the start the headset was too loose so it seemed like the picture was really blurry because it wasn't positioned correctly, but otherwise there wasn't anything interfering with the use experience. – It would have been bad if the vision was blurry all the time but it was nice that it had been made to fit everyone's head. (P7)

> I had to focus a lot to see around me in the application, because the quality was kind of really bad. It wasn't any HD quality but instead very grainy. (P8)

Lack of haptic feedback emerged from using hands to interact with VR. According to Participant 8, the experience was only lacking haptic feedback, which made the experience feel less real. Sensation of physical contact would allow another stimulus to contribute to sensation of presence as well as allow learning physical properties, which was not possible in VR solution participants tested in this study.

> It [using hands] felt a little odd at the start but I got used to it a bit like in real life picking up objects or such. I think it was a little better [than controllers] but if there was some haptic feedback it would then be much better. (P8)

Lack of narrational continuity value construct emerged from the participants feeling like the VR software did not adequately allow forming connections between refining processes depicted by the VR experience. The VR experience moved from one refining process to next canonically, but the optional narration was separated from the 360-video experience, and it was not enough for forming meaningful continuity. A user interface element showing how pure the metal was did not represent number of scenes left in the VR experience because early stages quickly increased refined product's purity while latter stages only gradually increased it. Therefore, the software did control temporal immersion, and the design of it the participants perceived negatively, decreasing the sensation of presence as the stages were perceived disconnected from one another.

> If there was a system that told we are now in stage 4 out of 8 it would have helped understanding the complete picture and keep my interest like « now we are over halfway, I can focus on this until end ». When I had no idea how far in the process I was, and I didn't know how long it will still take. – I can't remember if there was any summary or conclusion at the end, but that would have been useful for me. (P7)

Lacking freedom of movement felt like limiting the VR experience for Participant 5, which decreased the place illusion because they could not explore where they wanted. In the tested VR solution, the limitation was because of the software design as capabilities of the hardware does allow for 6 degrees of freedom. This means the desires of the user were limited by software, resulting in value co-destruction:

> I was in a big warehouse with the machinery and there was a long walkway leading from one end to another and I remember specifically wanting to take a stroll along that walk way and obviously the real world location would not have allowed hundreds of meters of walkway so that can feel a little limiting in terms of simply having a headset and not being able to move around. -- now that I think of it it could and it in the matter of the fact spark a bit of annoyance that I couldn't move around freely in terms of stepping, taking actual steps, but at the same time it could spark a bit of curiosity towards different areas, being able to see something but not being able to walk to it. (P5)

Visible play area borders are a combination of hardware and software of the VR platform providing users a virtual representation of borders where the play space in the room they are in ends. In the tested solution, moving away from the middle of the play space did make the barriers visible, which broke the place illusion of the virtual environment. The intention of the barriers is to ensure the user does not walk into walls during the user of VR, but in this study it was also observed to break place illusion and as such reduce presence (P3 & P5):

> But when you moved left or right, or forwards you could see a cage [play space borders] how much you can move in place. It was good because in scenes where there was a railing eight meters high, you could still see the cage so it reduced vertigo effect, in my opinion. (P3)

> For safety I think the barriers that were setup so I wouldn't walk into anything. I think they were good to remind the user that it still is a virtual world and you can't trust everything shown on screen. When there is an empty field it doesn't mean that there is an empty field in real life in the same area. (P5)

4.3 Experiential learning and relationship to value constructs

The role of the experiential learning in VR use is especially for this study because it presents a way to unravel learning from experience and the relationship of identified value co-creation and co-destruction constructs to VR learning experience. The goal of this chapter is to present the findings of this study regarding the experiential learning and evaluate how identified value co-creation and co-destruction constructs affect VR learning experience from experiential learning standpoint.

The themes concrete experience, applying concepts, spatial information, presence, and interactivity (Table 4) formed because of the focused interview themes and how the participants perceived these themes important for their learning experiences. What is especially interesting is how the value constructs relate to the facets of experiential learning. The value constructs presented in the chapters tie into Kolb's (1984) experiential learning theory's facets concrete experience, reflective observation, abstract conceptualization, and active experimentation.

Experiential learning was recognized influential to VR learning experience. Role of experience and personal significance of it for learning was well stated by Participant 2 and 4:

> It would be great in history education. -- It would be eye opening, seeing street from the past or daily life, how it has been in different ages on streets of London. It would allow experiences, much like travelling somewhere. I'd rather travel to New York than watch pictures of New York, so VR would bring experiences. (P2)

> …--For example, when we think about culture or art or such, if you want to learn about those you rather must experience them than read about them. In this kind of situations, where experience requiring teaching and experiences are hard to achieve, VR would be very useful. (P4)

Similar view was shared by participants 3, 5, 4, 6, and 8. The value of realistic experience in learning situation was clear from the way the participants themselves highlighted it.

The role of experiential learning is important for VR experiences for two reasons: First, the experiential learning facets are important for value co-creation and co-destruction process in context of learning. Second, ease of use in context of VR seems to depend on experiential learning process as represented by the data:

> It [using VR] was easy after a while once I got used to what the messages were and what they are informing me about, how I should move and how the device reacts to what I'm doing with my hands. It took a moment since for me it was a new device and new technology. It was a surprise, I expected it would take longer for me to get used to it [VR]. It was nice to know it isn't challenging technology to use. (P4)

According to findings of this study Stevens & Jouny-Rivier (2020) dual learning model does apply to VR experiences as well. It explains the observed learning processes where participant's experiential learning efforts were focused on the presented subject and on the VR device's usefulness and usability.

Because of the VR context, the antecedents of VR experiential learning were engagement, spatial information, interactivity, cognitive load, sociability, and presence which were explored from point of view of value constructs in previous chapters and here presented with the value constructs that were recognized to directly affect experiential learning (Table 14). Physical sensation was recognized to affect the perceived value of VR, but its direct contribution to experiential learning facets is unclear. Physical sensation was recognized to affect sensation of presence and engagement positively while also affecting engagement negatively. Therefore, role of it for the VR experience is definite but indirect for the experiential learning.

Value co-creation		Value co-destruction	
Engagement:	**13**	**Engagement:**	**3**
Interest	5	Annoyance	4
Fun	2	Forced experience	1

Excitement	3	Fear of falling	3
Attainment value	1		
Improved work life	2		
Improved well-being	1		
Improve financial decisions	1		
Improve society	2		
Improve personal goals	1		
Environmental values	3		
Improve career planning	2		
Learning is rewarding	4		
Intrinsic interest in VR technology	5		
Spatial information:	**4**	**Spatial information:**	**1**
Remembering locations	6	Reduced focus on other information	2
Remembering objects	5		
Remembering actions	5		
Remembering connections	2		
Interactivity:	**1**	**Interactivity**	**1**
Learning by trying things	2	Couldn't focus on information	2
Cognitive load:	**1**	**Cognitive load:**	**2**
VR reduces cognitive load by focus	2	Too much information	4
		Unable to control progress	3
Sociability:	**2**	**Sociability:**	**2**
Utility value from sociability	1	Sociability distracts from subject	2
Learning from sharing and discussing	3	Using VR reduces real interaction	1
Presence:	**3**	**Presence:**	**2**
Being able to see hands	3	Lacking freedom of movement	1
3 Degrees of Freedom	6	Lack of fidelity	2
Fidelity of virtual environment	1		

Table 14 Value constructs directly contributing to experiential learning.

Table 14 shows the VR learning themes and the number of value constructs that were connected to value co-creation and co-destruction side for each theme. The numbers presented with each value construct are the number of participants who experienced the said construct. Next chapters present the connection of the value constructs (table 14) to the individual facets of experiential learning as emerging from the data of this study.

4.3.1 Concrete experience

Concrete experience was defined by Howard-Morris (2020) as hands on involvement and active participation in real-world uncontrived experience. Comparing to the themes emerging from the TCA done for this this study, it would require spatial information, presence, and interactivity to meet the demands of the taxonomy. The value constructs of spatial information, presence, and interactivity mediate perceived concrete experience. Furthermore, sociability features of VR seem to also enable possibility for concrete experience, such as learning from conversing in other languages, presented as *utility value* (1) in the sociability value constructs.

Spatial information convoyed by a VR experience is extremely effective at delivering information in a manner which the user is familiar to because it imitates real surroundings, which humans are well versed in dissecting into rememberable knowledge. *Remembering objects* (6), *locations* (5), *actions* (5), *and connections* (2) were presented as main value constructs describing the benefits of spatial information from participants' standpoints, but it did come at cost of reduced focus the participants could spare to information delivered by narration or text. The spatial information was perceived memorable because of the realistic surroundings, 360-degree video making it feel like being surrounded by the virtual environment and stereoscopic view enabled by HMD.

Presence contributed to how believable the experience was, thus making it more real-world like experience where the spatial information could be internalized by the participants in a manner which imitates schema of knowledge acquisition in a real-world experience. *Being able to see hands* (3) and *3 degrees of freedom* (6) value constructs were especially highlighted in the category of presence. These VR platform features allowed control of the VR experience in lifelike like manner. Presence hindering experiences were things that distinguished VR experience from real, such as *lack of fidelity* (2) and *lacking freedom of movement* (1).

Co-presence was found to enable effective VR cooperative learning as the participants did find value in VR features that would enable communication through the VR to enable *learning from sharing and discussing* (3). These features could be user avatars representing the user movements. Contrarily, co-presence could be a distraction as *sociability distracts from subject* (2). Or alternatively *using VR reduces real interaction* (1) where the interaction with people in same room would be hindered because of visual isolation resulting from HMD.

The tested VR experience had little to no meaningful interactivity with the virtual environment. Thus, sensation of *being forced* (1) to specific experience emerged from the experience. Despite the lack of interactivity, the participants brought forth interesting views on how the VR experience could have been more beneficial for forming concrete experience through interactivity. First, *learning by trying things* (2) value construct did show participants' desires to improve their experiential learning potential by interacting with the presented machinery and see the actions affect the virtual environment. Second, *improved spatial understanding* (2) from interactivity would have emerged from changing point of view and moving in the virtual environment, which would have allowed HMD to deliver information more effectively using its stereoscopic image as well as enable learning by exploring.

Despite the lack of meaningful interaction with the virtual environment, the participants were able to test their perceptions about VR against the concrete VR experience. This means that they were able to press user interface buttons and try how natural moving the point of view is.

4.3.2 Reflective observations

The VR experience that participants did test had little to no meaningful interactivity with the virtual environment, and as such the role of the participants were more passive during the VR learning experience. Therefore, reflective observation should have been utilized by the participants. As explored in theoretical background, this facet of experiential learning comes from observing what is happening in the scene.

The observations during this VR experience were clear because the participants stated they had collected variety of spatial information as presented in findings chapter 4.2.3. This was also clear because when asked to describe what did happen in the VR experience the participants included descriptions of the surroundings and what was going on in them:

> I remember specifically when molten mixture was poured into a furnace or taken out of furnace. (P5)

> When something was smelted you could hear a sound and it did glow. And of course, I haven't seen molten metal like that or lava or anything, so I remember that. And random memories are those sheets and I remember about them that something was dripping down from them somewhere down and they recovered it or something. And I remember how that factory looked from outside when I was in a tower, and then there was sea or something close by. (P7)

> The factory was big and there are many stages in the copper refining process … (P8)

The participants preferring to put effort into internalizing spatial information over other available information during the VR experience does relate to the experiential learning and especially the reflective observation facet. This is because the VR platform features encourage collecting information much like in a real situation, and since the VR features did provide very little interactivity with virtual environment, the stage of reflective observations did highlight.

The reflective observations emerged as well in more reflective form where the participants were adding knowledge to their previous understanding about VR experiences or to their existing knowledge about the subject, when acquired from the new stimuli. This relates to both the VR use as well as the knowledge relating to the subject because some of the participants had anticipated the VR to be challenging to control or their previous understanding on the subject changed after the experience:

> Yes it [being easy to use] affected my experience because I didn't have to do other setup than put the device on my head. I was surprised that I did not need the controllers, but I could instead kind of see my own hands on the screen when I moved them. It was a positive surprise, and I did not need to learn any specific controls, so it worked easily. (P6)

> Old information [About metal refining in physics or chemistry] from my memory clicked in place like "Oh so this is how it worked" and so on. (P8)

The effects of cognitive load on VR learning were discussed in chapter (4.2.6) and it highlighted issue with the tested VR solution, where the participants felt like they could not control the information intake and their focus turned away from the detailed information (P2, P4, P5, P6 & P7). Therefore, the participants were less able to reflectively observe. The VR also had a positive effect on the participants' focus as they were unable to be distracted by the real surroundings, hence their information intake was focused on the lifelike experience (P4 & P8).

According to the findings of this study, sociability features could allow *learning from sharing and discussing* (3), where the VR users would benefit from co-presence of other participants, improving their knowledge gathering:

> Of course [VR experience] would have to be so that first I could with a friend focus on listening the speech and then through it discuss with the friend like « aah, I did not know that there was this and that behind it », like about the information we had gathered. (P7).

Co-presence was also found to have a negative effect on learning where *sociability distracts from subject* (2), thus reducing users' ability to gathering information about a subject, hence affecting the reflective observations facet.

4.3.3 Abstract conceptualization

When the participants were asked to tell how they perceived the purpose of the VR experience, the responses varied between teaching, general knowledge, and company partner relations. The use of acquired information about the subject to form generalizations for future use did vary mostly depending on the perceived usefulness of the said information. The participants stated that they had formed generalizations about the environmental impact of industry (P3, P6 & P7) as well as some understanding of metal processing (P2, P4, P6, P7 & P8).

> I had no preconceptions about metal refining, maybe mostly I was hoping that factories and mining does not damage the environment. [Interviewer: What you think about it now?] Its really good that in modern manufacturing they consider environmental questions, reusing the waste and so on. (P7)

> … but it kind of repeats, like once a stage is completed there always is some impurities left which cannot be separated so it gets taken back into the processing … (P8)

Emotional engagement stemming from the personal values interest, attainment, and utility value is crucial for taking observations and forming them into generalized concepts which could then be applied. Cognitive engagement and intrinsic interest values affect willingness to partake in the abstract conceptualization. Regarding the subject of the VR experience this observation becomes clear as the environmental impacts were important to the participants because of their emotional engagement:

> ... on the video it was well presented that it can be reused in variety of ways and the processes are well thought as well as each step is as useful as possible. Really

> interesting subject. – I have this idea generally about consumerism and recycling, that it is great when no waste is generated and everything can be recycled and then reused. (P6)

> I could look at a lot of stairs, devices, machines, people working, and I started thinking how it would be to work in a place like this [copper refining factory] because I should go to work after finishing upper secondary school. (P2)

While the similar role of engagement in deciding which information to generalize about the VR experience into other contexts did as well depend on the participant's personal values. For example, engagement utility value focused abstraction of Participant 1 towards application of similar VR technology in their field of work:

> I'm interested in understanding how VR could be used better in supporting business, and could it bring something new into my profession. (P1)

The perceived personal benefits were also especially important factor in deciding what generalizations from the VR experience were distilled. In this case, the participant interest was attained because of future benefits. The engagement chapter in findings describes variety of personal values which relate to perceived benefits. The participants focused on possibility of future use cases of VR, thinking usability (P1, P2, P4 & P8), how VR affected their well-being (P3, P4 & P5), and what kind of VR experiences they would want to test now (P1, P4, P6 & P7).

> I instantly started to think about how great opportunity this [VR] would be for learning and teaching standpoint, because as a learner I felt like when there were questions on the video it was much easier to focus on it, internalize and conceptualize what was going on when I was able to concretely see the environment. (P6)

4.3.4 Active experimentation

The rather passive VR experience resulted in the participants having to reflect how the information acquired during the VR experience could benefit them. The participants found learning experience to form meanings benefitting their perceptions about VR and the metal refining subject. The VR meanings regard usability of VR and what VR experience is good from the participants' perspective. The subject related meanings the participants found to be applicable for their perceptions about manufacturing and general knowledge.

Usability of the VR platform was the clearest cases of participants taking advantage of active experimentation. The participants had assumptions or previous experiences about using VR technology, but none of the participants had experienced VR solution which needed no controllers. The control method was perceived as intuitive and easy to use. I argue that sensation of intuitiveness comes from the participants actively experimenting controlling the VR experience, and it responds to their actions as expected because their previously learned generalizations are working for the new use case:

> Using it was easy. I just put the VR device on my head and this time I didn't need any controllers at all so it was easy because I could without troubles choose and press the buttons which the VR had. (P1)

> It didn't stutter or lag, and when I held my hand out it did show it exactly where it really was, so it didn't differ much from actually spinning around. (P3)

The VR testing did allow the participants to challenge their preconceptions about VR experiences. As presented with the physical sensation chapter, several participants were worries about how VR would affect them. Participants 4 and 7 were especially vocal about their preconceptions regarding simulator sickness and what the VR experience did mean for them in the future:

> I did personally benefit from this experience because if in the future I want to participate in VR things, I now know how I would feel or if I must take migraine medicine beforehand. (P4)

> Now I know if VR works for me, so I don't get sick or so. It was really good to get to test it for free before I'd buy my own headset. Now I have some background on knowing what I would invest into and the money would not go wasted. (P7)

The usefulness of VR was also possible for the participants to test by active experimentation as they did get to test one type of solution for learning purpose. As presented in the previous findings chapters, the perceived value of VR in learning context emerged from various reasons such as spatial learning, sociability, interactivity, and engagement. Many of those benefits were results of experiential learning facets and the active experimentation during the VR use did either confirm or prove the participants' assumptions wrong, resulting in the new ideas for how the participants could benefit from VR in the future. For example, in training for life saving situations (P3), learning from concretely seeing surroundings (P6), or making subjects more interesting which intrinsically are not (P7):

> … For example, in healthcare some dangerous situations or what you have to do when a person goes into epileptic shock, even though it is described in a book or shown from video, it is a shock when the situation is in front of you. VR learning could increase potential to act in real life situations. (P3)

> Maybe in subjects which are less motivating for me, like high school mandatory courses, it [VR] would help to internalize those subjects when the interest in the subject is not the motivator. It would help to be able to study those subjects in an interesting environment, comparing to gray book and gray classroom. – I was really excited to learn about the subject [metal refining] even though it is not initially interesting because I did get to see it all from so close. (P7)

The benefits for knowledge about the subject of the VR experience was less utilizable for the participants. Had there not been any connection between perceived relevance of the subject to the participant's values, they would not go effectively through stages of the experiential learning. In this study, the VR experience's subject was metal refining which by three participants (P1, P3 & P8) was deemed irrelevant to their life and they perceived themselves not the target group the experience. Therefore, their willingness to find connections between forming generalized concepts about the subject and putting them into use was greatly hindered. While only two participants (P4 & P5) stated the subject was interesting to them, other personal values enabled interest to the experience enough that most of the participants formed meaningful generalizations which they can utilize in their life. The important value constructs were: First, significance from shared values (P3, P5, P6 & P7) which means shared values such as recycling. Second, more informed decisions (P3), which regards willingness to acquiring products created by the company. Third, improved general knowledge (P4, P6, P7), which means understanding a subjects irrelevant to daily life is still rewarding because of the learning experience. Fourth, changing preconceptions (P7), where the experience resulted in a better understanding of the industrial emissions. And fifth, newfound engagement to the subject (P4).

5 DISCUSSION

This chapter focuses on the summary of the research findings, answers the research questions, and discusses the implications of the study for research and practice.

5.1 Answering research questions

The goals of this research were to identify prevalent value co-creation and co-destruction constructs in context of VR learning and how the identified constructs connect perceived value to prevalent VR learning themes. Furthermore, the research goal of this master's thesis was also to define the obstacles and benefits for the experiential learning in the immersive VR context. Thus, the research questions for this study were as follows:

1. *(Assisting question) What are the prevalent VR learning hinderances and benefits according to previous studies?*
2. *What are the prevalent value co-creation and co-destruction constructs emerging from virtual reality learning experience?*
3. *How the perceived user values affect experiential learning during VR use?*

The first research question was presented to assist the main goals of this study by creating the theoretical framework for this study and the focused interview themes. The recognized themes of VR learning were presence, social, engagement and emotions, cognitive load, physical sensation, and experiential learning. While the themes are likely not an exhaustive list of learning benefits and hinderances affecting VR learning, according to the literature review completed for this study they do cover the most prevalent VR learning hinderances and benefits. Furthermore, the role of the VR learning themes was intended to create initial and rough theoretical framework for this study as well as work as basis for the data collection using semi-structured focused interview method, so exhaustive list of VR learning themes was not necessary. Next the main points of the recognized VR learning themes are discussed. It is important to note here that these are findings from the literature review and not the empirical study.

Presence was recognized as a combination of immersive features and interactivity of a VR platform. The learning benefits included spatial knowledge, engagement, learning in context, by experimenting, and by collaboration (Dalgarno & Lee, 2010). These features lead to VR being more concrete experience (Kwon, 2018; Howard-Morris, 2020). Overall, presence affects learning by enabling engagement, collaboration, learning from experience, and emphasizes spatial information (Dalgarno & Lee, 2010; Kwon, 2018; Rupp et al., 2019; Howard-Morris, 2020; Parong et al., 2020).

Flow was recognized as mediator between presence and learning effects (Kim & Kye, 2008; Kwon, 2018; Bodzin et al. 2020). For the theoretical background, flow is important for how VR characteristics connect through experienced presence to flow and then on learning effects (Kim & Kye, 2008; Kwon, 2018). Although state of flow was recognized to be important mediator, it was not present in the empirical results of this study. This could be because the attempts to measure flow were inefficient or the sensation of flow blended in with the other themes.

The sociability learning effects were recognized as result of a VR platform enabling social interaction unlike other communication solutions (Mei et al., 2021). The VR platforms encourage discussion and interaction in social situations (Holopainen et al., 2019). The learning benefits therefore are improved communication, improved sharing of ideas, improved forming of shared understanding, trust building and more (Dupont et al., 2016; Pallot et al., 2017; Holopainen et al., 2019).

Cognitive load learning effects were recognized to result from combination of issues with usability, information density, and distractions (Wong et al., 2012; Makransky et al., 2017; Rupp et al., 2019). Thus, the learning outcomes are less effective.

Physical sensations were recognized to generally weaken the VR experience (Moss and Muth, 2011; Dziuda et al., 2014; Kim et al., 2018). Contrarily, they can also enhance the concreteness of the VR experience because of involuntary physical sensation that the users perceive positively (Kwon, 2018). Negative perception of physical sensation or simulator sickness could also reduce the users' ability to benefit from the VR or make them unable to focus on the subject because of reduced well-being.

Engagement is important for keeping the learner's attention on the subject (Dalgarno & Lee, 2010), willingness to further explore the subject (Rupp et al., 2019), and increase memorability of the experience. According to the theoretical background, engagement can come from interest in technology or variety of learning method provided by VR (Madathil, 2017; Rupp et al., 2019; Bodzin et al., 2020). It is a combination of behavioral, emotional, and cognitive engagement which together form personal engagement (Fredricks et al., 2004).

The experiential learning was the final main theme of theoretical background included. Kolb's (1984) experiential learning theory gives possibility to evaluate how concrete experiences enabled by VR turn to learning outcomes and then on perceived value. Furthermore, the experiential learning's facets concrete experience, reflective observations, abstract conceptualization, and active experimentation (Kolb, 1984) were found crucial for understanding VR learning.

2. *What are the prevalent value co-creation and co-destruction constructs emerging from virtual reality learning experience?*

The second research question was the first main research question of this study. It focuses on the value co-creation and co-destruction as it was recognized from this study's empirical part. The TCA was used on the data gathered from eight focused interviews to recognize twenty emerging themes. The themes were analyzed for relevant value co-creation and co-destruction constructs in learning context and the result of this were presented in the findings chapter. The emerging themes did closely follow the VR learning themes explored in the theoretical background of this study, and thus value constructs regarding engagement, social, spatial information, physical sensation, interactivity, cognitive load, and presence were highlighted. The connection of the perceived user value to VR platform features was also discussed where applicable, hence the following chapters start the discussion of the final research question on individual value construct level but mainly answer the second research question.

The findings of this study relating to the value co-creation and co-destruction constructs recognized in this study are presented in the updated model (Figure 9), which first was presented in the theoretical background section. The empirical study completed for this master's thesis did highlight value co-creation and co-destruction constructs regarding the recognized learning themes. Figure 9 presents the numbers of co-creation and co-destruction constructs, and in it the VR learning theme is weighted towards either co-creation or co-destruction side appropriately.

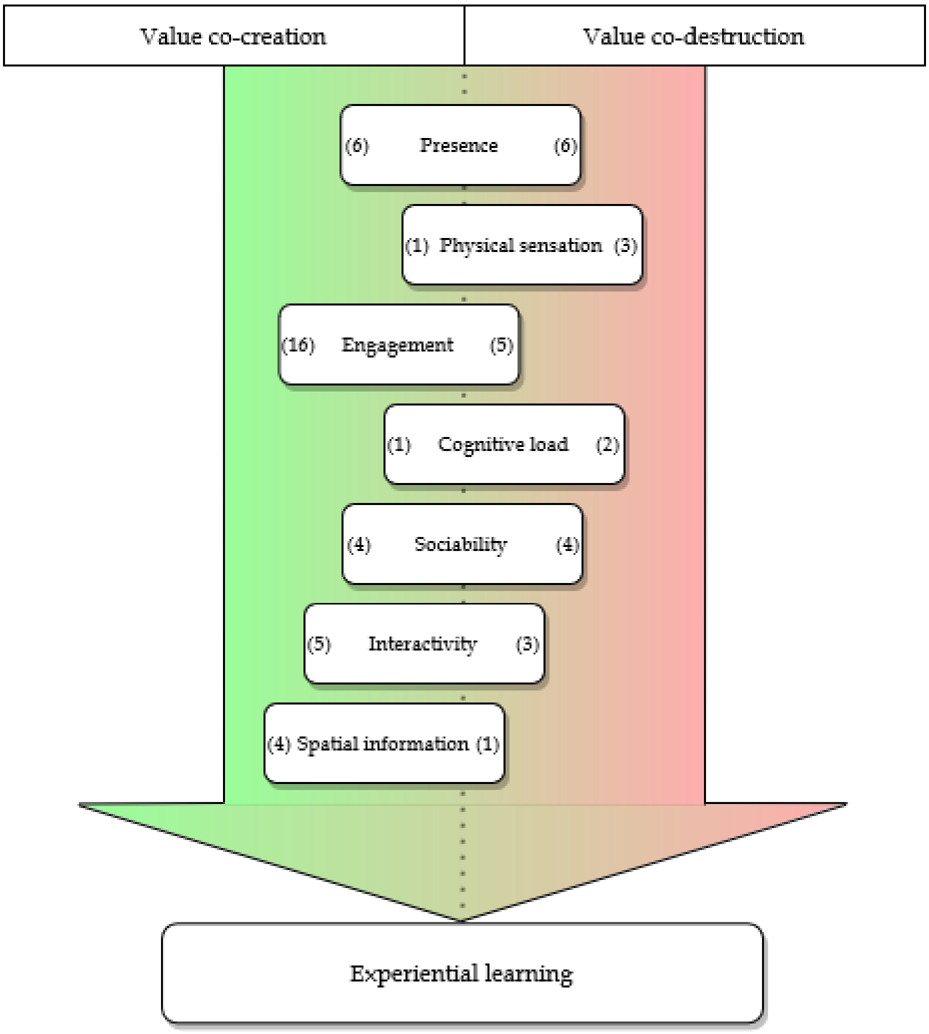

Figure 9 Recognized value constructs for all VR learning themes weighted to value co-creation and co-destruction.

Especially interesting finding of this study is that all learning themes recognized from previous studies have negative and positive effects which eventually or at least partially affect experiential learning, despite the previous studies included in this master's thesis were not considering positive value co-creation from cognitive load. The next chapter goes more in depth about the direct and indirect connection of each theme to the experiential learning in VR.

As presented in the figure 9 when comparing to the theoretical background (Figure 7), presence, sociability, and interactivity were found to be especially affected by both value co-creation and co-destruction, which was not as unambiguous in the previous studies. This is likely because of value-in-use thinking of S-D logic because in the case of this study a specific VR experience was explored in detail. Thus, the effectiveness of considering value-in-use proves to be advantageous for understanding VR learning experience and how VR affects the experiential learning. Spatial information was also added as crucial recognized antecedent to the experiential learning as it did emerge from the TCA done for this study. Engagement was expected to have both value co-creation and co-destruction occurrences, but in the case of this study it seemed like value co-creation did emerge more. This is most likely because during the interviews the participants were more able to identify and discuss their personal positive engagement and rather stating generic negative feelings, if they had any resulting from the VR testing, and these findings were presented in this study.

The number of value co-creation constructs recognized from the data of this by the themes were 16 engagement, 4 social, 4 spatial, 1 physical sensation, 5 interactivity, 1 cognitive load, and 6 presence related. The individual value co-creation constructs are presented in the table 15. The percentage presents the portion of participants that experienced value co-creation in that specific theme while the number shows how many participants experienced the specific value co-creation construct.

Value co-creation value constructs			
Engagement:	100%	Spatial information:	87.5%
Interest	5	Remembering locations	6
Fun	2	Remembering objects	5
Excitement	3	Remembering actions	5
Impressed by technology	1	Forming connections	2
Attainment value	1	Physical sensation:	37.5%
Improve work life	2	Excitement from involuntary reaction	3
Improve well-being	1	Interactivity:	100%
Improve financial decisions	1	Interest	4
Improve society	2	Learning by trying things	2
Improve personal goals	1	Improved spatial understanding	2
Environmental values	3	Curiosity from lack of freedom	2
Improved career planning	2	Satisfaction from freedom	1
Social interaction	1	Cognitive load:	25.0%
Learning is rewarding	4	VR reduces cognitive load by focus	2
VR provides new learning method	2	Presence:	87.5%
Intrinsic interest in VR technology	5	Being able to see hands	3
Social:	62.5%	3 degrees of freedom	6
Enjoyment from sharing experience	3	Fidelity of virtual environment	1
Learning from sharing and discussing	3	Social immersion	1
Safety from sociability	1	Physical sensation	3
Utility value from sociability	1	Visual isolation	1

Table 15 Value co-creation constructs of all VR learning themes.

Engagement values according to the findings are a mix of emotional values, social values, and cognitive values following the taxonomy by Fredricks et al. (2004). The engagement value co-creation was recognized in all the participants of this study. Thus, findings show that because of the variety of sources engagement can emerge from, it is likely a part of the learning experience in all cases of VR use. Engagement forms from emotional, behavioral, and cognitive values. The recognized emotional co-creation constructs affected interest values (4), attainment value (1), utility values (7). Where emotionally VR made experience more interesting, fun, exciting or impressive. Interest values were because of VR platform features such as interactivity, meaningful information, control, or concrete experience. Fun related to presence and novelty of the VR platform. Excitement came from presence causing an involuntarily reaction relating to high places or danger. Final interest value recognized was user being impressed by the level of technology and how real lifelike it felt. In only one case attainment value was recognized, where the knowledge of a questionnaire in the end of the VR experience did get the user to focus on the content. Utility values gave personal engagement to the VR experience. These included personal goals such using knowledge about VR experience to improve work, well-being, society, financial decisions, and personal goals. While the knowledge about the presented subject was engaging because of shared values with the content, or knowledge it gave about a possible future career. In engagement value constructs the utility value highlighted with the variety of personal meanings for the utility values the VR experience had, while interest value shows importance of hedonic values for engagement. Behavioral engagement co-creation constructs (1) were only recognized as a social interaction where co-presence with someone else in VR would make the experience more memorable. Cognitive engagement co-creation constructs (2) regarded VR providing possibility for more engaging learning or what especially highlighted in this study was the users intrinsically enjoying learning something new makes the learning experience engaging. This value co-creation construct was recognized not to directly relate to VR experience but rather to all learning experiences. Finally, intrinsic interest in VR technology did affect the engagement positively for 5 participants, which in this study was majority.

Social value co-creation constructs (4) were recognized in 5 out of 8 participants of this study. While the VR solution the participants tested did not have built in sociability features, the concept of social situations was explored in the focused interviews. The findings show that social co-creation would be result of enjoyment from sharing experiences, learning from sharing and discussing, safety, and utility value. Enjoyment from sharing experiences was because the user would find social situation in the VR entertaining, stimulating, memorable, or fun. While learning from sharing experience as a form of cooperative learning would have the users benefit from the improved knowledge gathering stemming from having another user to observe the virtual environment and share those observations. Safety user value came from having an observer who will prevent the VR user from hurting themselves by walking into objects or walls while they are visually isolated from the real space. Utility value of sociability referred to social situations in VR helping future goals, such as talking with someone from another country helps to improve language skills.

Spatial information value co-creation constructs (4) focus on the features of VR hardware such as motion tracking and stereoscopic picture enabling the user to realize locations, objects, actions, and form connections like they would in real life, thus helping spatial learning. 7 out of 8 participants were focused on the spatial information and recalled spatial information over other information about the VR experience. Thus, it was clear that in the cases where participants had a choice of multiple sources of information, they preferred to digest spatial information rather than narration, traditional videos, or texts. Therefore, cases where providing spatial information is crucial, VR seems to have excellent possibilities for learning.

Physical sensation related value co-creation constructs (1) were singular but 3 out of 8 participants stated it to have caused sensation of excitement. Excitement was already recognized in the context of engagement, and similarly it results from presence induced by stereoscopic picture and motion tracking of the VR platform. The relationship between physical sensation and presence was suggested by Kwon's (2018) study, the relationship was also clear in the findings of this study.

Interactivity related value co-creation constructs (5) were interest from interactivity, learning by trying things, improved spatial understanding, curiosity from lack of freedom, and satisfaction from freedom. All participants benefitted from one or more of these value co-creation constructs. Especially engagement from interaction was found to be important as well as learning from trying things, and understanding the presented virtual environment better by interacting with it more than what 3 degrees of freedom allowed. Thus, interactivity would allow the users to be active learners by trying things and exploring, rather than observe passively.

Cognitive load value co-creation constructs (1) were only singular, where two participants stated that the HMD solution did reduce their cognitive load as they were visually isolated from the surroundings or unable to multitask, thus improving their focus on the learning task. The positive effects of VR on the cognitive load were not discussed in previous literature.

Presence value co-creation constructs (6) represent which features co-created value to result in improved sensation of presence. 7 out of 8 participants experienced at least one of the co-creation constructs. In this study the VR platform features such as 3 degrees of freedom, being able to see hands, and perceived fidelity of the virtual environment were especially notable sources for improving presence. These features enabled realistic representation of a virtual environment, which the users' senses did perceive convincing and then on experience of presence emerged. The tested VR solution did not have social features, and thus co-presence was only recognized in one value construct where an avatar representation of another VR user interacting with the participant in VR would have resulted in possible co-presence. Finally, the visual isolation from the real world because of HMD solution did make the illusion of user being transported to some other place more striking according to one participant. As the findings of this study show, presence is directly related to concrete experience because the participants stated the VR experience to feel like being at the real location or they would have wanted to try experiences such as culture, art, or emergency training which require real experiences rather than pictures and lectures. Furthermore, the presence value constructs related to conveying spatial information, engagement, and concrete learning experience.

Next, the value co-destruction constructs findings relating to the VR learning experience are discussed. In this study's findings there were 24 individual value co-destruction constructs of which engagement had 5, sociability 4, spatial information 1, physical sensation 3, interactivity 3, cognitive load 2, and presence 6. The value co-destruction constructs are presented in the table 16. The frequency in discretionary sample for each theme, and number of participants experiencing each value co-destruction construct are presented as well.

Value co-destruction constructs			
Engagement:	75.0%	Interactivity:	50.0%
Annoyance	4	Couldn't focus on information	2
Forced experience	1	Frustration from usability	1
Fear of falling	3	Forced due to lack of control	1
Reduced social interaction	1	Cognitive load:	62.5%
Tried learning methods less effective	3	Too much information	4
Sociability:	62.5%	Unable to control progress	3
Social anxiety	3	Presence:	62.5%
Social judgment	2	Physical discomfort	1
Sociability distracts from subject	2	Lack of fidelity	2
Using VR reduces real interaction	1	Haptic feedback	1
Spatial information:	25.0%	Lack of narrational continuity	1
Reduced focus on other information	2	Lacking freedom of movement	1
Physical sensation:	50.0%	Play area borders	2
Vertigo	3		
Eye strain	1		
Worry of physical toll	4		

Table 16 Value co-destruction constructs of all VR learning themes.

Engagement value co-destruction resulted in variety of emotional (3), behavioral (1), and cognitive costs (1). The emotional costs were such as annoyance, forced experience, and fear of falling which all were a result of VR platform's features like usability, immersive qualities resulting in negative perception of physical sensation, or lack of control due to perceived low interactivity. The behavioral costs were due to the HMD causing visual isolation and thus it is harder to interact with people around, which for one participant was clearly undesirable quality. The cognitive engagement cost was because of tried learning methods being less effective, such as writing notes while learning. The results highlight the emotional costs which emerged in 8 cases while cognitive costs emerged in 3 cases. Comparing to the co-creation, the co-destruction has far fewer differing constructs likely because the engagement can emerge from variety of personal reasons which are easier to discuss in an interview situation, but lack of engagement emerges mostly as negative emotional responses or VR failing to fill some preconception the user has.

Sociability value co-destruction constructs (4) were based on assumptions and perceptions the participant had after their VR test experience, since there were no social features to test and only one passive observer in the test situation. Despite this, the participants had strong varying reactions for suggested social scenarios stemming from the VR testing experience and their social preferences. The social anxiety (3), social judgment (2), and reduced interaction (1) were the value co-destruction constructs for social situations where there would be people around in the same room while the participant is using HMD VR solution. These were mostly because of visual isolation, where the participant felt like they could not see what the observers are looking at or the observers would be judging the participants the actions and they thought they would look embarrassing or silly while using VR. These thoughts did change completely if the observers would be people they trust or are good friends with. The impact of visual isolation on the social value co-destruction seemed to depend as well if the observers would be able to see what the VR user is doing in virtual environment or being able to participate instead of only observing. Sharing the VR space with someone did in two cases emerge as negative towards the learning experience as according to the findings, it could distract from the subject.

Spatial information value co-destruction construct (1) finding shows that in two cases, the participants preferred to pay attention to only spatial information as it was made so compelling by the VR platform's characteristics that they paid no attention to other types of available information. While this finding might be result of immense spatial information that was available, it is likely that the reason for other information being discarded was cognitive load. The information overload is discussed more with cognitive load value co-destruction later.

Physical sensation value co-destruction constructs (3) regarded the negative perception of the involuntary reactions body had to the realistic stimuli enabled by movement tracking and stereoscopic picture. The participants experienced vertigo and eyestrain. The software features affected the sensation of vertigo in the participants. Said features can also be used to reduce vertigo, like in this study, play area borders were recognized to reduce vertigo because it reduced the sensation of presence. Eyestrain was likely because of the VR hardware, but it is possible that the quality of the 360-video was low and caused some eyestrain as well. While the resolution of the screen affected two participants' experience, most perceived the quality enough high that it did not affect their sensation of presence. The participants stated that software showing play space as virtual representation of the real space did reduce sensation of vertigo but reduced sensation of presence. Thus, using software features to control presence would be effective method to reduce simulator sickness although it clearly comes at the cost of presence.

Interactivity value co-destruction constructs (3) regarded control and usability. Control, or lack of control was because the tested VR solution did offer minimal interaction to control the pacing of the experience because the 360-video solution offered no interaction with the virtual environment and the participants were only able to bring up additional information at times. Furthermore, the findings show that lack of control affects the learning process negatively because the user is not able to pick when they are ready to advance to the next part. The lack of interactivity reduced the participants' need to do more than look around and press single buttons here and there if they so desired. Furthermore, the VR platform allowed using hands which did mean the participants did not need to get used to which button does what on controllers, but instead they could see their hands in the virtual environment and press the button as if they were doing it in real world, making the experience intuitive. There was only a single recorded case where the user felt like there were any issues with usability. Arguably, lack of interactivity, using hands to control intuitively, and perceived ease of use are connected. Therefore, intuitive features seem to be important for reducing issues with usability and time it takes for users to adapt effectively interacting with the virtual environment. Another benefit of intuitive design is that it encourages sensation of presence by providing interactivity which fits users' schema of reality.

Cognitive load value co-destruction constructs (2) relate to amount of information and controlling it. These constructs emerged from the visual information surrounding the participants and lack of software side control. As previous studies show, the cognitive load in VR is caused by abundance of information which also was clear in this study. What is especially interesting, is that since the participants were unable to control their progress, they felt like it was a major factor for the perceived cognitive load as they were rather focusing on the spatial aspects instead of trying to take in other information. Therefore, being able to control VR experiences' progress is especially important for learning situations as it reduces cognitive load and increases engagement because the participants can in learning situation choose what they desire to take their time with and what not.

Presence value co-destruction constructs (6) show the main reasons the participants sensation of presence was disturbed such as lack of fidelity, lack of interactivity, lack of narrational continuity, and visible play area borders. These four cover the most (66.7%) of the value co-destruction constructs regarding presence and they all relate to software, while the rest (33.3%) relate to hardware. The latter two were physical discomfort and lack of haptic feedback. This highlights the role of the software in experience of presence, and clearly the 360-degree video solution had several issues that were deemed immersion breaking by the participants. Despite this, the users clearly experienced sensation of presence which was a result of both hardware and software affecting the sensation.

The individual value co-creation and co-destruction constructs present multiple connections between them to one another, and most importantly the perceived values of the VR participants. Next, the third research question is further examined.

3. *How the perceived user values affect experiential learning during VR use?*

In this study, experiential learning model (Kolb, 1984) was examined and multiple connections between the recognized TCA themes and the facets of the experiential learning model were proposed. This is relevant for the goals of this study for two reasons: First, the VR learning was recognized to be heavily depending on the experiential learning. Second, because Stevens and Jouny-Rivier (2020) did show that in the context of online configurators, experiential learning is antecedent of technology acceptance model (TAM) which leads to perceived user values. They proposed a dual learning model where the perceived value of the system is a combination of TAM and the value of the offering. Therefore, in the context of VR, the findings of this study propose that value constructs relating to engagement, sociability, spatial information, interactivity, cognitive load and presence directly affect the experiential learning process, while sociability and physical sensations affect the VR learning experience which then on affects the experiential learning process. Here only the value constructs that were recognized to affect the experiential learning or the VR learning themes affecting it are considered, hence the different number of value constructs are presented in this section compared to the total number of value constructs that were recognized in this study. The total value constructs regarding VR learning themes can be seen to affect the complete experience, but for reliability and rigidity of this study, the connections that were clear from the findings of this study are only considered here. Figure 10 presents how recognized value constructs affect VR learning themes, and furthermore how they affect experiential learning in VR. The relationships are presented as arrows to imply direction of the effect. The numbers with each line present value co-creation constructs in green (above) and value co-destruction constructs in red (bellow).

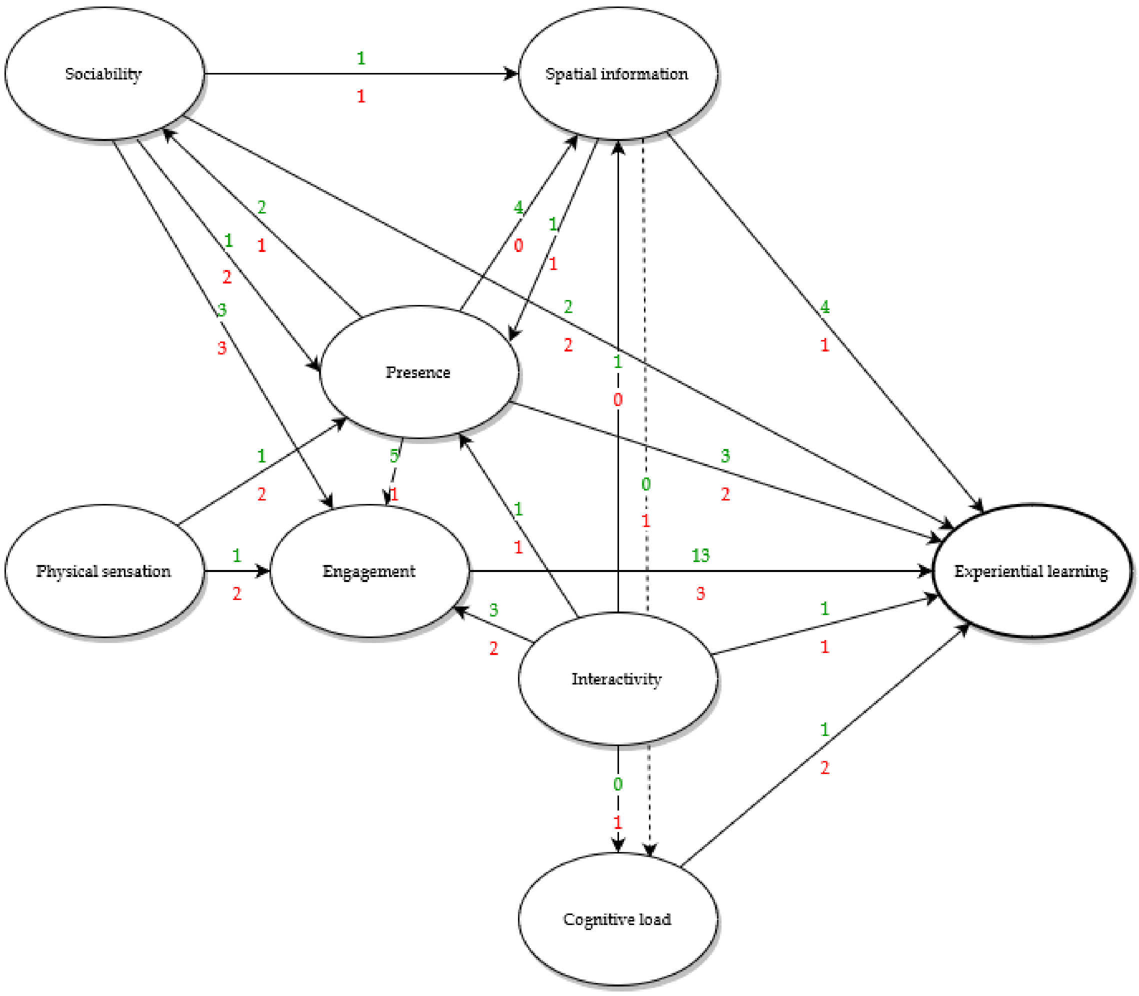

Figure 10 How value co-creation and co-destruction constructs affect VR learning themes and leads to the experiential learning.

As presented previously, engagement, sociability, spatial information, interactivity, cognitive load, and presence directly affect experiential learning process while physical sensation affects the other VR learning themes, indirectly contributing to experiential learning as shown in the figure 10.

13 engagement value constructs connected to the experiential learning. Those were *interest, fun, excitement, attainment value, improved work life, improved well-being, improved financial decisions, improve society, improve personal goals, environmental values, improve career planning, learning is rewarding,* and *intrinsic interest in VR technology.* Value co-destructions constructs were *annoyance, forced experience, and fear of falling.* These engagement value constructs affected what information the users would internalize in the abstract conceptualization phase of the experiential learning.

The sociability value constructs affecting experiential learning were *utility value* and *learning from sharing and discussing.* Negative effects were from *sociability distracts from subject* and *using VR reduces real interaction*. These constructs regard cooperative learning and sociability affecting focus on the subject.

The spatial information value constructs affecting experiential learning were *remembering locations, remembering objects, remembering actions,* and *forming connections.* Negatively affecting value construct was *reduced focus on other information*. Spatial information was distinguished from presence as presence was intended for user experienced sensation. Furthermore, spatial information in VR was recognized as important source of knowledge which the participants did remember and focus on, thus its contribution to experiential learning should is significant.

The interactivity value constructs affecting experiential learning were *learning by trying things.* Contrarily, negative effect was from *couldn't focus on information* value construct. The tested solution did have very little possibility for interactivity, thus being unable to control the experience was found to affect information gathering and hence experiential learning. As shown by the findings, the participants were able to test their preconceptions about interactivity and actively experiment with how VR works.

Cognitive load affected experiential learning positively because of *VR reducing cognitive load by focus,* where the user does not get distracted by other stimuli than what the VR presents. Therefore, the concrete experience through VR highlighted. The negative value constructs were *too much information* and *unable to control progress,* where users are presented with too many stimuli or they are not able to take their time with presented information, thus causing cognitive load that lowers their experiential learning potential during VR use.

The presence value constructs affected experiential learning by making the virtual experience a more concrete one. This included positive constructs *being able to see hands, 3 degrees of freedom,* and *fidelity of virtual environment* as well as negative value constructs *lacking freedom of movement* and *lack of fidelity.* These, again, depended heavily on the individual and their personal experiences with virtual environments. Some users desired more fidelity and freedom, which could be argued to result from previous experiences with virtual environments. The presence was recognized to affect concreteness of the experience.

Furthermore, the study did reveal connections between the VR learning themes. Sociability affects to engagement positively by being socially engaging (*learning from sharing and discussing, sociability distracts from subject matter,* and *utility value from sociability).* The negative effects towards engagement were *social anxiety, social judgment,* and *reduced social interaction*. Sociability affected presence because of social immersion *sociability distracting from subject matter*, where co-presence makes them distracted from subject, but seeing other user's avatar causes playfulness and interaction within virtual environment, much like in real situation. Sociability affecting presence negatively comes from *social anxiety* and *social judgment,* hence the user would be distracted from the place illusion because the user acknowledges people around might be judging their actions, thus they do not want to fully immerse into the VR, and they avoid acting naturally in it. Sociability affects spatial information because of similar value construct; *Learning from sharing and discussing* allows VR users to share information they otherwise would have missed. With the participants of this study, it emerged as participant finding it important for noticing information as they could only look to so many directions during the 360-video experience and inevitably they would miss something, thus having someone there to share the experience with would lead to more complete understanding. Contrarily, negative effect of sociability to spatial information was similar to previous VR learning themes; *Sociability distracts from subject matter* is important as it could affect the spatial information gathering, because users might be busy interacting with each other, hence not paying attention to the virtual environment.

The spatial information value constructs regarding fidelity did affect presence (*fidelity of virtual environment* and *lack of fidelity)*. These were attributed to spatial information because the participants did regard the visuals presenting spatial information either high quality and detailed or lacking desired resolution. Thus, spatial information presented by VR platform contributes to user experienced presence. Furthermore, spatial information partially causes cognitive load because of abundance of spatial information in VR can be overwhelming as shown by *reduced focus on other information* value co-destruction constructs.

The interactivity value constructs were shown to affect engagement, spatial information, and presence. Engagement because of interactivity was recognized from *interest, curiosity,* and *satisfaction from freedom,* while negative value constructs were *forced experience* and *frustration from usability.* Therefore, interacting with virtual environment makes users more interested in the VR experience and satisfied with the VR experience, while lack of interactivity or usability issues lead to lower engagement. Interactivity affected spatial information positively by allowing better understanding of spatial features by enabling exploration and different perspectives as presented by value construct *improved spatial understanding*. Interactivity affected presence according to the findings by allowing *3 degrees of freedom*, but also *lacking freedom of movement* value co-destruction construct did show missing freedom of movement features made the place illusion weaker.

Presence affects engagement, spatial information, and sociability value co-creation and co-destruction constructs. Value constructs emerging from presence in engagement were *interest, fun, excitement, impressed by technology,* and *VR providing new learning method.* Only co-destruction one in this context was *fear of falling* which is related to physical sensation enabled by presence. Spatial information value constructs *remembering locations, remembering objects, remembering actions,* and *forming connections* emerge from combination of spatial information and presence, while negative value construct is *reduced focus on other information.* These spatial information value constructs are affected by presence because it is dominant VR characteristic in making users feel like the virtual surroundings are real, which is enabled by the stereoscopic picture and head tracking. The users rather focus on visual fidelity and virtual environment's spatial properties rather than focus on reading and listening in VR. Presence also affects sociability as users are able to *learn from sharing and discuss* more effectively because VR can convey information more effectively than other digital mediums. VR solutions can have lifelike virtual communication, depending on the VR platform's capabilities. Social situations shared by co-presence were also recognized enjoyable for the participants. Although issues recognized with sociability during user emerged from *using VR reduces interaction* value construct which shows that when user is immersed into VR their interaction with people observing is hindered. This relates to sociability's effects on presence and highlights that co-presence by sharing virtual environment is important. Features such as avatar representation of the observer using a desktop to control the avatar could result in co-presence even without the observer using VR.

Physical sensation did not have direct contribution to the experiential learning according to findings of this study, but it does contribute to presence and engagement experienced by VR users. The physical sensation value co-creation construct *excitement from physical sensation* and co-destruction construct *vertigo* as well as *eye strain* affect engagement the users feel because they are excited by the realistic sensation of danger or high places while other users perceive similar sensation undesirable or uncomfortable. Eye strain caused annoyance, thus making the user experience worse. The same value constructs also affect presence, where desirable physical sensation causes excitement like in real situations while heavy simulator sickness makes the experience uncomfortable and reminds of the fact that the user's body is not experiencing what the user is seeing.

According to the finding, the experiential learning process is used for both determining perceived ease of use and perceived learning outcome, which leads to perceived value of the VR as proposed in chapter 4.3. This finding utilizes the dual learning model by Stevens and Jouny-Rivier (2020) but extends it to VR context. First, the connection between experiential learning facets and value construct themes emerging from this study are discussed and after it the relationship of the dual learning model to findings of this study is discussed.

Concrete experience is affected by spatial information, presence, physical sensation, and interactivity. These themes were found to contribute to the realness of the virtual experience as presented previously. VR platform's sociability also was recognized to lead to more concrete experience.

Reflective observations were highlighted in this study because the lack of interactivity the VR platform provided. This resulted in passive learning where the participants would observe the surroundings rather than actively trying to interact with it. The role of spatial information in what the participants did recall was especially clear because they did state little to none detailed information about the process but plentiful details about the surroundings and sizes. This highlighted the role of VR platform's features allowing users to collect spatial information much like in a real environment. The role of cognitive load at this stage was also found to be important determining what kind of information the participants observe as in this study, they observed spatial information over other. The role of sociability in reflective observations did emerge as cooperative learning where users would discuss and share information they are gathering, but it was found to also have possibility for distractions, hindering the process.

Abstract conceptualization facet according to the findings is affected by personal significance of the subject. This means the participants formed generalizations about subjects that they perceived useful for their future. Thus, the engagement theme as presented in this study connects especially to this facet of the experiential learning. The engagement stemming from personal interests, utility, and cognitive engagement were found to be important for the willingness to partake in the abstract conceptualization. The role of personal engagement was found to affect both the subject presented by the VR solution as well as the use of VR itself.

Active experimentation in the VR experience's subject was not possible because of the software limitations, but the participants did clearly partake in the experiential learning phase regarding the VR experience itself. The findings show that the participants experientially studied how the VR platform works, what it is good for, and how they could utilize it in the future.

Overall, the value of VR experience rather than the subject was highlighted when questioned how the participants would benefit from the experience. This could be because of what the participants were especially focused on. Five of the participants were intrinsically interested in VR technology even before the testing, and once having had the experience all participants were interested in trying it again. Contrarily, only two of the participants stated they had some interest towards the metal refining subject. Therefore, the findings further suggest that the personal relevance in the experiential learning is especially important.

Finally, the problem with usability affecting learning in VR. In this study, the participants had little to no previous experience in using VR and in only one case there were some issues with the usability. It was previous presented that the low interactivity or intuitiveness of the user experience were reasons for this. The intuitiveness would be more intriguing answer for the perceived usability from the experiential learning standpoint, because the user is going through two experiential learning cycles at once: One for learning how to use the system and another for the subject. The intuitiveness would mean the previous abstractions of how to use the VR system are perceived correct and the user can operate VR according to them, thus they can focus on the subject. This is aligned with Stevens and Jouny-Rivier (2020) dual learning model.

5.2 Relation of the findings to previous studies

The value co-creation and co-destruction perspective for the recognized VR learning themes is especially interesting because it shows the relationship of each VR learning theme to the user and the source of the said value co-creation or co-destruction construct as presented previously.

Actors in value co-creation are important for co-production of value (Lusch & Vargo, 2006; Vargo, et al., 2008; Ranjan & Read, 2016). The participants of this study were recognized as the main benefactors. During the participants using the VR platform, the value was formed which was presented by the recognized value co-creation and co-destruction constructs. Thus, value-in-use as seen in S-D logic (Vargo & Lusch, 2004) confirmed. This study recognizes VR hardware and software as main sources of value co-creation, while value co-destruction was, in this case, often because of the software. The various features of the VR platform and how the users perceived them did formulate the co-created or co-destructed value. Considering the components of VR platform from a value perspective is rare in previous literature. Often the components are regarded as just the full VR platform (e.g. Nussipova et al., 2020). Approach taken in this study to separate them when possible did allow yet another benefit for more intricate examination of value-in-use, thus giving more valuable results for practice and literature.

Most of the engagement value constructs fit the taxonomy presented by Fredricks et al. (2004), because it did have emotional, behavioral, and cognitive sides as well as considered costs. Therefore, value co-creation and co-destruction side were present. Only differing engagement value was intrinsic interest in VR technology, which was separated from interest in the subject to highlight the difference in user having interest in VR before partaking to a VR experience. Intrinsic interest comes from the user's institutions, rather than the VR experience. This study did also present a more in-depth reasoning for how VR engagement forms, stemming from user values and what affects them. The previous studies presented general reasons such as interest, gaming features, and VR experience (Bodzin et al., 2020), thus this study presents rich new value-based information about VR engagement.

The importance of the sociability in VR learning experience was clearly present by the findings of this study. Especially interesting was the findings regarding value co-destruction as they were recognized equally important in social VR use experience. This is diverging compared to the previous studies where value co-creation was heavily favored, and social value co-destruction was not presented (e.g. Pallot et al., 2017; Holopainen et al., 2019). Partially, this could be because of the VR testing setting that had no social interaction other than the guide observing the VR testing situation, and therefore the participants perceived social situations where they would be using VR more negatively than how they would have actually experienced it. The findings regarding social value co-creation such as enjoyment, knowledge sharing, and safety values were consistent with the previous studies regarding value co-creation from cooperation or sociability (e.g. Pallot et al., 2017; Mei et al., 2021; Holopainen et al., 2019; Salam & Farooq, 2020). The sociability value co-destruction finding regarding HMD VR solutions reducing interaction with the people in same space was in line with the study by Brown et al. (2016).

The effectiveness of VR in convoying spatial information to a user is prevalent in previous studies regarding learning benefits of VR. This also was recognized in this study's findings. Parong et al. (2020) and Makransky et al. (2019) proposed that presence does not equally help with all learning tasks, and it could be because of other information than spatial information needed for the learning task. The findings of this study point towards same conclusion because 7 out of 8 participants did recall detailed spatial information clearly over all other. The reason for this could be cognitive load, which was also recognized to severely affect internalization of information during the tested VR experience as was presented in the value constructs of chapter 4.2.6 regarding cognitive load findings. This observation is also consistent with study by Makransky et al. (2019).

Physical sensation depending on users' interpretation can lead to increased presence as shown by the findings. This is in line with Kwon's (2018) study. The same effect was perceived differently depending on the user which is a great example of value-in-use (Lusch & Vargo, 2004) where the institutions of the user can decide the value outcome. The induced vertigo from virtual heights was also excellent for memorability as many of the participants did highlight it from the VR experience in good or bad. The participants experienced no medium or strong simulator sickness symptoms such as nausea. This could be because of the relatively short VR testing but likely the 3 degrees of freedom that the VR software restricted the movement to did as well reduce motion sickness, as suggested by Dziuda et al. (2014) and Kim et al. (2018).

Interactivity enabling the users to learn by active experimentation and exploring the virtual environment were findings that corresponded to the previous studies about the role of interactivity in VR experiential learning (Kwon, 2018). The limited interactivity in the tested VR solution did cause value co-destruction stemming solely from the software design, but despite the lack of interactivity with the subject, the users were recognized to have experientially learned about VR use. Furthermore, for less VR experienced users 3 degrees of freedom is satisfying enough. Clearly this is as well depended on the institutions of the user. Congruent relation about value-in-use and institutions affecting VR experience was presented by Nussipova et al. (2020).

Increased presence was recognized to be because of VR features interactivity, cognitive challenges, sociability, and physical sensation. These are similar to expected causes of presence from the literature. What is especially interesting regarding presence findings is that because of the user centric approach the source of the value-in-use could be examined as well as the benefit of it. Presence did affect value constructs of engagement, sociability, spatial information, and interactivity while it was also important for creating lifelike experience for the user and thus enabling the experiential learning. These findings are similar to Dalgarno and Lee's (2010) learning benefits of presence, although the findings of this study can be connected to specific features such as 3 degrees of freedom, being able to see hands, or HMD blocking the users view, making the findings more descriptive of the phenomena. Slater (2009) did also argue that user being able to perceive their body in virtual environment would be strong cause of presence, which this study's findings confirm.

Because previous studies have recognized usability as an issue in VR experience (eg. Makransky et al., 2017; Holopainen et al., 2019; Rupp et al., 2019; Nussinpova et al., 2020), it was interesting that only one participant had any issues with the usability, which was especially surprising because participants had little to no previous VR experience. This could be explained by the intuitiveness of use in the tested VR solution, as presented in previous chapters. The users did not need to go fully through the experiential learning process to learn how to control the VR experience as it did fit their previous schema of how to look around and press buttons in real life. Intuitive design in VR software and hardware features such as no need for controllers could help with issues stemming from usability when the users are new to VR experiences. Interestingly, previous studies do not consider the experiential learning's role in usability of VR. Furthermore, the findings show that experienced presence seemed to connect to the virtual environment behaving as previous schema of the user expects which is in line with findings of Sanches-Vives (2016).

Finally, the experiential learning theory as presented by Kolb (1984) and how this study's findings compare to previous. The application of experiential learning in VR context has been focused on the virtual concrete experience that the VR provides, rich with contextual information and possibility for interactivity (Kwon, 2018) but interestingly the other facets of experiential learning model have been only examined once (Fromm et al. 2021) according to the literature review. Fromm et al. (2021) focused on user centric approach, which differs from the value approach of this study, although there are some similarities such as examining VR platform's elements for the sources of the experiential learning affordances. This study suggested clarifications to the experiential learning facets from user value perspective:

On concrete experience the findings do not differ from the findings of study by Kwon's (2018) where spatial information, presence, physical sensation, and interactivity were important for concrete experience, although this study proposed physical sensation to indirectly contribute. Furthermore, sociability was also proposed to affect presence in form of co-presence. Co-presence or sociability leading to more concrete experience enabled by the sociability features of a VR platform was recognized in only one case, but it could have more meaningful implications to the concrete experience. Especially this could be true if the VR platform did have sociability features as suggested by previous studies (Davis et al, 2009; Müller, 2011). In the study by Fromm et al. (2021) co-presence was found especially important for concrete experiences enabled by VR in group tasks, this is supported by the findings of this study as well.

Reflective observations were found to be heavily focused on spatial information. The benefit of improved spatial knowledge in VR use has been recognized by previous studies (Dalgarno & Lee, 2010; Parong et al., 2020). The role of cognitive load at this stage was also found to be important determining what kind of information the participants observe. In this study, they observed spatial information over other. Cognitive load's relation to presence was suggested by Makransky et al. (2019), but the findings here specify it to information presented by VR and preference towards the information that VR characteristics emphasize which is spatial information. Fromm et al. (2021) presented that observing what other people do in VR would allow for reflective observations, but in the case of the tested VR solution, this did not become apparent, although the desire for interacting with the virtual environment to observe how it would affect it was clear in this study. Holopainen et al. (2019) did present similar social VR setting where observers of VR use contribute to the experience. Therefore, the findings of these studies suggest that in cases where a learner can observe through a screen or co-presence in the virtual environment what another user sees or does, reflective observations can happen.

Abstract conceptualization process being guided by the personal significance on what information the user generalizes for future use was not found in the previous literature. Although it is uncertain if this is completely unique finding since the literature review for this study is not exhaustive especially not on the experiential learning, but the relationship between personal significance and abstract conceptualization is clear from the observed findings of this study. This could be partially reason why previous studies see engagement as a benefit of VR learning (Atsikpasi & Fokides, 2021), but engagement alone does not always mean better learning performance as found by Madathil et al. (2017). From this study's point of view, it would be because the engagement is focused on the VR experience and not learning the subject, thus abstraction is done about VR instead of the subject. Of course, other factors such as type of learning task as presented earlier do affect the effectiveness of VR learning as proposed by Makransky et al. (2019).

Active experimentation in this study was mostly focused on testing the perceptions about how to use VR and the experience, rather than the subject itself. It was suggested that it could be because the VR solution did not provide means to interact with the surroundings for testing and receiving feedback. Fromm et al. (2021) presented that active experimentation phase would be connected to interaction with objects, intelligent agents, feedback, and realistic scenario. The suggested connection to lack of interactivity with the virtual environment does seem to align with Fromm et al. (2021) study's connections to VR features. The difference between the findings of this study and Fromm et al. (2021) regarding the experiential learning facets could be because of the different VR solutions. The different VR features affect user experience and the experiential learning.

5.3 Implications for research

This study utilized the S-D logic perspective on value-in-use, where the value of the service forms during use from co-creation and co-destruction depending on how the VR user perceives the service (Lusch & Vargo 2004). Thus, service value is based on the subjective experience. As presented in this study, the S-D logic had not been previously used to understand VR services in learning context and the previous studies focusing on VR value co-creation were few. The empirical findings of this study support usefulness of the S-D logic for examining learning in VR services as it was found to allow examining VR learning outcomes, processes, and sources for specific learning outcome. This approach did also make it possible to understand personal motivations stemming from more than just the learning process, thus allowing differentiating value outcomes resulting from VR platform and learning. Furthermore, value-in-use perspective allows us to understand how same feature did lead to different learning and value outcomes for different users.

This study took initial steps to open discussion for how to explore VR services in learning use from value-in-use perspective. The recognized learning themes and the presented value constructs can be used by future research as basis to understand value co-production in VR learning context. The value constructs present reasoning for connection between VR feature, learning outcomes, and user experience, which was unique contribution for VR learning context.

Nussipova et al. (2020) did show that activities in using immersive VR technology led to emotional response and thus value-in-use was formed, but their study did leave details of cognitive processes open. The findings of this study present more nuanced understanding of user actions and perceptions leading to learning in immersive VR. The findings of this study did explore meaningful value constructs that affected the experiential learning process, resulting in learning outcomes and perception of VR usefulness, which together formed perceived value of the service from user standpoint. This contributes to dual learning model by Stevens and Jouny-Rivier (2020) by extending it to VR context, which is discussed more later. Furthermore, the proposed value constructs were directly related to the VR learning themes (Figure 9) and their effect on and relationships to the experiential learning were presented (Figure 10). These findings regarding the formed theoretical framework contribute to the literature by closely defining how different VR learning themes contribute to the experiential learning during VR use from S-D logic value co-creation and co-destruction perspective, which has not been done by previous studies to same extent.

Secondly, this study proposed specific VR learning value constructs to affect specific facets of the experiential learning theory by Kolb (1984). Concrete learning experience has been linked with VR learning by multiple studies and here, more specific value constructs were determined, where views of previous studies seem to support it. More interestingly, value co-processes were found useful for determining what information the users absorb and distill during the reflective observation and the abstract conceptualization facets. This study did show that the value constructs describing engagement were useful for determining what information the specific user preferred to gather during the learning process. As shown by previous studies, high engagement to VR learning use does not always correlate with learning results (Madathil et al., 2017). This study's findings show that engagement can be directed to subject learning or VR learning which can determine the target of successful learning outcomes. This seems to be unique contribution of this study regarding use of the S-D logic in unraveling VR learning services and learning outcomes. Overall, this approach can be used to understand how specific learning outcomes form during the experiential learning process from the VR service properties and the user's personal institutions.

The usability of VR service has been a nuance in both theoretical and practical domains. This study proposed that users engage in simultaneous experiential learning processes where one is focused on learning to use the VR device during while they are also engaged in one regarding the learning subject. Therefore, success in putting previously made generalizations about how to use VR is important for lowering cognitive load and focusing on the learning subject. This extends dual learning model presented by Stevens and Jouny-Rivier (2020) from context of product configurators to understanding value formation into VR services. Following their model, TAM's perceived usefulness of the service, ease of use, and how the service supports the experiential learning stages combine into total perceived value of the VR system. This study did show the VR learning process can be unraveled using the S-D logic, and thus the differences between value outcomes from VR platform's usability, content, and how personal institutions affect them were possible to be exposed.

5.4 Implications for practice

The implications of this study for practice are for both education and service design. This study's recognized value constructs presented a connection between value and learning outcomes to features of VR platform. This allows managers to examine learning services from perspective of more practical benefits and hinderances relating to VR platform features.

First, the educational implication of this study. The study shows that managers can evaluate VR learning platforms by understanding needs they have for their learning VR solution from practical standpoint, and then compare them to VR platform features which affect these required needs presented by this study. In this study, the value outcomes focus on the user perspective where the user outcomes formed from VR learning and VR use. The relationship of the value outcomes to the VR platform features was determined where applicable and the value outcomes were categorized according to the recognized VR learning themes, forming value constructs. Thus, the value constructs describe rich connection between the practical VR learning outcomes and VR features for managerial use. Therefore, the managers can evaluate VR features. For example, freedom of movement affects ease of use negatively while positively impacting spatial information collection and engagement. Alternatively educational managers can decide desired value outcomes and evaluate what platform features generate them. Thus, managers can make more informed decisions regarding their educational needs.

Previously, VR learning solutions have been seen as set of outcomes that depend on multiple VR system properties and are affected by multiple variables of the VR systems. While this is true, previous studies have not presented nuanced view of concrete subjective educational VR service learning and value outcomes as this study did, which is especially beneficial for practice.

Following this, the study did clarify role of engagement and usability in VR learning outcomes by detailing how it affects internalization of information for the learners. Using this understanding, the VR education can be designed to engage learners more effectively and to internalize the subject instead of just enjoying the VR experience. The findings suggest that making the subject meaningful for the participant's personal values is important in drawing attention from just playing around with the VR to the learning subject. Furthermore, as presented by previous studies, usability of the system is important for value outcomes. This study did further expand on the subject of VR usability as it was found to depend on how well the use experience matches learners' previous schema during the experiential learning. Therefore, educators should either focus on intuitive designs such as devices without controllers and real-life matching navigation and interaction with the virtual environment, or alternatively the VR device should be first tested out of the learning situation and then proceeded to the learning situation. This is suggested because of the finding regarding simultaneous experiential learning of VR use and subject would result in notable increase in cognitive load and then on to worse learning outcomes. This conclusion is also supported by findings of the previous studies (Makransky et al, 2017; Rupp et al., 2019).

Second, from the service design perspective, this study provides concrete implications for designing VR services as well as specifically VR learning services. Although the focus of this study was on the VR education, the method used to examine VR platform from the S-D logic value-in-use perspective was found effective for unraveling how service design affects the perceived value outcomes. Use of the S-D logic to guide practical service design is not a new phenomenon, and its value has been extensively explored. This study's specific contribution was taking more thorough perspective in value-in-use and co-production, and how it can be used to evaluate specifically VR learning service.

To use a concrete example, features such as using bare hands for controls, control over progress, and freedom of movement were especially prevalent in this study when examining value those produced for the users. The S-D logic perspective allowed this study to examine such features for how and what values they form for the user. Using bare hands enabled more intuitive user experience, where the user's previous schema of how they would push buttons or grab objects fits the VR use. This did lead to usability and presence, and then on engagement. Sanches-Vives (2016) did propose that virtual environment behaving according to the expectations of a user would increase sensation of presence which is aligned with the findings of this study. Allowing the participants to focus on the experience rather than VR device. Control over progress did affect learning experience by allowing user to decide amount of information which reduced cognitive load and increased engagement. Value co-destruction in the social situations could be reduced by features such as sharing view to a screen or rather using virtual social situations than having observers in the same room. These were just few examples of the 37 value co-creation constructs and 24 value co-destruction constructs recognized in this study which all can be used to better understand how user experience forms in VR learning services, thus contributing to better service design. As apparent from the value constructs, the service designers can evaluate how specific features affect value-in-use as well as they can recognize device or software features which affect the experience in desired manner.

As seen by the intricate findings of this study regarding how service features connect to value-in-use and learning outcomes. Service designers can consider taking advantage of a similar value-in-use based evaluation method for their VR learning platform to understand how the value co-creation and co-destruction emerging from it affects users' experiential learning, as shown to be an effective method by this study. This approach to evaluation of VR services during the service design would lead to user satisfaction and more effectively reaching business or educational goals.

6 CONCLUSION

This study did explore learning during immersive VR use. The goal was to understand more in-depth how the perceived user value-in-use in this context formed, and how it connects to the VR learning themes. Therefore, the study needed to first explore how VR affects learning. This was done to form a theoretical framework for this study presenting initial relationships of VR learning themes and their relationship to the experiential learning. Then, the learning specific VR value co-creation and co-destruction occurrences were explored in an empirical study to evaluate and test the framework. Furthermore, the emerging value constructs were then used to explore connection between perceived values and VR platform's features, as well as the experiential learning.

The theoretical background of this study was formed from a literature review. First, the main characteristics of VR immersion, presence, and interactivity were used as starting point. Second, prevalent learning effects of VR were explored and recognized to be connected to presence, flow, sociability, cognitive load, physical sensation, engagement, and learning from experience. Third, the lens to understand value formation, which was the main goal of this study, the S-D logic (Lusch & Vargo, 2004; Vargo et al., 2020) was honed. The S-D logic relevant literature was explored as well as previous VR value formation literature. The theoretical background's intention was to create basis for the empirical part of this study in form of the theoretical framework.

The empirical part of this study used qualitative methods to meet the goals of this study to understand VR value co-production in use during a learning experience. The focused interview method (Hirsijärvi & Hurme, 2008) was chosen for this study's data collection method because it would be fit for explorative study and allow the participants to express their views on the themes formed from the literature review. For the study, eight focused interviews were conducted where the interviewees were students from local education consortium Gradia. All the participants were active students, and with little to no previous experience in VR. This allowed similar background between the participants especially because as part of this study a VR testing events were arranged. All the participants did test a immersive VR experience. The subject of the VR experience was metal refining process, where 360-degree video from inside a metal refining factory was pictured. Oculus Quest 2 HMD VR device was used as the VR test platform. The device and software were provided by Metso Outotec. The focused interviews lasted average of 38 minutes and 55 seconds, which resulted in transcribed data set of 23743 words.

The data from the focused interviews was analyzed using thematic content analysis method (Anderson, 2007). There were twenty emerging themes from the data analysis, which presented variety of value co-creation, co-destruction and learning nuances for the findings. The relation of the themes was examined by comparing them to the previously recognized VR learning themes to evaluate the theoretical framework.

The first main finding of this study did present 37 value co-creation constructs relating to engagement (16), sociability (4), spatial information (4), physical sensation (1), interactivity (5), cognitive load (1), and presence (6). Contrarily, total of 24 value co-destruction constructs were recognized relating to engagement (5), sociability (4), spatial information (1), physical sensation (3), interactivity (3), cognitive load (2), and presence (6). The recognized value constructs described the value co-production outcomes during the use of the VR platform as perceived by the user. These constructs included connection to the VR platform's features or user institutions where available from the data, as well as the co-created or co-destroyed perceived value for the user. The value-in-use perspective and co-production of value did bring fruitful results regarding how value forms in context of VR learning.

The second main finding of this study was theme to theme connections between recognized VR learning themes as well as their connection to the experiential learning by Kolb (1984). The recognized connections show how the VR learning themes affect one another and the experiential learning. They were proposed to be useful for explaining perceived VR learning benefits and hinderances. The experiential learning was found to be directly affected by value co-creation and co-destruction constructs of engagement (13 co-creation and 3 co-destruction), sociability (2 co-creation and 2 co-destruction), spatial information (4 co-creation and 1 co-destruction), interactivity (1 co-creation and 1 co-destruction), cognitive load (1 co-creation and 2 co-destruction), and presence (3 co-creation and 2 co-destruction). The number of value constructs affecting the experiential learning directly differs from total number of recognized value co-creation constructs because not all constructs were recognized to affect the experiential learning directly. Only VR learning theme not recognized to affect the experiential learning directly was physical sensation, but it affected engagement and presence, thus indirectly affecting the experiential learning according to findings of this study.

The third main finding in addition to the connections discovered between perceived value outcomes and VR platform features, was proposed direct connections between the value co-creation and co-destruction categories to the facets of experiential learning processes by Kolb (1984). Presented value constructs did show connections between perceived user values and the VR platform's features.

The value constructs found to connect to the concrete experience were similar to previous studies where spatial information, sociability, presence, and interactivity would affect concrete experience. Physical sensation was presented to indirectly affect it unlike in study by Kwon (2018). The reflective observations were found to be affected by VR platform's characteristics, thus highlighting spatial information collection instead of other available information in the context of this study. The abstract conceptualization facet was proposed to be affected especially by personal significance of the subject. This means that when contested, choosing which generalizations to form is mainly decided by the perceived significance of it for the user. The active experimentation was recognized to be happening because the users were mainly focused on testing their previous preconceptions and formed generalizations on how the VR platform works, but they were doing less active experimentation about the learning subject of the VR solution. The experiential learning being used for both learning to use the VR platform and learning about the subject was also recognized, which expands Stevens and Jouny-Rivier (2020) dual learning model to the VR service context.

This study contributes to the literature in several ways. First, this study shows that the S-D logic (Lusch & Vargo, 2004) can be used to unravel value-in-use, co-creation, and co-destruction of value in the context of VR services. This is especially clear in the findings that show different value outcomes from same VR service use, thus subjective nature of value outcome is clear. For example, physical sensation was perceived positively and negatively because in three cases caused sensation of excitement while three cases it was perceived as undesirable. Also, the benefit of this approach to understand VR services and VR learning was demonstrated by the nuanced and varied connections that the S-D logic perspective allowed to be found between VR features, personal institutions, and value outcomes. Second, the theoretical framework formed from the literature review was enhanced and detailed to represent connections between VR learning themes and the experiential learning. The theoretical framework gives more intricate understanding of how the VR themes affect the experiential learning during VR use. Third, the proposed connections to the experiential learning theory (Kolb, 1984) presented interesting possibility to understand antecedents of VR experiential learning and how they affect the learning outcome. For example, the abstract conceptualization facet was found to be heavily affected by engagement as the user's personal interests and perceived personal benefits guide what the user generalizes. Fourth, this study extends dual learning model (Stevens & Jouny-Rivier, 2020) preliminarily into VR learning context. This perspective can be used to unfold VR service value formation considering role of both the VR platform use experience and the value of the subject. Furthermore, the dual learning model was shown to be useful for understanding role of ease of use in VR learning outcomes. The users are focused on experientially learning about how to use the VR platform while they are experientially learning about the presented subject. Thus, new users or challenges in usability hinder the subject learning. Overall, the implications for literature are foundational work for the co-creation or co-destruction focused VR learning service thinking.

The implications of this study for practice are mainly for education and service design. Education can benefit from the results of this study by better understanding the benefits and hinderances of offerings with specific VR features or use cases. This can assist in choosing which VR hardware and software best corresponds to desired value or learning outcomes during use of the VR platform. Therefore, the value co-creation and co-destruction constructs presented in the findings have practical use as is. The insights about the experiential learning process can also be used to benefit practice, as those describes significance of perceived personal value to what the participants focus their generalization and thus learning efforts on during a VR learning experience. Multiple valuable connections between the experiential learning and VR learning themes of this study were pointed out in the findings. The implications for service design are as well related to the value co-creation and co-destruction constructs presented in this study, but in more generalizable manner as this study did show that value formation as seen in the S-D logic is an excellent for evaluating perceived value as it emerges from use of VR services. This was especially unprecedented perspective in the learning context and provides great basis for VR learning service design especially as the S-D logic has been successfully used to assist service design in other contexts.

6.1 Limitations

This study is not without limitations. First, the theoretical background regarding VR learning is not an exhaustive review, but rather a synthesis of main recognized themes found in the literature explored for this study. Therefore, some learning effects of VR might not have been included in the literature review of this study which would affect the findings due to the research design. Despite this, the results of the study, even if incomplete regarding all the facets of VR learning, does show interesting and transparent insight about the included VR learning themes as well as their relationship to the experiential learning.

Second, moving on to the empirical limitations. The tested VR solution was rather case specific, as in it was a 360-degree video solution with limited interactivity. Since only one VR solution was tested, the generalizability of this study is not as good as if multiple solutions were tested and data gathered from them. Different VR solutions with different features such as 6 degrees of freedom or sociability features could have caused different perceptions and thus differing results. Although the approach used in this study did allow examining discretionary sample with extremely similar previous experiences and forming more accurate generalizations in the case of this specific VR solution. Furthermore, as presented in previous chapters this study did provide several generalizable results relevant for practice and literature.

Third, number of the interviews is on the low side, which was a result of time constraints as well as surprisingly low number of participants considering the total size of the possible participant pool. The preferred number of interviews would have been as many as needed until no new data is found as stated by Hirsijärvi & Hurme (2008), but this was unrealistic due to the time constrains and the low number of participants. Consequently, low number of initial participants also forced to opened up the backgrounds of the participants to include not just final year students of upper secondary school creating some variation in the discretionary sample. As stated in the empirical section, this could also be a benefit, as differing backgrounds with same VR experience can allow more diverse findings. Despite this, all the participants were recruited from active student background and locally from one institution, thus their backgrounds are relatively similar which makes the results of this study dependent on only one discretionary sample. Therefore, the discretionary sample can be considered homogenous, which is a limitation on the generalizability.

Fourth, in the case of this study, author of this master's thesis was the interviewer who did not have previous experience in the focused interview method and the two conducted exercise interviews were found less than optimal. It could be suggested that skill of the interviewer was somewhat limiting earlier interview results, but those interviews did still provide quite rich data for this study.

Fifth, similar problem as in the previous case, the thematic content analysis was solely completed by the author of this master's thesis who also conducted the interviews. This creates a possible limitation in objectivity of the analysis process, because of personal connection to the study and the material. Second coder would have been useful to ensure objectivity, but in the case of this study it was not possible as it is a master's thesis. To reduce the impact of this limitation, the analysis process steps and choices were thoroughly described in the empirical section of this study and feedback about the process was requested from the method supervisor of this study.

6.2 Suggestions for future research

This study did stir up multiple possibilities for future research. As the purpose of this study was to examine VR learning from the S-D logic value perspective, it did open up several possibilities for creating further understanding regarding value co-creation and value co-destruction. The value constructs presented in this study are rather general presentation of the co-production process resulting from use of VR platform. Therefore, more intricate examination of the value co-creation and co-destruction would be desirable to further define how these processes connect to features of VR platforms. For example, future studies could examine personal values resulting from use of VR service in learning context. This could mean using value typologies such as by Tuunanen and Kuo (2015) or similar to define personal value and use them as basis for understanding how VR learning affects user values from various perspectives. Another possibility could be using means-end (Gutman, 1982) model more thoroughly to explore VR learning. This could result in a more intricate understanding of how VR learning values connects to service attributes. Although this study did create foundation for this, it should be further examined to better understand the value chains. Furthermore, this study did examine VR learning as a whole, thus future studies could rather focus on a specific VR learning theme from the S-D logic perspective to more entirely define value constructs relating to it, or how it affects the experiential learning through value.

Stemming from the limitations of this study, other VR platforms should be studied in the learning context. The tested VR solution had no sociability features and very limited interactivity. It was also presented that some aspects of this study's results regarding the experiential learning facets when compared to Fromm et al. (2021) study did differ. It was suggested to be partly because of the tested VR solutions. Therefore, other types of VR solutions examined from value perspective should enrich the understanding of how VR platform features affect experienced value. The differences between this study's findings and Fromm et al. (2021) findings in the experiential learning connections did show that testing variety of VR solutions would be important to understand more thoroughly how the experiential learning facets are affected by VR. The future studies should consider quantitative methods, where multiple VR solutions are tested and examined. Overall, this study did focus on qualitative methodology, thus the proposed results of this study are great for basis of scientific discussion, but the field would greatly benefit from quantitative approach to similar research problem. The proposed theoretical model for connections between the VR learning themes and the experiential learning from value co-creation and co-destruction perspective is dependent on the results of one data set as stated previously, which was limited by nature of master's thesis. Therefore, quantitative research with larger and more varied data sets could produce more generalizable insights on how VR affects user's experiential learning.

This study also proposed connections between the value constructs and facets of the experiential learning model by Kolb (1984). It should be expected that the connections presented in this study between the themes of VR learning and the experiential learning are not exhaustive, but it opens up discussion to how to improve experiential learning in VR as well as how the specific VR learning themes affect it. Further studies regarding value-in-use and co-production during the VR learning experience would greatly benefit VR learning use and further expand upon the experiential learning theory.

This study did show that the value view of the S-D logic can be used to unravel VR experience outcomes in learning context. Furthermore, it was recognized from the literature review that there is only a handful of studies that examine VR from value perspective. Taking these findings into account, further studies on VR value formation are direly needed to understand the intricacies of value formation in VR use. This would especially benefit VR service design as the number of VR platforms in teaching, training, and entertainment use is skyrocketing with the improving technology and affordability of it.

Finally, the role of the experiential learning in usability of VR has been mostly unexplored by previous studies. Therefore, more research is required to further to shed light to proposed importance of dual learning model (Stevens &

Jouny-Rivier, 2020) which was briefly explored by this study. Further studies could examine the connections between experiential learning, TAM and perceived VR service value, which would give more insight into usability issues that keep hindering VR learning experiences. Furthermore, it could clarify applicability of the dual learning model to explain value formation in the context of VR services.

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APPENDIX 1 THE FOCUSED INTERVIEW FRAMEWORK

Background questions

- Age
- Gender
- Highest education, current education, or profession.
- Did you have previous experiences about metal processing or the subject?
  - Through which media?
- Have you used VR devices before?
  - What type? (Oculus, Index, 360 video, Google cardboard)
  - For what purpose? (Education, entertainment)
  - How much?

The focused interview themes and assisting questions

1. Using the device

- Why were you interested in testing VR?
- What assumptions did you have about using VR?
- How did VR's usability and controlling it feel?
- How did it feel to use the device?
- Did it feel safe to use the device?
- How did it feel that you couldn't see the real room where you were or what happened around you?

2. Focus and content

- How did answering the end questionnaire go?
- What helped to focus on the content of the VR tour?
- What in turn disrupted the focus on the content of the VR tour?
- What do you think of the information that the app or device told you about the process?

3. Presence, immersion and freedom

- What did you think of the content of VR application?
- How did time seem to pass when using VR?
- What do you think of freedom of movement in VR?
- What about the speed of the tour progress?
- What do you think of Interactivity in VR?

4.Education ja experiential learning

- What was the experience like?
- What happened in the experience?
- What do you think the experience is for?
- How do you benefit/be able to apply this experience and what you have learned?

- When would you choose VR for learning use?
- When would you choose more traditional media, such as video or paper, for learning?
- What did you think about use of VR in the context of learning/presentation?

5. Communication, preconceptions ja sociability

- What previous perceptions, opinions or information did you have about metal processing?
- What do you think now about metal processing / VR?
- How would other people being present in the room where you are using VR affect you?
- Would you have liked to be able to share the VR experience with others? (Social aspect)
- How did the presence of an instructor during your VR experience affect you?

5. Interviewee's own additions

- Was there anything else you wanted to highlight about your VR experience or something we did not discuss about?