Immersive Virtual Reality in Experiential Learning – A Value Co-creation and Co-destruction Approach

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Abstract

Immersive Virtual Reality (later VR) has its potential in enabling learning experiences. Several studies adopt experiential learning as a key concept to understand the outcomes of VR. This study consists of two parts – the first part conducts a systematic literature review on VR experiential learning and suggests seven main dimensions for the concept identified by the existing literature: engagement, sociability, contextual information, physical sensation, interactivity, cognitions, and presence. The second part adopts a value co-creation and co-destruction approach to empirically test the construction underlying VR experiential learning. The findings indicate 33 value co-creation and 19 value co-destruction constructs contributing to the seven dimensions. The suggested seven value construct dimensions combined with our own empirical findings and the theory of experiential learning, our research results build understanding about the experiential learning in the VR context and further encourages future VR learning research to test and validate these propositions.

Keywords: Virtual reality, experiential learning, value co-creation, value co-destruction, design features.

1. Introduction

This study considers immersive Virtual Reality (later VR) platforms combining a software to present a virtual environment and a hardware, such as Head-Mounted Display (HMD) (Pallot & Richir, 2016). Fully immersive VR solutions have shown their potential in improving users' learning motivation, engagement, and enjoyment in various education and training contexts (Atsikpasi & Fokides, 2021). By providing realistic experiences, VR is especially powerful in generating experiential learning (Kwon, 2018; Fromm et al., 2021). The experiential learning theory is a holistic model of the learning process where the role of experience is central in the learning process (Kolb 1984). Experiential learning consists of four stages: active experimentation, concrete experience, reflective observation, and abstract conceptualization (Kolb, 1984). Although some studies suggest that these stages of experiential learning are central in various VR education and training contexts (e.g., Kwon, 2018; Fromm et al., 2021), we need research and understanding of the value constructs that contribute to experimental learning.

In the present study, we propose value constructs which consist of perceived user value, relation to the VR platform or source of the value, and relation to learning dimensions. To explore how these value constructs can clarify construction of VR experiential learning, this study consists of two parts – the first part systematically reviews the literature on VR experiential learning and suggests seven main value construct dimensions for the concept: engagement, sociability, contextual information, physical sensation, interactivity, cognitions, and presence. The second part is empirical, adopting a novel approach of value co-creation and co-destruction (Plé & Cáceres, 2010; Echeverri & Skålén, 2021) to further test and analyze value constructs underlying VR experiential learning. By considering beneficial, but also disadvantageous constructs, i.e., tensions, the present study can provide improved theoretical interest and contributions (Palmatier, 2016).

The findings of the present study indicate 33 value co-creation and 19 value co-destruction value construct items contributing to the seven main value construct dimensions which are then proposed to contribute to experiential learning stages. These findings provide a better understanding for the future research of the structure of experiential learning in a VR context and encourage to further studies to validate the propositions.

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2. Theoretical background

2.1. Experiential learning

Kolb's (1984) theory of experiential learning has influenced the understanding of learning in immersive VR. Previous research promotes VR's ability to enable experiential learning (Fromm et al., 2021). The experiential learning theory is a holistic model of human learning, explaining how humans adapt to a social and physical environment (Kolb, 1984). To learn a skill, the learner needs to go through the four experiential learning stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). The learning stages form a cycle where concrete experience works as a basis for reflective observations, which then can be distilled into new abstract concepts and tested in the active experimentation stage (Kolb & Kolb, 2012).

Being a high-level theory, the Kolb's experiential learning theory's central themes and concepts are open to interpretation by scholars (Howard-Morris, 2020). Since detailing the theory in a clear context is necessary for implementation, testing and further theoretical development, the four stages should be clarified. This also gives an opportunity to explore some reasoning why the previous studies consider experiential learning to be prevalent in VR.

Firstly, a concrete experience is considered a real-world experience with hands-on participation (Howard-Morris, 2020). Real-world experience is rich with contextual information while hands-on participation requires active involvement with objects, environment, and people. The collection of subjective personal meanings to abstract concepts is important in the concrete experience stage (Kolb, 1984). Further, previous studies present the idea that VR enables concrete experiences through immersion and interactivity resembling reality (e.g., Kwon, 2018).

The second stage, the reflective observation stage, is a stage during which the learner takes a more passive role by observing the subject and what is happening because of the actions of others or their own. Less interactive VR experiences where the learner is traveling along predefined path without interactivity with virtual environment induces observer type learning (Kwon, 2018; Radiant et al. 2020). Reflecting requires analytical skills from the learner (Kolb & Kolb, 2012).

The third experiential learning stage, abstract conceptualization, is an act of distilling reflections about a subject into an abstract concept which can then be used to explain multiple situations (Kolb, 1984).

Last but not least, in the active experimentation stage, a learner tests formed personal implications by trying to solve the phenomenon at hand (Kolb & Kolb, 2012). VR experiences with instant feedback and high interactivity, such as being able to pick up and play with items found in a virtual environment, enable active experimentation (Kwon, 2018; Fromm et al., 2021).

The main 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 shown by previous studies where usability has hindered learning outcomes (e.g., Makransky et al., 2017; Holopainen et al., 2019; Rupp et al., 2019). This suggests that experiential learning may play a dual role in assessing the advantages and disadvantages of VR.

2.2. Value co-creation and co-destruction

Value manifests as an improvement or deterioration in the well-being of the actor (Vargo & Lush, 2018). The value of a service is determined in use by the beneficiary and co-created through resource integration by the actors (Vargo & Lusch, 2008; Vargo, Maglio & Akaka, 2008). Value co-creation focuses on collaboration between the customer and the service provider, during which the value of the service emerges (Vargo & Lusch, 2008; Vargo et al., 2008). This means the collaborators are active participants in the value co-creation, combining their resources to generate value (Vargo et al., 2020). Commonly, value co-creation is referred to in a positive sense (Vargo, Akaka, and Vaughan, 2017). In their work, Ranjan and Read (2016) present co-production as an important antecedent to value co-creation, forming from knowledge, equity, and interaction, which can be the collaborators resources.

In contrast, value co-destruction is an interactional process, much like co-creation, but one that leads to a decline in well-being for at least one of the involved parties (Plé & Cáceres, 2010). Value outcomes depend on the actor and the context (Vargo, Akaka, & Vaughan, 2017) which means one process can create value in one situation for one person while for another it destroys value (Plé & Cáceres, 2010; Echeverri & Skålén, 2021).

Both value co-creation and co-destruction are crucial for understanding user experiences. Understanding the value co-creation process and outcomes allows one to predict the effects of a service to its users (Ranjan & Read, 2016). Learning outcomes are a tangible way to evaluate and improve VR applications. As the concept of value co-creation and co-destruction has not been utilized in the context of experiential learning and VR, it thus has its potential to create new knowledge on the effects the recognized dimensions have on VR experiential learning.

3. Research Methodology

The present study applies two research methods: a systematic literature review (SLR) to conceptualize dimensions that affect VR experiential learning, and an empirical study testing and building the structure of experiential learning in a VR context.

3.1. Systematic literature review

The SLR was chosen as a method to comprehensively understand how academic literature perceives immersive VR dimensions that affect experiential learning. The literature search was done using four online academic research databases: Elsevier ScienceDirect, Elsevier Scopus, IEEE Xplore, and Springer Link. These databases were chosen because they comprehensively cover VR and learning focused academic literature.

For the search, the keywords used were strict to ensure relevance of the results for the immersive VR and experiential learning context. The keywords used were "experiential learning", "virtual reality", "head-mounted display", "immersi*", and "Kolb". Synonyms considered were "experimental learning", "VR", and "head mounted display". The main keywords regarding experiential learning, virtual reality, immersi* were searched for in the title, abstract, or keywords. Because of his original influential experiential learning theory publications, Kolb was searched from the reference field. As the final search term to specify the solution type, head-mounted display keyword was used.

During the search process, results were restricted to only include peer reviewed conference papers and journal articles, resulting in a total of 39 papers. Next, the papers were initially reviewed by title and abstract to remove duplicates, foreign languages, and papers without full text available. Following this, the resulting 35 papers were evaluated by title, abstract, and keywords for initial fit. The conditions for inclusion in the literature review were those studies to consider VR experiential learning and focusing on immersive VR. After the initial evaluation, 20 papers remained. Finally, the twenty remaining articles were thoroughly examined to distinguish studies considering dimensions affecting experiential learning. The final number of studies fulfilling all the presented criteria was four. Information regarding the recognized dimensions, how they affect VR experiential learning, results, and used methodology were then extracted from the studies.

3.2. Empirical study

The empirical study consisted of data collection using a focused interview method and thematic content analysis of the collected data. In the study, a value co-creation and value co-destruction perspective is central and is used as an analytical lens in the empirical study.

For focused interviews, it is especially important that the participants have similar experiences regarding the subject of study (Merton & Kendall, 1946). Thus, all participants were selected from volunteers interested in testing VR so that they had little to no previous experience with immersive VR and they tested a specific VR solution. In total, the study involved eight Finnish adults: 4 female, 3 male, and 1 other between 18 and 47 years old, with a mean age of 23 years (referred as Participants 1 to 8 or P1 to P8). All participants were actively studying in a local upper secondary or vocational school.

As material, the tested VR solution employed a 360-degree video based educational tour of a metal refining plant with some interactive elements such as optional animated videos and a short questionnaire. The experience was designed for a head-mounted display Oculus Quest 2 and took advantage of its hand tracking features so that the participant did not need hand-held controllers to interact with the virtual environment. Each participant tested the VR solution for 20 to 25 minutes, going through the full tour and the questionnaire while being observed by a researcher. The intention was to stimulate experiential learning where the participants would explore a real-life like environment related to a metal refining process as well as experientially explore the application of immersive VR for learning. After the testing, first impressions were collected and within five days the focused interview was conducted.

As the focused interview method only loosely follows a pre-planned set of questions and rather focuses on themes (Merton & Kendall, 1946), it is especially effective for exploring subjective experiences. The interview themes were chosen to follow hypothetically significant value construction dimensions discovered in the literature review: presence, physical sensation, engagement, cognition, sociability, interactivity, contextual information, and experiential learning stages. The focused interview segments lasted an average of 38 minutes and 55 seconds per interview.

To analyze the resulting transcription data thematic content analysis (TCA) following Anderson (2007) methodology was used. The main advantage of TCA for the study is its low hovering approach to data analysis making it excel in discovering new views according to how the data presents them. Hence, the intention is to distinguish common voices from the data, rather than interpret it (Anderson, 2007).

For the TCA, an analytical lens of value co-creation and co-destruction (Vargo & Lusch, 2008, Plé & Cáceres, 2010; Echeverri & Skålén, 2021) was applied to better understand how the VR dimensions are reflected in experiential learning stages. The participants' subjective perspectives on how VR hardware, software, use situation, and personal institutions in combination affect the VR value construct dimensions is central for the study. Thus, the interactive and phenomenological approach to value by co-creation and co-destruction (Vargo, Akaka & Vaughan, 2017) was seen as especially beneficial.

The TCA resulted in twenty themes containing detailed constructs around value co-creation and value co-destruction, with emerging themes having common motives or interconnections. For example, interactivity, presence, and freedom of movement themes all partly consider locomotive interactivity but have other differing elements, thus these were kept separate to avoid overgeneralization during analysis. This approach also ensured that the interconnections were preserved. Although twenty themes emerged using the TCA method, not all emerging themes considered VR experiential learning because the TCA method extracted common voices or the relevant content was represented by the examined dimensions (e.g., interactivity, engagement, and presence dimension represent all value constructs in the freedom of movement theme). The emerging value constructs under each dimension are further discussed in section 5.

4. Results of the SLR: dimensions affecting VR experiential learning

The conducted SLR found fourteen studies that use experiential learning theory in immersive VR education context, while only four of them more closely considered dimensions affecting the VR experiential learning. In other studies, the experiential learning theory has been applied to immersive VR education in a variety of areas: Emergency training (Mitsuhara et al., 2019; Xiao et al., 2020), nursing (Hannans, Nevins and Jordan, 2021), math (Zhou, Li and Bian, 2020), business (Fromm et al., 2021), foreign languages (Bian et al., 2022), science (Kwon, 2018), chemistry (Edwards et al., 2019), pedestrian traffic training (Feng et al., 2021) and retail employee training (Lau and Lee, 2021). All fourteen studies are recent, dating between 2018 and 2022.

Previous studies mostly use quantitative methodology and survey data collection. Two studies did interview data collection (Fromm et al., 2021; Feng et al. 2021), while one study utilized observations for data (Li. Ip & Ma, 2019). One study used an SLR focusing on VR in post-second level education and skill training, although their focus was not on experiential learning but rather recognized it and social constructivist approaches to be recommended (Concannon, Esmail & Roberts, 2019).

Four studies that evaluated dimensions affecting VR experiential learning were Fromm et al. (2021), Kwon (2018), Bian et al. (2022), and Lau and Lee (2021). The methodology, dimensions they recognize, and key findings are presented in Table 1.

In their recent work, Bian et al. (2022) used a quantitative study to explore VR learning environments which promote experiential learning. Guideline 1 suggests decreasing the amount of attractive but task-irrelevant distractors, while guideline 2 suggests guiding attention from task-irrelevant distractors to task-relevant elements (Bian et al., 2022). Their study focuses on improving performance by maintaining flow while reducing distractors. Recognized important antecedents to experiential learning performance were focus, interaction, motivation and engagement. Furthermore, the results of the study by Bian et al. suggest that task-irrelevant contextual information is a distractor causing cognitive load which then results in worse experiential learning performance.

In the qualitative study by Fromm et al. (2021), focus was placed on creation and testing immersive VR learning environments which enable experiential learning. Their study presented several design principles which affect specific stages of experiential learning in VR. For example, VR social features or system-enabled instructions enhance the abstract conceptualization stage, and the reflective observation stage requires appropriate performance feedback from the system (Fromm et al., 2021).

Kwon's study (2018) focuses on confirming experiential learning to be possible in VR. His findings show that the experienced presence allows for a more concrete experience which then enables experiential learning. According to Kwon, presence is mediated by vividness and interactivity, but also physical sensation contributes to it.

In their study, Lau and Lee (2021) explore knowledge sharing and transfer in organizations using immersive VR to train retail employees. They found that a successful VR learning environment can improve learning motivation, process, and satisfaction. Lau and Lee suggest three principles for the implementation of such factors: careful selection, appropriate design and pedagogical strategies, and effective use of virtual stimuli such as stereoscopic image, presence, and multisensory interactions.

All in all, the SLR shows that previous studies have recognized engagement (Bian et al., 2022), sociability

(Fromm et al. 2021), contextual information (Fromm et al. 2021; Kwon, 2018), physical sensation (Kwon, 2018), interactivity (Fromm et al. 2021; Kwon, 2018; Bian et al., 2022; Lau and Lee, 2021), cognition (Bian et al. 2022) and presence (Kwon, 2018; Lau & Lee, 2021) dimensions affecting VR experiential learning.

Table 1. Reviewed studies

Citation	Method	Key value construct dimensions	Key findings
Fromm et al., 2021	17 interviews (qualitative)	Contextual information, interaction, sociability, realistic scenario	Design elements of the key dimensions enable holistic experiential learning process.
Kwon, 2018	42 surveys (quantitative)	Interactivity, fidelity, presence, physical sensation, flow	Immersive VR enables experiential learning. Immersive VR benefits learning due to its vividness, interactivity, and presence.
Bian et al., 2022	111 Surveys & quiz (quantitative)	Focus, interaction, motivation, engagement, flow	Reducing fidelity enhances focus without damage to flow experience, enhancing learning.
Lau & Lee, 2021	326 surveys (quantitative)	Knowledge sharing, presence, stereoscopic image, multisensory interaction	Fitting application of VR increases learning motivation, process, and satisfaction. Effective use of stereoscopic image, presence, and multisensory interactions improves learning.

4.1. Theoretical approach

The SLR did present seven main dimensions contributing to experiential learning: engagement, sociability, contextual information, physical sensation, interactivity, cognitions, and presence. Their construction as well as positive and negative effects on experiential learning are often not considered by previous studies. The following findings formed the basis for the framework tested in the empirical study.

Presence is mostly recognized as having positive effects on experiential learning, such as better understanding of spatial features (Lau and Lee, 2021; Fromm et al., 2021), making a virtual experience more concrete (Kwon, 2018; Fromm et al., 2021), and positively affecting engagement (Zhou, Li, and Bian, 2020; Bian et al., 2022). Nevertheless, presence can lead to distractions (Bian et al., 2022) which suggests value constructs relating to presence dimension could affect experiential learning negatively.

Although the physical sensation dimension mainly has negative effects on learning in the form of simulator sickness (e.g., Bian et al., 2022), Kwon (2018) presents the view that it can have a positive effect in improving the sensation of presence because VR gives sensations similar to those which one would experience in a real situation.

As a combination of VR characteristics (Rupp et al., 2019; Fromm et al., 2021) and personal elements (Fredricks et al., 2004), the engagement dimension affects learning performance. VR engagement is considered a result of presence (Rupp et al., 2019), or game-like elements (Fromm et al., 2021). Education literature sees engagement emerge from an individual's interests, goals, and personality (Fredricks et al., 2004). Thus, it is arguable that VR features or content can also play a positive or negative role in engagement depending on personal institutions. Indeed, engagement affects academic performance (Rupp et al., 2019; Bian et al., 2022) and willingness to further explore the subject (Rupp et al., 2019).

The previous studies suggest that the cognition dimension has negative effects on VR experiential learning (e.g., Bian et al., 2022). Moreover, the cognition dimension includes a cognitive load which reduces participants' ability to take in information (Markansky et al., 2017; Rupp et al., 2019). This may be due to the fact that VR's excess fidelity can be a distraction (Bian et al., 2022) or other factors requiring task-irrelevant cognitive effort from the learner.

Due to co-presence (Fromm et al., 2021), improved mutual understanding (Lau and Lee, 2021; Holopainen et al., 2019), and feedback (Fromm et al., 2021), sociability positively affects VR experiential learning. In addition, learning from collaboration or life-like interaction have been a major focus of scarce VR co-creation literature (e.g., Pallot et al., 2017).

For VR experiential learning affordances, interactivity is especially important because it enables hands-on experience (Kwon, 2018), but VR learners can be worse off due to added complexity (Makransky et al., 2017). Tactile and locomotive interactivity contribute to a more concrete experience (Kwon, 2018; Fromm et al., 2021) and sensation of presence (e.g., Kwon, 2018; Bian et al., 2022; Lau & Lee, 2021). Further, interactivity can make less experienced VR users focused on usability instead of the learning subject (Makransky et al., 2017).

5. Results of empirical study

In the present study, the theoretical approach proposed seven dimensions. In total, 33 value co-creation constructs and 19 value co-destruction constructs relating to the seven dimensions were discovered using TCA methodology, as described in section 3. The recognized value constructs can be used to better understand the role of the VR dimensions in each experiential learning stage and are summarized in Table 2, where P1 to P8 are referring to the participants of the empirical study.

Table 2. Value constructs by dimensions and experiential learning stages as extracted by the empirical study

	Concrete experience	Reflective observations	Abstract conceptualization	Active experimentation
Engagement			Interest (P1, P2, P4, P5, P7), fun (P2, P7), excitement (P2, P5, P7), impressed by technology (P5), attainment value (P2), improve work life (P1, P6), improve well-being (P4), improve society (P3, P6), improve financial decisions (P7), improve personal goals (P7), environmental values (P3, P6, P7), improve career planning (P2, P6), social interaction (P8), learning is rewarding (P4, P5, P6, P7), VR provides new learning method (P1, P7), intrinsic interest in VR technology (P1, P5, P6, P7, P8). Annoyance (P2, P4, P5), forced experience (P8), fear of falling (P3, P5, P8), Tried learning methods less effective (P5, P7, P8)	Significance from environmental values (P3, P6 & P7), more informed decisions (P3), improved general knowledge (P4, P5, P6, P7), changing preconceptions (P7), newfound engagement to the subject (P4)
Sociability	Utility value (P7), learning from sharing and discussing (P4, P6, P7), social anxiety (P4, P6, P7), social judgment (P2, P3), sociability distracts from subject (P5, P7), VR hinders real interaction (P3)	Learning from sharing and discussing (P4, P6, P7), sociability distracts from subject (P5, P7)		
Contextual information	Remembering objects (P2, P3, P4, P5, P7), remembering locations (P2, P3, P4, P6, P7, P8), remembering actions (P4, P3, P5, P7, P8), and forming connections (P3, P4)	Remembering objects (P2, P3, P4, P5, P7), remembering locations (P2, P3, P4, P6, P7, P8), remembering actions (P4, P3, P5, P7, P8), and forming connections (P3, P4) reduced focus on other information (P4, P7)		
Physical sensation	Excitement from involuntary reaction (P2, P5, P7), Vertigo (P3, P4, P8)			Worry of physical toll (P3, P4, P5, P7)
Interactivity	Learning by trying things (P3, P8), improve spatial understanding (P5, P8), forced due to lack of control (P8), frustration from usability (P5)	Lack of control hinders focus on information (P4, P7)		Learning by trying things (P3, P8), improve spatial understanding (P5, P8), frustration from usability (P5)
Cognition		VR reduces cognitive load by focus (P4, P8), too much information P2, P4, P5, P6), unable to control progress (P4, P5, P7)		
Presence	Being able to see hands (P5, P7, P8), 3-degrees of freedom (P1, P3, P5, P6, P7, P8), Fidelity of virtual environment (P7), visual isolation (P8), physical sensation (P2, P5, P7), lacking freedom of movement (P5), lacking fidelity (P8), Play area borders reduce presence (P3, P5)	3-degrees of freedom (P1, P3, P5, P6, P7, P8), fidelity of virtual environment (P7, P8), social immersion (P7), lack of narrational continuity (P7, P8), lacking freedom of movement (P5), lacking fidelity (P7, P8)		

5.1 Concrete experience stage

In this study, contextual information value constructs which emerged during VR experiential learning of multiple participants were remembering objects (P2, P3, P4, P5 & P7), locations (P2, P3, P4, P6, P7 & P8), actions (P4, P3, P5, P7 & P8), and connections (P3, P4). The cost of rich contextual information delivered by the VR platform was reduced focus on narration or text form information (P4, P7).

The participants mainly experienced spatial immersion (being able to see hands – P5, P7, P8), 3-degrees of freedom (P1, P3, P5, P6, P7, P8), or lacking freedom of movement (P5) and fidelity value constructs (fidelity of virtual environment – P7, and a lack of fidelity – P8) contributing to the presence dimension. Though the physical sensation dimension seems to increase with a higher presence, resulting in excitement from involuntary reaction (P2, P5, P7) such as a rush of being in a high place, it was also perceived as a negative sensation of vertigo (P3, P4, P8).

Because of co-presence, where cooperative learning during VR experience would enable realistic learning scenarios, the sociability dimension contributes to the concrete experience stage. Thus, VR features which would enable social interaction are seen important. The contributing value constructs were learning from sharing and discussing (P4, P6, P7), utility value from sociability (P7), and sociability distracts from the subject (P5, P7). Using HMD solutions in a social situation hinders the concrete experience, where value co-destruction occurs because using VR hinders real interaction (P3), and causes social anxiety (P4, P6, P7) and feelings of social judgment (P2, P3).

The tested VR application allowed no meaningful interaction with the virtual environment, which reduced the potential for hands-on experience. To improve their knowledge collection, the participants desired tactile and locomotive interactivity. While tactile interactivity enables learning by trying things (P3, P8) where interacting with a virtual environment shows concrete connection between actions and results, locomotive interactivity improves spatial understanding (P5, P8) as the learner can change their perspective and explore.

5.2. Reflective observations stage

In the empirical study the reflective observations stage was seen especially important because the tested VR solution was designed to be a 360-degree video tour, resulting in passive learning during the VR experience. New knowledge was acquired by the participants from the VR stimuli which was added to their previous understanding of both the VR experience and the subject. This became clear as the participants had preconceptions about VR being challenging to control (e.g., Participant 6: "I was surprised that I did not need the controllers. It was a positive surprise, and I did not need to learn any specific controls, so it worked easily."), or that their understanding about the subject did change after the experience. In the tested VR solution, lacking narrational continuity (P7, P8), lacking freedom of movement (P5), and lacking fidelity (P7, P8) appeared to negatively reflect on this stage.

In the reflective observations stage, the participants were especially focused on contextual information: "I remember specifically when molten mixture was poured into a furnace or taken out of the furnace" (P5), or "I remember how that factory looked from outside when I was in a tower, and then there was a sea or something close by" (P7). Such focus on collecting contextual information could be explained by the VR platform features such as fidelity, presence, and stereoscopic image encouraging contextual information collection.

The cognition dimension seems to contribute to the reflective observations stage because of the preference for internalizing contextual information. Indeed, as participants were unable to control the pacing of information, their focus turned away from detailed information (P2, P4, P5, P6, P7). This was apparent in both cognition and interactivity dimensions. Contrarily, visual isolation by HMD emerged as a value construct easing the cognitive load, reducing impact of the surroundings on the learning experience (P4, P8).

When VR platforms enable learning from sharing and discussing (P4, P6, P7), the sociability dimension seems to reinforce the reflective observation stage. Moreover, learners benefit from the co-presence of other participants. However, sociability can distract from the subject (P3, P7), hence reducing the learner's focus on observing.

5.3. Abstract conceptualization stage

We propose that engagement has two roles for enhancing and enabling experiential learning especially in the abstract conceptualization stage. First, the participants formed generalizations for the future depending on the perceived usefulness of the information. The engagement value constructs suggest reasoning for what information the participants abstract. Engagement was found to stem from personal reasons and depending on the personal values, benefits, or motivation according to which the participants focused their experiential learning efforts on different aspects of the VR experience. In particular, hedonic values like excitement (P2, P5, P7) and environmental impacts of the metal refining industry enabled emotional engagement to the subject (P3, P6, P7). In addition, personal future benefits were important for what information the participants distilled: improving work-life (P1, P6), career planning (P2, P6), well-being (P4), financial decisions (P7), society (P3, P6), and personal goals (P7).

The second role of engagement in experiential learning is improving focus and participation because of VR. The participants in this study experienced emotional engagement and intrinsic interest in the VR technology, which made the perceived boring subject interesting. However, engagement focused only on VR technology does not always help in learning the subject. As three of the participants stated the subject was irrelevant to their life (P1, P3, P8), their willingness to generalize concepts and test them was greatly hindered, yet they still internalized information about VR technology and how they could benefit from it.

5.4. Active experimentation stage

The usability of the VR platform was the clearest case of participants indulging in active experimentation. In this study, the participants had assumptions about using VR technology. The hand-controlled VR experience was perceived intuitive and easy to use by the participants despite them not having previous VR experience. Therefore, we propose this intuitiveness comes from the participants actively experimenting with controlling the VR experience, and it responds to their actions as expected because their previously learned generalizations are working for the new use case. This was because the participants did not need to learn new control schemes but rather used their hands to interact with the virtual environment like in the real world.

The participants of this study experimented with the usefulness of VR for learning. The perceived value of VR for learning purposes emerged from the dimensions of spatial learning, sociability, interactivity, and engagement. Generally, these benefits are the result of experiential learning stages and the active experimentation stage confirms previous assumptions to be true or untrue. For example, this resulted in confirmations of how to benefit from VR in the future, such as training for life saving situations (P3), learning from concretely seeing surroundings (P6), making perceived dull subjects interesting (P7), or VR enabling convincing experiences (P2, P3, P4, P5, P6, P8). As well as these positive aspects, negative preconceptions were tested, such as worry of VR's physical toll (P3, P4, P5, P7) which did reduce the participants' willingness to test VR, thus hindering learning possibilities.

While only two of the participants stated they had some interest in the subject of a metal refinery, connections to utilizable information about the subject encouraged complete experiential learning cycles such as significance from shared values (P3, P6 & P7), more informed decisions (P3), improved general knowledge (P4, P5, P6 & P7), changing preconceptions (P7), or newfound engagement to subject (P4).

6. Discussion

6.1. Propositions

Seven main dimensions were proposed emerging from the SLR: engagement, sociability, contextual information, physical sensation, interactivity, cognitions, and presence. Moreover, the SLR found that the main bulk of the VR experiential learning studies employ quantitative methodology in a variety of educational contexts. Despite the fact that the experiential learning theory is considered the most influential learning theory in a VR (Radianti et al., 2020), only few studies have been found which consider the effect of VR dimensions on the experiential learning theory, namely Kwon (2018), Bian et al. (2022), Fromm et al. (2021), and Lau and Lee (2021). Furthermore, the aforementioned fourteen VR experiential learning studies all date from between 2018 and 2022, which shows the freshness and growing academic interest towards immersive VR experiential learning.

In the present work, the empirical study proposes to contribute to the literature and practice in a number of ways. First, the study pilots the use of both the value co-creation and co-destruction in the context of VR education research and shows that it is effective for unraveling how the dimensions are reflected in subjective experiential learning in immersive VR. In addition, it exposed detailed connections between VR features, personal institutions, and the stages of experiential learning rooted in experienced value, where previous studies have only focused on the general connection of dimensions (Kwon, 2018; Lau & Lee, 2021) or a limited set of design guidelines (Fromm et al., 2021; Bian et al., 2022).

Secondly, the concrete experience stage was found to be constructed by dimensions of contextual information, presence, interactivity, and sociability which is aligned with findings of previous studies (e.g., Kwon, 2018; Fromm et al. 2021). The co-destruction value constructs of sociability, physical sensation, interactivity, and presence dimensions present design choices which resulted in a distraction from the concrete experience; in contrast, the co-creation value constructs expose proposed enhancing features (Table 2).

Thirdly, the reflective observations stage was found to be dominated by contextual information and observations resulting from it. We propose that the cognition dimension limits the learners from absorbing all the information because of how information dense the VR learning environment can be and how VR features boost contextual and spatial information acquisition. Previous studies recognize cognitive load to hinder VR learning, but the effects of it on specific information types were not explored in the studies (Makransky et al., 2017; Bian et al., 2022).

Fourthly, we proposed that in the abstract conceptualization stage the learner's engagement determines what information they generalize. In particular, emotional engagement, personal values, utility values, and perceived personal benefits were found to affect the focus of abstract conceptualization. The result of this did manifest as task-irrelevant information being generalized; during the use of the VR technology, the learners focused their attention on learning about the VR technology rather than the subject which reduces task-relevant learning potential. Previous literature has considered engagement as a benefit of immersive VR for learning (e.g., Atsikpasi & Fokides, 2021; Bian et al., 2022) but the present study presented a more nuanced view of how some of the experiential learning benefits of engagement dimension occur.

Fifth of all, the findings of the active experimentation stage propose that VR learners indeed employ experiential learning for both VR use and subject learning, which would extend Stevens and

Jouny-Rivier's (2020) dual learning model towards a VR context. In the present study, the participants were found to experiment with VR usability, VR usefulness, and the subject. Furthermore, we proposed the perceived intuitiveness to be a result of successful active experimentation.

The findings regarding the experiential learning stages can already benefit educational managers in determining what type of VR learning solution best fits their needs and evaluating how to better support a VR experiential learning process before and during training. The value constructs of each dimension present multiple guidelines for how the construct benefits or hinders the experiential learning stages (Table 2), which can then be used to evaluate value of specific dimension.

Finally, VR learning service developers can use the study's value constructs to better understand the effects of design decisions on VR learning environments. Compared to previous studies (e.g., Fromm et al., 2021; Bian et al., 2022), the present study adds a more comprehensive perspective to how the dimensions affect VR experiential learning. Moreover, the proposed value constructs for each dimension can be used as rough design principles for what features to emphasize or avoid in developing more effective VR experiential learning solutions. Indeed, we propose that the value construct perspective can also be used to understand connections between dimensions, e.g., allowing more tactile and locomotive interactivity will increase the sensation of presence and then enable more concrete experiences, but simultaneously make the VR solution harder to use and increase the possibility of simulator sickness. In addition, the presented value co-creation and destruction lens can be utilized to examine VR experiential learning services in development.

6.2. Limitations and future research

This explorative study has a few limitations which should be addressed in the future research. First, the number of interviews for the explorative study is small and from a single educational consortium. This might reflect in the results because of the homogeneous demographic and small sample size. Therefore, future studies should replicate the methodology in larger sample sizes and in various locations for more transferable results. This approach could also better understand differences between different VR user demographics. Secondly, though the study did exhaustively explore value constructs of the specific VR platform configuration, VR platforms vary. Therefore, to form more generalizable design guidelines, the methodology of this study should be applied to VR platforms with different features to evaluate how those features are reflected in the value outcomes. Third, the dimensions affecting VR experiential learning should be further evaluated for interconnections and their relationship to experiential learning. Existence of causal relationships could be explored by future quantitative studies. Consequently, future VR learning research should aim to test and validate the presented propositions of this explorative study. Finally, the used SLR had strict keywords but more varied approach for a study focused on SLR could find more dimensions.

6.3. Conclusion

This explorative study aimed to clarify how VR dimensions are reflected in experiential learning. The study used an SLR on the use of experiential learning theory in immersive VR context. Moreover, an empirical study was conducted to test the recognized dimensions using value co-creation and co-destruction as an analytical lens. The value co-creation and co-destruction perspective provided an effective tool to explore subjective experiential learning process in VR context. As a result, the study's findings propose that the recognized seven dimensions have a role in VR experiential learning, and the presented value construct items show detailed reasoning for recognized subjective positive and negative outcomes. Further, the interconnections between dimensions were proposed, explaining the complexity and tension of design decisions. The present study also proposes that the experiential learning process is used for determining VR's usability, usefulness, and learning a subject. Furthermore, the role of engagement in the VR experiential learning process was clarified, determining the focus of learning effort between VR and subject.

7. References

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