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GETTING READY TO LEARN IN VR

A study on the onboarding process in collaborative virtual learning environments

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Program and/or course:	International Master’s Programme in IT & Learning
Level:	Second Cycle
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Supervisor:	Géraldine Fauville
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Abstract

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Keywords:	VR, Virtual reality, collaborative VR, collaborative learning, immersive virtual environments, virtual learning environments, user onboarding, VR onboarding.

Purpose: VR’s unique affordances offer significant potential for education, but the steep learning curve hinders users from fully benefiting from the technology. Onboarding plays a pivotal role in bridging the gap between novice users and the complexities of collaborative VR environments, contributing to the broader goal of making VR education more accessible and user-friendly. The study’s aim is to address this gap by identifying newcomers’ issues during onboarding and design an instructional activity to facilitate the onboarding process.

Theory: This study is informed by situated learning and cognitive load theory. VR’s immersive nature aligns with situated learning, promoting experiential understanding and social interaction within shared authentic environments. The immersive environment in VR can overload users’ working memory. When designing VR content, it is therefore essential to consider cognitive load and create well-structured learning materials to optimize learning outcomes.

Method: The overarching research method of this study is design thinking. Within the phases of the two iterative cycles, participant observation and semi-structured interviews were employed, with data subjected to thematic analysis. The iterative nature of the design process allows for the refinement of the onboarding activity. By closely involving participants and actively seeking their insights in both iterations, this study ensures that the instructional activity is designed with users’ needs in mind.

Results: First, challenges in the onboarding in collaborative VR were identified. To mitigate these challenges, a new instructional activity was designed, emphasizing clear, contextually relevant instructions, and a gradual introduction of functionalities. Participants preferred autonomy and practical tasks for learning. The study contributes to the advancement of onboarding strategies in the context of collaborative VR, ultimately enhancing the potential of VR for education.

Foreword

I wish to express my sincere gratitude to Dr. Géraldine Fauville for introducing me to the world of VR and supervising my thesis work. I am grateful for your guidance and support as well as the personal encouragement you provided during my internship and thesis journey.

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1. Introduction

This chapter sets the background and context of the study, laying the foundation for the research by highlighting the importance of onboarding challenges for the effective integration of virtual reality in educational settings. Additionally, the chapter outlines the rationale behind the study, the research aim, and the specific research questions to be addressed. Furthermore, it provides an overview of the thesis structure.

1.1. Context of the study

The recent rapid development of immersive virtual reality (VR) technology has unlocked a multitude of new possibilities and applications in diverse fields. As this technology continues to become more accessible and affordable to both households and institutions, its popularity and widespread adoption are increasing (de Back et al., 2020; Šašinka et al., 2019). The widespread availability of high-speed internet connection, namely 5G technology, is expected to enhance the accessibility of VR platforms as most VR applications require stable internet connection. Online spaces where people can interact, communicate, and share information virtually are playing a substantial role in people's lives and this trend is likely to continue as technology advances, making virtual environments (VE) more sophisticated and accessible (Pimentel et al., 2022). Critical thinking, problem-solving, and collaboration skills are essential for today's changing world and work environment as opposed to the routine tasks required by jobs in the 20th century. This shift presents the education system with numerous new possibilities, but also with the expectation of equipping young people to succeed in a rapidly changing world of technology, economics, and society (Makransky & Petersen, 2021).

Collaborative learning is a prominent approach in modern pedagogy which allows multiple users to interact and work on tasks together, triggering learning mechanisms (Šašinka et al., 2019). Jackson & Fagan (2000) theorized that virtual environments could offer distinctive collaborative opportunities combining the strengths of computer-based collaboration and face-to-face collaboration. Jin et al.'s (2022) work emphasizes the creation of realistic social environments to host collaboration as one of the key aspects of VR. The digital space in which multiple users share the same virtual environment, interact with it and each other is referred to as a collaborative virtual environment (Han et al., 2022). The unique affordances of VR, which are described in the literature review, make it a powerful learning tool that could potentially contribute to a paradigm shift in education (Han et al., 2022; Jin et al., 2022; Šašinka et al., 2019). Heather Bellini et al. (2016) predicts that VR might reach 15 million learners by 2025 and it is therefore of utmost importance to develop more informed educators, developers, and policymakers to prepare society for this ongoing transition (Pimentel et al., 2022). Research on VR for education is rapidly increasing. Makransky and Petersen (2021) identified over 2400 articles regarding VR in education between 2019 and 2020. However, as pointed out by Wu et al. (2020) more research on the practical application of VR for education is still needed.

1.2. Rationale of the study

A user must be familiar with the technology and must know how to operate it in order to effectively learn in the VR environment (Han et al., 2022). Freeman et al.'s (2022) study on the engagement of individuals in collaborative activities using collaborative VR[1], unveils that the steep learning curve of the onboarding process is one of the key aspects hindering the effective use of collaborative VR. Due to the novelty of VR, many users are not familiar with the hardware and software used in collaborative

[1] The literature reviewed in this study mentions either social or collaborative VR. However, for the purpose of this study, we will consistently use the term "collaborative VR", regardless of the term used by the authors as we are focusing on the learning component rather than the social aspects.

VR and might get overwhelmed by the novel experience. While this emerging technology introduces numerous new possibilities, it also poses new challenges to novel users, such as challenges related to the isolation from the real world and coordination and navigation in VE, which can lead to frustration (Chauvergne et al., 2023). Additionally, operating the controllers and navigating the VE might quickly overwhelm the user's working memory, leading to a higher cognitive load and reduced capacity for effective learning (Queiroz et al., 2023; Zhong et al., 2022). These difficulties hinder users from effectively engaging with VR, highlighting the need for efficient onboarding for novice users (Freeman et al., 2022; Khojasteh & Won, 2021).

1.3. Aim & research questions

Some studies highlight the significant role of onboarding in VR to avoid introducing this technology in education without the means to succeed (Chauvergne et al., 2023; Khojasteh & Won, 2021). Other researchers are pointing out the significance of collaborative VR for the future of education (de Back et al., 2020; Freeman et al., 2022; Šašinka et al., 2019). Yet, we could not find any studies focusing on the onboarding process for collaborative VR specifically. The aim of this research project is therefore to address this gap by investigating the onboarding process in collaborative VR platforms for educational purposes and designing an instructional activity that would address the encountered difficulties to aid this process. Although the available educational material aimed at younger children is increasing, most VR headsets are simply not designed for children. Additionally, there's not enough research yet about the long-term effects on children (Bailey & Bailenson, 2017). This study, therefore, focuses on higher education students.

The research questions of this study are:

> *RQ1: What kind of issues do newcomers encounter during the onboarding process in collaborative VR?*
>
> *RQ2: What instructional activity can be designed to facilitate the onboarding in collaborative VR?*

1.4. Outline of the study

This thesis includes a literature review to define VR technology, its affordances and challenges, and its application in education, followed by a brief overview of onboarding in VR. With the use of previous research on VR and collaborative VR specifically, we also provide a conceptual background to design appropriate VR instructional material in terms of usability. The theoretical framework provides an overview of the theories influencing the choices and point of view of the study, namely situated learning and cognitive load theory. The methodology section describes the structure of the data collection and analysis and the iterative procedure of the research based on design thinking. The methodology is followed by the analysis of participants' feedback and design of the instructional material and the presentation of the collected findings of each iteration cycle. Subsequently, we discuss the findings and end the thesis with some concluding thoughts, limitations, and recommendations for future research.

2. Literature review

This chapter provides an overview of VR, defining key terms, describing the affordances and challenges of VR in education, and emphasizing the importance of onboarding in the context of novel technologies in general and VR specifically. There is a subtle and easily overlooked difference between onboarding *for* virtual reality and onboarding *in* virtual reality, and this distinction is impossible to capture using the limited filtering criteria in a database search which posed challenges in extracting information, resulting in the adoption of alternative approaches.

2.1. Key definitions

Virtual reality (VR) is a computer-simulated environment in which the user has the impression of "being there" and the ability to interact with objects (Manetta & Blade, 1995). According to Craig et al. (2009, p.1), VR "creates an image of a world that appears to our senses … [like the] real world". Similarly, Freeman et al. (2017, p 46) state that VR simulates "the physical presence of people and/or objects and realistic sensory experiences". As noted by Jin et al. (2022), a common thread in most of the definitions is the immersive view achieved through simulations. Biocca (1992) indeed highlights the importance of this psychological characteristic of virtual reality, which transcends the technology used.

These simulated environments are accessed via a head-mounted display (HMD) (see Figure 1) that blocks the view of the physical world (Nguyen et al., 2017). The development of the first HMD dates to the late 1960s and focused on its deployment for military flight simulators (Karutz & Bailenson, 2015). In the following decades, HMDs were sometimes used for training simulations and research (Blanchard et al., 1990; Usoh & Slater, 1995), however, the technology was expensive and its availability extremely limited. In the mid-2010s the rapid technological advances allowed HMDs to become more affordable and subsequently more accessible (Hill & du Preez, 2021). One common feature among all HMDs is the use of a tracking system (Makransky & Petersen, 2021). These systems can track the users' position, digitally compose it, and display it to the users (Fox et al., 2009) creating a sense of depth perception through the rendering of distinct images for each eye (binocular overlap), and providing stereoscopic depth (Blascovich & Bailenson, 2006; Karutz & Bailenson, 2015). Users' movements are tracked and represented through avatars in computer-generated simulations. The combination of tracking systems and spatial navigation technology enables realistic interactions with the environment and other users (Bailenson, 2018; Jin et al., 2022).

The hardware used to access VR encompasses a wide range of technologies; commercially available HMDs range from low-cost wearable goggles that can hold a mobile phone screen in front of the user and turn it into an HMD utilizing the phone's built-in tracking system (e.g. Google Cardboard), to more advanced devices with spatial sound, tactile feedback and other sensing technologies that can enhance the users' immersion level (e.g. Oculus Quest 2) (Hill & du Preez, 2021; Jin et al., 2022; Karutz & Bailenson, 2015).

The digital space in which users perform actions is referred to as a virtual environment (Hill & du Preez, 2021). The virtual surroundings are rendered to the users' senses or a combination of senses, allowing the users to experience the virtual world as a physical space (Blascovich & Bailenson, 2006). While the perceived experience in a virtual environment may feel real, it does not always replicate realistic virtual surroundings (Fox & Bailenson, 2009). If users perceive themselves as part of the virtual environment, being present, the virtual environment can be classified as an immersive virtual environment (Blascovich & Bailenson, 2006). When multiple users can simultaneously access and interact with each other in the same digital space, it is referred to as a collaborative virtual environment (CVE) (Han et al., 2022).

Figure 1

Person using a Meta Quest 2 HMD (Meta, 2023a)

2.2. Technological features of VR

Certain features of VR are particularly significant for the context of learning and enable novel affordances in education. In this section, Pimentel et al.'s (2022) classification is used as a starting point to emphasize the most relevant technological features for the purpose of this study.

2.2.1. Interactivity

One significant feature of VR is its increased interactivity compared to traditional media. By tracking users' movements and rendering virtual environments accordingly, VR enables active interaction with the virtual world (Won et al., 2014). This active interaction results in enhanced cognitive engagement compared to conventional media (Hill & du Preez, 2021). As noted by Makransky and Petersen (2021), interactivity is linked to the degree of control given to the user over the virtual environment.

2.2.2. Immersion and presence

Immersion relates to "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" (Slater & Wilbur, 1997, p. 606). Immersion can also be defined as an objective technological characteristic that measures the degree of vividness of the virtual environment and its ability to shut out the real world (Cummings & Bailenson, 2016). It should not be confused with presence, which is the subjective feeling of being in the virtual world (Berkman & Akan, 2019; Cummings & Bailenson, 2016). Although these terms are sometimes used interchangeably, it is the immersive nature of VR's movement-tracking technologies that contributes to a higher level of presence (Cahalane et al., 2016).

While immersion is a quantifiable description of what a technology provides, presence is "a state of consciousness" often described as the feeling of "being there" (Slater & Wilbur, 1997, p. 606). The user's body reacts to the virtual environment (VE) similarly to how it would in the physical world, giving a sense of being part of the simulated environment (Bailenson, 2018; de Back et al., 2020). Several studies focus on presence in VE. Wirth et al. (2007) emphasize the importance of perceiving the VE as a believable space using spatial cues. The combination of these two dimensions is referred to as spatial presence (Cummings & Bailenson, 2016). Presence is further divided into two subcategories: self-presence (identification of the virtual self as the actual self) and social presence (identification of virtual social actors as real social actors) (Oh et al., 2018; Makransky & Peterson, 2021). Social presence refers to the feeling of “being there with someone”. Won et al. (2014) explain how identification with an avatar is possible through the concept of embodied cognition.

VR allows users to extend their natural opportunities and experiences beyond their physical limitations. For example, flying, which is not possible in the physical world, can be simulated in VR by using an avatar of a bird and tracking the user’s hand movements to render them into flapping wings. Bailey et al.’s (2016) research demonstrates that VR’s advantage in fostering presence over other media lies in the rendering of the user’s physical behavior in the avatar. The author further hypothesizes that this could lead to increased recognition of body ownership and more profound and transformative interactive encounters. Consequently, this would enhance feelings of engagement, immersion, and shared presence in social virtual reality collaboration.

2.3. Affordances and limitations in the educational context

The immersive, interactive, and multi-sensory characteristics of VR make it well-suited for specific learning objectives and approaches, but not recommended for others. This section outlines the affordances that VR brings to the educational context and the situations in which VR, if well-designed, can effectively enhance learning and address the limitations of this technology.

2.3.1. Affordances

Gibson (1979) defines affordances as the inherent potential actions that an environment provides to an organism, thereby influencing an organism’s behavior and interaction with the environment. Norman (2013) redefines Gibson’s concept of affordances for product design. He defines affordances as observable properties that prompt actions with objects, emphasizing the visible qualities that convey an object’s function. Unlike Gibson, who considers affordances as environmental facts regardless of the context, Norman emphasizes the perceivable properties suggesting an object’s use, departing from Gibson’s concept of direct perception (Cheng & Proctor, 2019). In this context, affordances are to be understood as particular qualities that align with specific learning objectives and processes and have the potential to enhance learning (Pimentel et al., 2022).

2.3.1.1. Motivation and interest

Virtual learning environments *“*can be used to facilitate learning tasks that lead to increased intrinsic motivation and engagement*”* (Dalgarno & Lee, 2010, p. 20). Several studies focus on the effect of learning in virtual environments on learners’ enjoyment, interest, and motivation, consistently confirming positive outcomes (Bailenson, 2018). The increased engagement and motivation are influenced by the high level of presence (Makransky et al., 2019). The participants in Han et al.’s (2022) study emphasized the high level of creativity that VR offers. VR opens doors to novel applications of firsthand experiences, which show having positive effects on students’ belief in their abilities, particularly self-efficacy, thus reaffirming the crucial role of motivation in learning (Pimentel et al., 2022).

2.3.1.2. Personalization & contextualization

Virtual learning environments “can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through the contextualization of learning” (Dalgarno & Lee, 2010, p. 20). By utilizing tracking and spatial mapping, learning environments can adapt to students and foster interaction between the student and the environment. It is clear, therefore, that VR has the potential to offer interactive learning experiences. VR allows for visual cues of concepts with stereoscopic 3D and true-to-size models, enabling a clearer spatial representation (de Back et al., 2020). It additionally offers the ability to *mod* and customize the environments, empowering users by giving them control over their own spaces, thereby enhancing the individualization of the learning experience (Karutz & Bailenson, 2015).

As mentioned in the previous chapter, a key aspect of VR is the level of immersion it offers. This quality can be leveraged to provide meaningful and immersive storytelling, introducing students to a topic, and helping them gain a deeper understanding of the context. It can also be used to help students identify with a novel avatar and role, explore identity, and develop social skills (Pimentel et al., 2022). An example of this is role-playing a specific character in a historical event. For instance, Time Studios offers a learning experience where users take on the role of a witness at Martin Luther King Jr.'s *I Have a Dream* speech in Washington in 1963.

2.3.1.3. Making the impossible possible

Virtual learning environments "can be used to facilitate experiential learning tasks that would be impractical or impossible to undertake in the real world and facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain" (Dalgarno & Lee, 2010, pp. 18-19). Virtual environments can be designed to immerse the student in a context relevant to the learning material. The unlimited creative possibilities that VR offers allow users to witness things that are usually impossible to see in real life (Bailenson, 2018). With VR, it becomes possible to overcome the limitations of reality and manipulate time, space, and gravity (Šašinka et al., 2019). This affordance is particularly useful in the educational context to simulate experiences that would be too expensive or dangerous to conduct in physical reality, such as virtual field trips (Fauville, 2017; Bailenson, 2018). These otherwise impossible experiences are one of the settings identified as optimal for the deployment of VR. While VR has the potential to enhance learning, its benefits may not be applicable in all situations. It is therefore important to question whether the use of VR is necessary. Bailenson (2018) introduces the acronym DICE to guide informed decision-making in this regard. VR is best suited for experiences that are otherwise *Dangerous, Impossible, Counterproductive,* or *Expensive* to conduct in real life.

2.3.1.4. Collaboration & social interactions

Virtual learning environments "can be used to facilitate tasks that lead to richer and/or more effective collaborative learning than is possible with 2-D alternatives" (Dalgarno & Lee, 2010, p. 23). Being part of a community plays a significant role in learning. Communities provide a rich environment in which students can participate in authentic activities and acquire knowledge and skills by interacting with more experienced members (Lave & Wenger, 1991). VR aids in the development of a community by hosting virtual meetings, games, and social networks (Pimentel et al., 2022). However, VR adds the ability to orchestrate users' actions and verbal communication (Dalgarno & Lee, 2010). By providing additional cues, VR enhances the connection with other users, ultimately facilitating the development of a learning community (Han et al., 2022). In Queiroz et al.'s (2023) study on the effects of collaborative learning, participants who built an environment together scored higher in terms of learning compared to the control group.

2.3.2. Limitations

Alongside its benefits, VR also faces several limiting factors that challenge its integration into educational settings. These factors encompass concerns about equity and accessibility, privacy and safety implications, the scarcity of suitable educational content, the impact of cognitive load on the learners, and the necessary adaptation of the mode of instruction. Addressing these limitations can lead to informed strategies for the successful incorporation of VR in education.

2.3.2.1. Equity

One barrier to the implementation of VR in education is the lack of accessibility. HMDs and VR content are generally not designed with inclusivity in mind, posing challenges for students with disabilities or limited mobility, particularly when it comes to using the controllers. Accessibility can also be understood in a broader sense, encompassing fair and equal access to resources for all students. VR currently lacks sufficient accommodations to support large-scale adoption. For instance, issues arise with the compatibility of headbands and certain hairstyles or hairpieces, as well as the discomfort experienced by users wearing glasses (Pimentel et al., 2022). Prolonged exposure to VR can cause discomfort like eye strain and nausea (Queiroz et al., 2023). For example, participants in both Han et al.'s (2022) and Hill & du Preez's (2021) studies reported experiencing dizziness. The concept of an avatar moving smoothly within the virtual environment can lead to simulation sickness. This occurs because when the avatar changes its position gradually, frame by frame, without any physical movement on the part of the user, it can cause a sense of disorientation (DeVeaux & Bailenson, 2022). A frequently adopted solution to address this issue is teleportation, where designers deliberately omit perceptual cues regarding the avatar's movement (Bailenson, 2018). Simulator sickness has been reported in several studies to affect women more frequently than men, potentially due to inter-pupillary distance (IPD). Although this distance can be adjusted, the shortest available distance may still be too large for individuals with smaller faces, marking a gender bias which can be attributed to the predominant influence of white and able-bodied males within the field (Jun et al., 2020; Mado et al., 2021). The same can be said for children, as their IPD is significantly smaller than adults'. Filipović (2003) measured a mean of 51 mm IPD in five years old children compared to 63 mm in adults over 20 years old while the Oculus Quest 2, for example, is optimized for IPD between 56mm and 70mm (Meta, 2023b).

Affordability is another crucial aspect to ensure that this technology becomes accessible to everyone. While the price of HMDs has significantly decreased in recent years, providing personal HMDs for every student would still be too expensive for most educational institutions (Li et al., 2021). Additionally, VR often requires a stable internet connection, which poses another barrier to widespread adoption (Dede et al., 2017). Equity barriers, as identified by Jin et al. (2022), are the primary reasons for the limited adoption of VR, particularly because these issues are not evenly distributed among the population.

2.3.2.2. Privacy and safety

Every activity in VR generates user data that is stored by the corporations behind the technology. This data can be analyzed to extract nonverbal behavioral variables that may potentially reveal sensitive information. This data collection, known as big data, is often linked to companies aiming to predict users' purchasing habits. Consequently, it is crucial to understand how to ensure students' safety and privacy before introducing VR into educational settings (Karutz & Bailenson, 2015).

2.3.2.3. Lack of educational content

Despite the constant increase in the number of VR applications, there is a significant lack of educational content to meet the needs of the educational system. This shortage is partly due to the prohibitive cost and time required to design quality learning environments. Additionally, educators face challenges in identifying content that aligns with specific topics, learning goals, and target age groups, as there is currently no appropriate platform to facilitate this process (Mado et al., 2021).

2.3.2.4. Mode of instruction

The mode of instruction in VR presents a new challenge for educators. In a 2D-virtual experience, users perceive both the physical and the 2D-virtual environment simultaneously (Cahalane et al., 2022). This is not the case in VR as HMDs block the view from the external world. In a more traditional setting with a computer, the student can point to an area on the screen to draw the educator's attention and ask questions about the specific topic, but in VR, their visuals are not shared. When a student in VR points at something with the controller in the virtual environment, the educator will see the physical finger pointing at their surroundings in the physical world. Educators, therefore, need to adapt their mode of instruction since they cannot rely on nonverbal communication, and the auditory cues are limited as HMDs include speakers that muffle outside sounds when reproducing audio media. This challenge is particularly evident in the onboarding context, where establishing communication with VR novices is crucial (Chauvergne et al., 2023).

2.3.2.5. Cognitive load

VR provides immersive simulated experiences with multiple visual and auditory stimuli. While these rich experiences can be engaging, learners may also feel overwhelmed by the abundance of stimuli (Zhong et al., 2022). The presence of these stimuli can increase cognitive load, consuming the limited cognitive resources required for processing them, thereby hindering effective learning. Han et al. (2022) emphasize that meaningful learning necessitates students' attentive consideration of details in the presented information, which becomes difficult to achieve when their cognitive capacity is overloaded. Additionally, as highlighted by Chauvergne et al. (2023), novices may experience a "wow-factor" in VR that can be distracting.

2.4. User onboarding

Nielsen (1994) stated that it should be possible for users to achieve a comfortable proficiency level for a system to be usable. A user-friendly interface can aid this process but in the case of more complex software it requires some guiding. Onboarding is the process of familiarizing users with the product and can take various forms, including tutorials, guides, and training sessions. Whenever users want to interact with a new digital product, some form of onboarding is involved. This is particularly necessary for more complex products where general knowledge or experience is not sufficient. The primary goal of onboarding is ultimately to help users reach a reasonable level of proficiency in the shortest time possible.

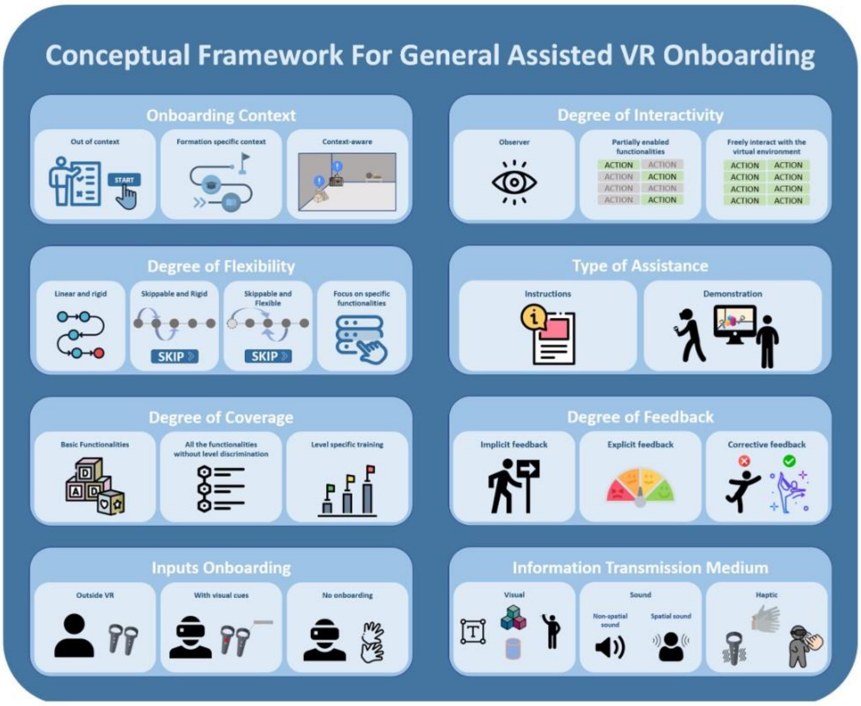
Onboarding in VR is crucial for first-time users due to the potentially overwhelming number of sensory inputs of the experience. VR hardware and the interaction paradigm it encompasses are new to most users and vary greatly from other technologies, consequently, transferring onboarding techniques is impossible. According to Chauvergne et al.'s (2023) exploration of VR onboarding, there are two primary forms of onboarding in VR: tutorials and training sessions. Tutorials allow users to follow instructions or videos and complete the onboarding process independently. Instructions in tutorials should be minimal, as too much information can increase the cognitive load and confuse the user, and action-oriented, as it can help keep the user focused, engaged, and motivated.

On the other hand, onboarding with an instructor, in which a physical person gives synchronous instructions and demonstrates actions to the learners, allows for a more personalized and interactive student-paced mode of instruction (Chauvergne et al, 2023). This mode of instruction, though, raises several implications for communication. Firstly, HMDs isolate users from the physical world, limiting communication in training sessions. Secondly, the novel technology requires controllers that are different from remotes or other types of controllers users might have used before, hindering knowledge transfer. Lastly, there is no established interaction convention in VR between different applications, further limiting transfer and resulting in a need for onboarding even for experienced users. Chauvergne et al. (2023) also highlight the instructor's lack of awareness of the users' virtual environment and suggest utilizing screen mirroring, an option that streams the user's view on an external screen. Several studies report challenges faced by participants when assigned tasks in VR due to the learning curve associated with the technology. Participants in Bailey et al.'s (2016) study complained about the lack of knowledge regarding the collaborative features of the platform and limited help from existing tutorials. Participants in Han et al.'s (2022) study reported difficulties with assigned tasks and experienced technical issues including dead batteries, connectivity problems, and software-related problems. The authors emphasize the need for onboarding to enable students to fully benefit from the educational potential of VR and avoid distracting struggles with the technology.

Chauvergne et al.'s (2023) study offers a comprehensive overview of existing onboarding methods in VR and a conceptual framework (see Figure 2) that helped identify different approaches within the tutorials.

Figure 2

Conceptual framework of assisted virtual reality onboarding from Chauvergne et al. (2023)



In this framework, Chauvergne et. al. (2023) identify and categorize onboarding's characteristics in several categories, which are briefly summarized below.

Onboarding Context: Onboarding can occur "out of context," where learners are not actively using the application (e.g., video tutorials), in a "formation-specific context," where tutorials are presented within a part of the application allocated to learning, and can be "context-aware," where instructions are given within the application when users need them. The latter is the one that is used most when onboarding is facilitated by an instructor.

Degree of Flexibility: Learners during onboarding can have different levels of flexibility in choosing the order and parts of the training to follow. It can be linear and rigid (set specific order), skippable but rigid (specific order with some steps skippable), skippable and flexible (replaying, starting at a specific step), or non-linear (functionalities can be learned in any order).

Degree of Coverage: Tutorials can encompass varying levels of functionality. It can include only basic functionality demonstration, training for all functionalities without discrimination, or level-specific training where users choose based on their experience level.

Inputs Onboarding: Tutorials can occur on 2D screens outside VR, inside VR with visual cues or virtual models, and sometimes without formal onboarding for inputs.

Information Transmission Medium: The level of interactivity learners have during onboarding compared to regular application use can be varied. It can range from observation-only (e.g., videos, demonstrations), partially enabled functionalities, to free interaction encouraging discovery learning.

Type of Assistance: The forms of assistance provided during onboarding can vary greatly. This can include instructions for practical actions or goals, simple or open-ended instructions, demonstrations, and models for learners to follow.

Degree of Feedback: Feedback is crucial in onboarding as it can validate or improve users' actions. It can be implicit (moving to the next step after the correct action), explicit (indicating success/failure), or corrective (indicating mistakes and how to rectify).

Instruction Modalities: The modes of instruction delivery can take several forms; visual, audio, and haptic. Visual aids and auditory instructions and effects are common, while haptic feedback is less prevalent (Chauvergne et al., 2023).

3. Theoretical framework

In this section, we explore the theoretical framework that informs this study. We integrate two complementary theories, situated learning and cognitive load theory, to comprehensively understand the challenges novice users encounter and design an effective onboarding activity. VR's immersive nature facilitates the construction of concepts and fosters social interactions within virtual learning environments that resemble environments from relevant real-world settings. These characteristics of VR align with the situated learning perspective (Lave & Wenger, 1991). Situated learning emphasizes learning in social and contextual environments. In this study, we utilize it to analyze how social dynamics and context shape user onboarding. However, it is essential to acknowledge that the immersive nature of VR can increase users' cognitive load (Kirschner & Hendrick, 2020). Cognitive load theory, rooted in cognitive psychology, examines how the mental workload placed on learners during knowledge and skills acquisition can impact their learning and retention. In this study, it helps us analyze users' cognitive load in VR onboarding and minimize the risk of cognitive overload in the designed onboarding activity. These two theories allow us to understand the social and contextual aspects of learning while simultaneously managing cognitive load helping us design an effective onboarding activity.

3.1. Situated learning

Situated learning is a learning theory that emerged in the early 90's with Lave & Wenger contrasting cognitive perspectives that were popular at the time. Knowing in situated learning is understood as the ability to participate in social practices and learning is therefore the process of creating and reinforcing an individual's participatory abilities (Greeno et al., 1996). The significance of the social context is underlined in the situated learning perspective. Learning takes place in so-called communities of practice, in which participants share ideas and have debates that enable and facilitate learning (Lave & Wenger, 1991). According to the idea of legitimate peripheral participation, a novice joining a community of practice will first observe and then gradually become increasingly active in the community, ultimately taking a central role as an expert. Situated learning highlights the importance of learning in authentic environments that resemble the environment in which the knowledge will be applied.

Virtual learning environments have the potential to actualize realistic and authentic learning environments in situations where it is impossible to do it in real life. The immersion experienced while learning in VR facilitates the construction of concepts based on their direct engagement and intuitive understanding of the environment (Jackson & Fagan, 2000). According to Cummings & Bailenson (2016), a greater immersion level allows the users to internalize the experience and perceive it as personal. These ideas are in line with the situated perspective, according to which the best way to learn is through authentic firsthand experiences (Lave & Wenger, 1991). A second aspect that differentiates virtual learning environments from less immersive technologies is the embodiment of avatars, which allows users to learn collaboratively in a shared social space.

In Lave & Wenger, the sequence of instruction follows the student's progress. Lave & Wenger revisit Vygotsky's (1930) theory of the zone of proximal development, which emphasizes that the interaction with peers or an instructor in a suitable environment enables certain internal developmental processes, that allow learners to acquire knowledge that they would not be able to gain on their own. In line with this theory, instructions should be learner-centered, and educators are expected to provide content-appropriate and suitably sequenced educational contexts.

3.2. Cognitive load theory

Collaborative VR immerses users in complex virtual worlds in which novices can encounter a multitude of challenges such as grasping the nuances of the interface and mastering spatial orientation.

Addressing these challenges plays an important role in ensuring user engagement within the collaborative VR platforms. A seamless transition is facilitated by effective problem-solving during the onboarding process. However, CLT theorizes that the information capacity of working memory is limited and that learners become independent only when they develop knowledge schemata allowing them to solve problems without exceeding the working memory's capacity (Kirschner & Hendrick, 2020). Existing literature suggests that the acquisition of schemata through conventional problem-solving skills among novices may be less effective compared to alternative approaches (Kirschner & Hendrick, 2020). According to Sweller (1988), the distinguishing factor between experts and novices in problem-solving is domain-specific procedural knowledge and suggests that conventional skills used by novices, means-end analyses, require too much working memory resulting in a cognitive overload that hinders the acquisition of schemata. An expert presented with a problem in their domain will recognize it, recall, and deploy a problem-solving strategy they applied before to a comparable problem and follow the steps to solve it. The problem-solving strategy choice is based on the expert's previously acquired and memorized knowledge. A novice does not have that knowledge and experience and will therefore most likely use some kind of means-end analysis, trying to decrease the distance between the starting point and the solution while trying to find relevant information. When faced with a new problem, for example, a novice will probably start by breaking down the problem into smaller steps and look for the solution through trial and error, which might not be the optimal approach. Although it is possible to solve problems using means-ends analysis, doing so does not facilitate the acquisition of schemas. During this problem-solving process, the working memory is allocated to searching for information and is consequently unable to acquire knowledge to store in long-term memory (Kirschner & Hendrick, 2020).

According to Han et al. (2022), meaningful learning requires students' attentive consideration of the details in the presented information, which is impossible to achieve if the student's cognitive capacity is overloaded. Sweller (1988) therefore, highlights that learners must acquire factual understanding and practical expertise in the relevant subject area before solving problems to develop their skills, implicitly reinforcing the importance of an onboarding stage when dealing with new tools and technologies before using them concretely. Cognitive load is not only intrinsic, coming from the workload posed to the working memory by the task but also extrinsic, influenced by the design of the task itself. Immersive VR offers multiple visual and auditory stimuli that can increase cognitive load, filling the limited cognitive resources needed to process them (Pimentel et al., 2022; Zhong et al., 2022). Makransky & Petersen (2021) suggest that the use of virtual learning environments leads to a higher cognitive load than with less immersive media due to its design. HMDs offer a wider field of view, which is further enhanced by the user's freedom to look around. The learner's focus is therefore not forcibly led to the learning content and the user has to extrapolate the useful information themselves.

This theory sheds light on the influence learning tasks has on learner's information processing, but it simultaneously helps instructional designers to present learning material to improve learning outcomes (Sweller et al., 2019). When creating learning environments, it's crucial to account for three types of cognitive load; intrinsic, which pertains to the complexity of the input and the learner's expertise level in processing them, extraneous, depending on how the information is presented and the tasks a learner performs, and germane load, which correlates to the working memory resources that are necessary for learning.

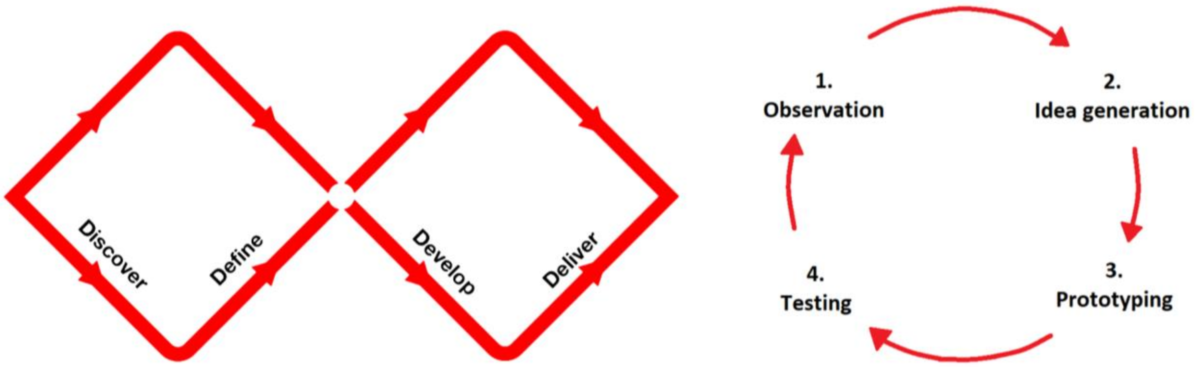
4. Methods

This study adopted an intra-paradigm research design, incorporating mixed qualitative methods. As highlighted by O'Reilly et al. (2020), the term *mixed methods* commonly refers to the integration of qualitative and quantitative approaches. However, the employment of a combination of approaches within an overarching qualitative paradigm can be complementary and offer different perspectives, thereby providing deeper and more comprehensive insights.

In this study, design thinking served as the main method to design an onboarding activity for collaborative VR in higher education. The application of design thinking provides a human-centered and iterative framework, guiding the research process toward a human-centered design (Norman, 2013). The design process model proposed by the Design Council (2005), the Double Diamond (see left image in Figure 3), alternates divergent and convergent phases iteratively. First, the problem should be understood and defined. Then various solutions should be considered and tested. As pinpointed by Norman (2013), designing with a focus on meeting human needs is an essential aspect of the design process, making it imperative to embrace Human-Centered Design principles. The author proposes the integration of the Iterative Cycle of Human-Centered Design (see right image in Figure 3) or spiraling method, according to which the users should be observed, ideas generated, prototypes created, and tested. The phases align and complement each other, forming a cohesive and comprehensive design process that continually refines and improves the design solution based on users' feedback and insights.

Figure 3

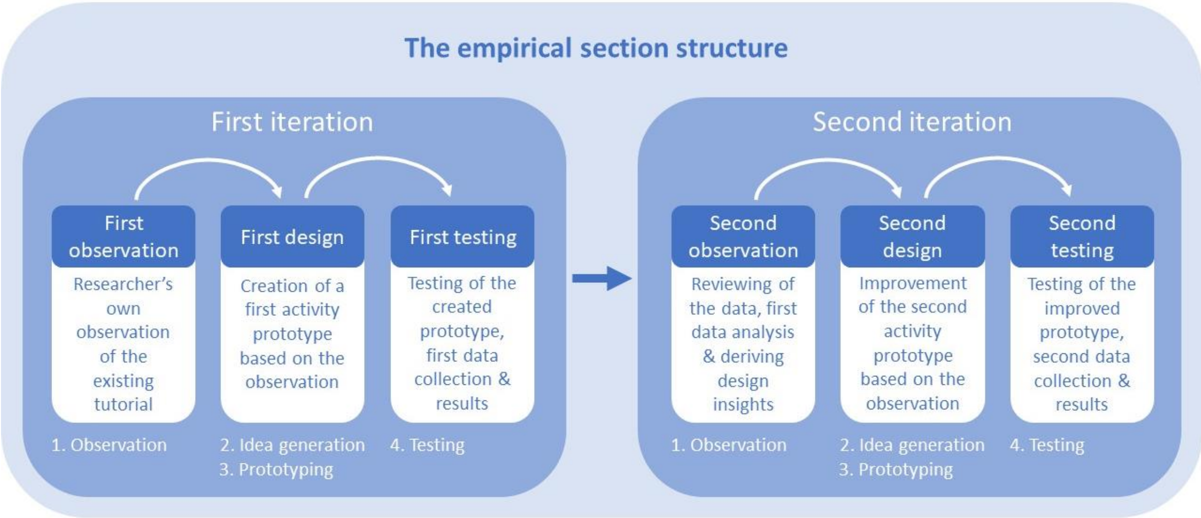
Double Diamond on the left (Design Council, 2005) and Don Norman's Iterative Cycle of Human-Centered Design on the right



The study followed a variation of the iterative design process described by Norman (2013). Two full iteration cycles of it were conducted. In Figure 4 below, the steps of the two iterations are described.

Figure 4

The procedure steps of the iterative cycle



The "First design" section in the first iteration and "Second design" section in the second iteration encompass both the *ideation* and *prototype* stages proposed by Norman (2013). Within both the "First discovery phase" and the "Second discovery phase" two distinct yet interconnected data collection methods were employed: observations and semi-structured interviews. This approach was selected to achieve a comprehensive exploration of participants' experiences and perceptions. Video data was captured during the observation phase, where participants took part in the tutorial, which allowed the viewing of interactions with the onboarding activity, which are not possible to see through normal observation. When a user opens a menu in a VE for example, other users cannot see it. T

The collected video data underwent several preparation and editing steps. The video recordings of the participants' views and the researcher's views were cut, merged, and synchronized using Microsoft's video editor, Clipchamp, to create a cohesive video to allow simultaneous viewing of both perspectives. In some cases, sections of the video and audio recordings went missing due to technical errors. In those cases, backup audio was synchronized with the corresponding visual content to ensure a smooth reviewing experience within Clipchamp. During this step, the data was also cleaned to enhance the subsequent analysis. Furthermore, subtitles were added to the video using Clipchamp's automatic subtitling system, which utilized speech recognition technology to generate accurate subtitles. The addition of subtitles aided the review process by providing textual support for the audiovisual content. The subtitles were manually checked for discrepancies and cross-referenced with the original source to ensure accuracy.

Individual semi-structured interviews were conducted with participants, allowing for an in-depth exploration of their perspectives on the onboarding activity. The semi-structured format provided flexibility, allowing the participants to openly express their thoughts. The interviews were transcribed using Word's automatic transcription system. Despite the efficiency of the automatic transcription system, a manual review was conducted. The edited data was meticulously scrutinized and cross-referenced with the raw data to ensure the accuracy and integrity of the edited version. Thematic analysis was then employed to explore and make sense of the collected interview data. This method provided a rich and comprehensive understanding of the shared meanings and experiences within the dataset, facilitating the exploration of the research questions and the generation of insightful findings through systematic identification and organization of the data (Braun & Clarke, 2012). The analysis therefore combined an exploratory, inductive, and deductive approach (Tracy, 2013). In this study, the analysis followed the six phases of thematic analysis outlined by Braun and Clarke (2006). First, a thorough understanding was gained by deeply immersing in the data. This involved repeated reviewing of the data and note-taking of initial impressions and ideas. The familiarization happened simultaneously with the multiple reviews and cross-referencing required in the preparation stage. Initial codes were generated by reviewing the final edit of the data and identifying specific events and issues, which were then tagged with identifying markers to create initial codes. The analysis process then continued with the grouping of related codes to identify patterns and create themes that were relevant to the research questions. This involved reviewing the coded data and examining similarities, differences, and connections among the codes. Coding and theme creation is an iterative process that requires constant revision and iteration. Therefore, they were carefully reviewed for consistency and coherence multiple times. The codes were constantly refined and adjusted to consolidate the identified themes and ensure the codes accurately captured the essence of the content. Themes were then named in a clear and informative manner to accurately represent the underlying content. Some themes were also grouped creating subthemes. Braun and Clarke (2012) suggest the use of subthemes for broad patterns within the data that manifest in diverse ways. The same codes were then used to tag specific events in the video data. This way, a multifaceted understanding of the participants' experiences was achieved. Additionally, through the triangulation of the findings from observations and thematic analysis, a clearer connection between the participant's comments and the actual experience was established.

4.1. Environment and equipment

The study was conducted at the Knowledge Lab at the Applied IT Faculty at the University of Gothenburg. The Knowledge Lab features a spacious area where participants can safely perform tasks without the risk of bumping into objects or walls. The Knowledge Lab also provided the hardware necessary to conduct the study, three Meta Quest 2 (Figure 5) with controllers. The Meta Quest 2 headset is a standalone VR device (Jin et al, 2022). The headsets were equipped with the previously installed app First Steps, a tutorial on the controls in VR offered by Meta, and ENGAGE, the selected collaborative platform. Han et al. (2023) noted that the combination of Meta Quest 2 headsets and the ENGAGE platform used in their study offers an improved level of stability compared to other VR hardware and software they used before, which was marred by technical errors. Additionally, the representation of the avatars in ENGAGE is more realistic compared to most collaborative VR platforms, which encompass cartoon-like and half-body avatars (see, for example, the avatars in Horizons or Glue).

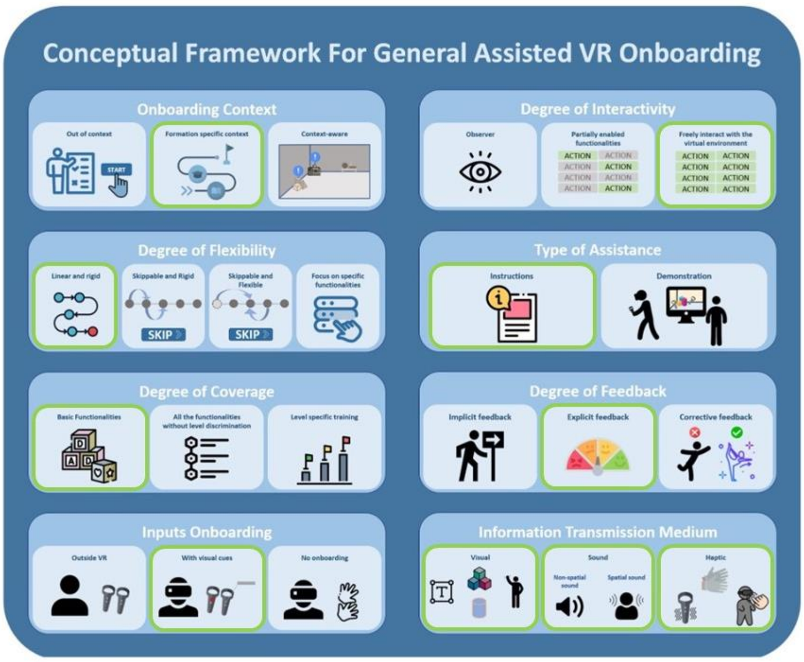
Figure 5

Meta Quest 2 headset (Meta, 2023c)

The First Steps tutorial was designed by Meta to provide a first experience with VR that teaches users how to use the physical controllers of the Meta Quest 2, the headset used for this research. The tutorial is primarily linear, with tasks spawning progressively, the user, however, can go back to earlier tasks freely (see Figure 6).

Figure 6

First Steps's characteristics (adapted from Chauvergne et al.'s Conceptual framework for general assisted VR onboarding, 2023)

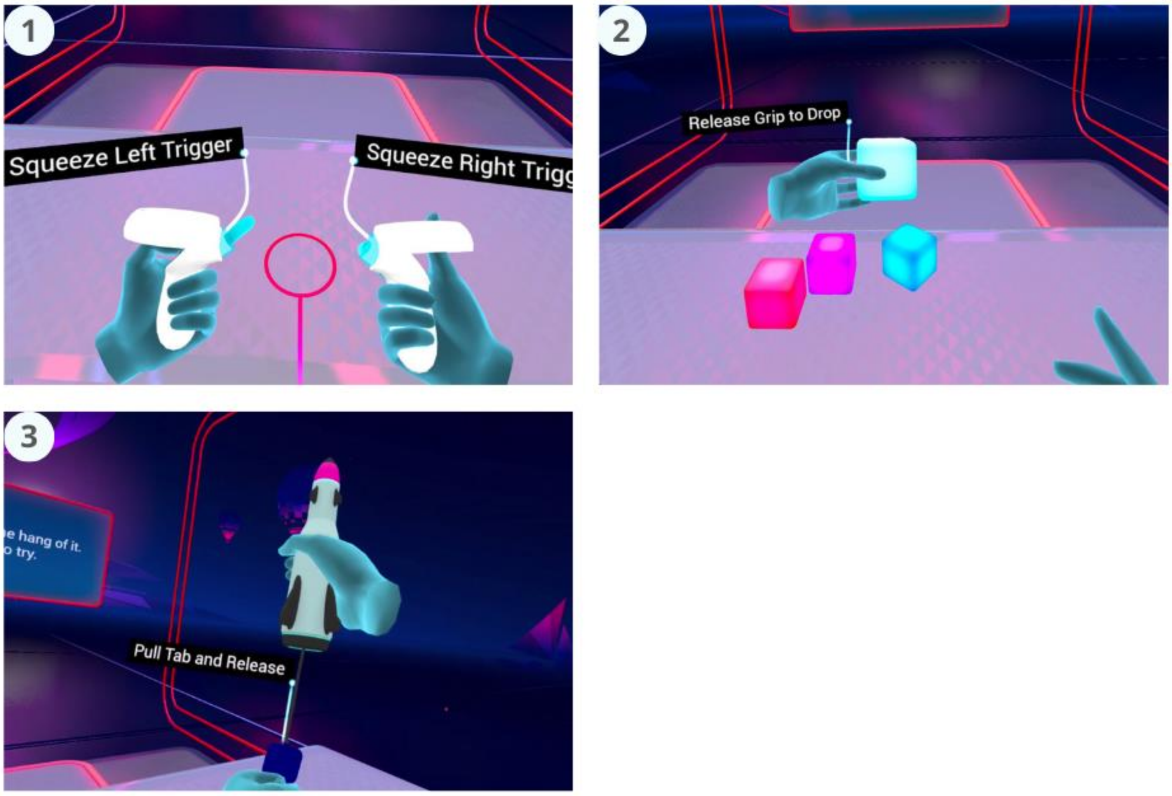


Note: The characteristics of the specific design are circled in green.

The various sections are not skippable (Chauvergne et al., 2023). The users first get familiar with the positioning of the controls directly (see image on the left in Figure 7) by interacting with all the buttons, joysticks, and touch controls [example 1 - First steps[2]]. Then, the visual render of the controllers disappears and the users get the opportunity to use their *virtual hands* to perform small interactive and entertaining tasks like grabbing and throwing objects (see the second image in Figure 7) or play table tennis [example 2 - First steps]. Next, the users are offered more complex tasks that require a combination of both hands (see the third image in Figure 7) and more complex and skillful operation of the controllers [example 3 - First steps].

Figure 7

Screenshots of the First Steps tutorial



Note: In the first image, the user is learning how to use the controllers and pressing all the buttons, in the second one, the user is manipulating cubes and in the third image, the user is releasing a rocket with both hands by grabbing it with one hand and pulling the tab with the other.

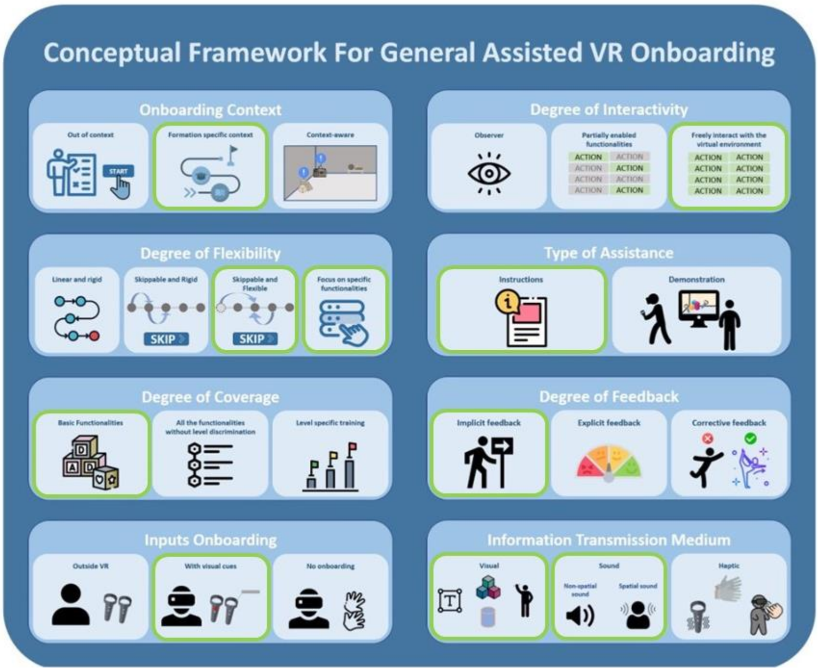
In the First Steps tutorial, two games are also included, one where the users can interact and dance with a robot and one in which the users can shoot floating shapes with guns. For the purpose of this study, however, the participants skipped the two games due to time limitations.

[2] Given the visual nature of this thesis, we have included links to excerpts of the recordings from the used applications and from the interaction with participants. The supplementary material is intended to provide readers with a more comprehensive understanding of the visual content discussed throughout the text. In these excerpts, "H" stands for the host, the researcher, and "P" for the participant.

ENGAGE is a collaborative VR platform where users can meet and explore and interact with various VE. It also includes an integrated tutorial, Tutorial Island. The tutorial includes the basics needed to attend meetings and explore virtual environments. The mode of instruction in Tutorial Island is very flexible: after a first segment on movement and virtual button pressing, which is skippable, the users have the freedom to select the tutorial topic autonomously (see Figure 8).

Figure 8

Tutorial Island's characteristics (adapted from Chauvergne et al.'s Conceptual framework for general assisted VR onboarding, 2023)



Note: The characteristics of the specific design are circled in green.

Users first learn how to navigate in the VE (see the first image in Figure 9) which allows them to reach the remaining topic-specific tutorials, placed at the end of a path in front of the users [example 1 Tutorial island]. The second section of the tutorial includes several billboards placed in a semi-circle. Each billboard shows different topics and users can choose which feature they want to learn about by pressing on the info button under said feature without a preferred order (see the second image in Figure 9). The topics that the tutorials cover are the teleportation, using portals to change locations, operating the session menu (see the third image in Figure 9), sitting and standing up from virtual chairs, how to enable and disable the microphone, how to share and find the shared media, where to find the controls in the settings and how to exit a session.

Figure 9

Screenshots of Tutorial Island

Note: The first image shows the first section of the tutorial with instructions on how to look around and teleport, the second one shows the placement of the subject-specific tutorials and the third one shows the tutorial for the menu with a model of the controllers and the controls tutorial.

The tutorials include various degrees of interactivity. Most of the subject-specific tutorials require no - to minimal interaction. In the tutorial for the menu, for example (see the third image in Figure 9) a model of the controllers is shown to the users. The users can replicate the line of instruction, however, there is no feedback for the users' actions. In the tutorial on sitting instead, different kinds of seats are placed in the area, and the users can try to sit on different chairs. Still, no direct feedback is provided for users' actions, however, the users' point of view changes when they sit down and they can observe their legs being bent, which provides some kind of direction to the users. Then again, when the users reach the area with the subject-specific tutorials by moving from their original position, their spawn point, the users receive direct feedback and the instructor's avatar automatically appears in front of them to guide them forward.

Some potential issues were identified prior to the data collection, especially issues regarding some existing bugs in Tutorial Island in ENGAGE and issues related to cognitive overload. While familiarizing with the environment before the data collection, two bugs were identified[3]. At the beginning of the tutorial, the participants are instructed to follow a firefly with their gaze. However, there is no firefly to be around [error 1 – Tutorial island]. Additionally, the *Information* button under the last screen of the semi-circle, the *Exit Session* tutorial is not functional. An outstanding amount of visual and auditory information was also identified. The instructions given are multi-platform and

[3] The identified bugs applied to the ENGAGE version v3.2.3. The bugs were fixed with more recent releases.

multi-language instructions. The given instructions do not refer to the user's platform only, but they include instructions for all the supported platforms (computers, mobiles, tablets, VR headsets). This could make it more difficult for the users to recognize and extract the relevant information. The instructions are also written in several languages on the screens, which adds to the amount of information given and might make it more confusing as well.

4.2. Participants recruitment

Six university students with a background in education or teaching experience and knowledge in IT were recruited for the first iteration through purposive sampling. The participants did not have prior experience in collaborative VR platforms. According to Cohen et al. (2018), purposive sampling is often employed to selectively choose the sample, specifically targeting people who possess extensive expertise on specific issues. This non-probabilistic sampling approach was chosen to ensure that participants can play a dual role and provide feedback from two perspectives: as students and users of the collaborative platform, and as knowledgeable experts in education and IT. Another five participants were recruited through convenience sampling method. All the participants had to meet the same criteria: be university students and have no prior experience in ENGAGE or other collaborative VR platforms. In Table 1 below, students' information is reported. Given that an enhanced level of immersion and interactivity plays a pivotal role in this study, experiences with basic forms of VR, such as 3D movies and smartphone-based VR devices like Google Cardboard, were not considered relevant. On the other hand, some participants had limited exposure to more advanced HMDs, having used them once or twice. However, none of the participants had extensive exposure to immersive VR, and any experience in collaborative VR as this was a part of our exclusion criteria.

Table 1

Participants' information

Session	Participants	Education	Pronouns	Prior VR experience
First iteration	P1	Education & IT	She/her	Limited
	P2	Education & IT	She/her	Limited
	P3	Education & IT	She/her	None
	P4	Education & IT	She/her	None
	P5	Education & IT	He/him	None
	P6	Education & IT	She/her	Limited
Second iteration	P7	Social Sciences	She/her	Limited
	P8	Education & IT	She/her	None
	P9	Global studies	She/her	Limited
	P10	Global studies	He/him	Limited
	P11	Education & IT	She/her	Limited

4.3. Ethical considerations

Informed consent was a crucial aspect of the ethical process. Before each iteration of the data collection, participants signed the informed consent form (see Appendix 1) and were reminded of the purpose and aim of the study and what they could expect from the session. All the participants were at least 18 years old and could therefore make an informed decision about their involvement. Participants were informed about the possibility of experiencing discomfort or motion sickness and notified that they could withdraw from the session if they felt uncomfortable at any time.

All collected data was kept confidential and stored on a password-protected computer for the time necessary to analyze it. Personal information will not be disclosed to anyone outside the research team. The participants' personal and identifiable data were not included. The video sections incorporated in this study and disseminated through hyperlinks to a Microsoft OneDrive folder were chosen carefully and edited to ensure that any identifiable information was removed. Several participants, for example, signed their names on the whiteboard in ENGAGE, and the segments were therefore not displayed. Additionally, participants' voices in the videos were muted. A significant potential ethical issue arises regarding the appropriateness of revealing participants' avatars, as they could potentially lead to identifying participants. Avatars can indeed resemble the users and pose additional discriminatory risks, as they can include identifiable features such as skin color or clothing with religious significance. This concern is similar to using nicknames, where names given to avatars might make them recognizable and traceable back to the participants. In this study, all participants shared a common nickname, "ITLGU," which stands for the program and university, "Information Technology and Learning at Gothenburg University," while the avatars were generated randomly, except for their gender.

4.4. First iteration

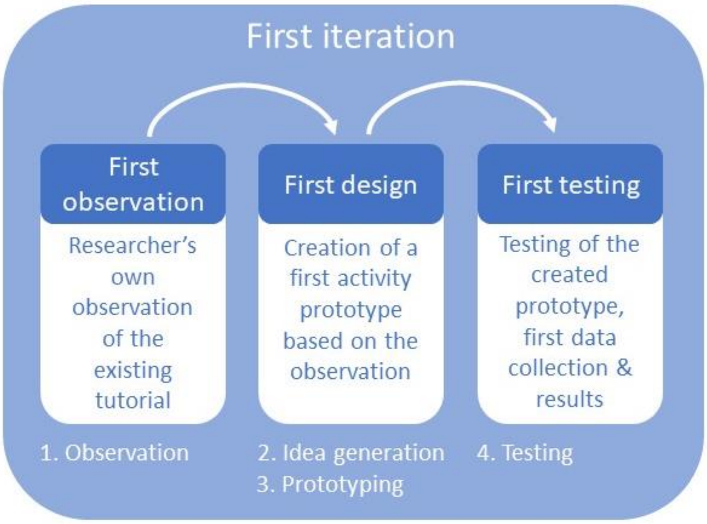
During the first iteration, the collaborative VR platform ENGAGE was first explored, and a first prototype was developed and tested addressing the defined main problem.

4.4.1. Procedure

The study followed a variation of the iterative design process described by Norman (2013) and explained in detail in the Methods section. To aid the understanding of this section, below is an overview of the steps in the first iteration (Figure 10).

Figure 10

The steps of the first iteration



4.4.1.1. First observation

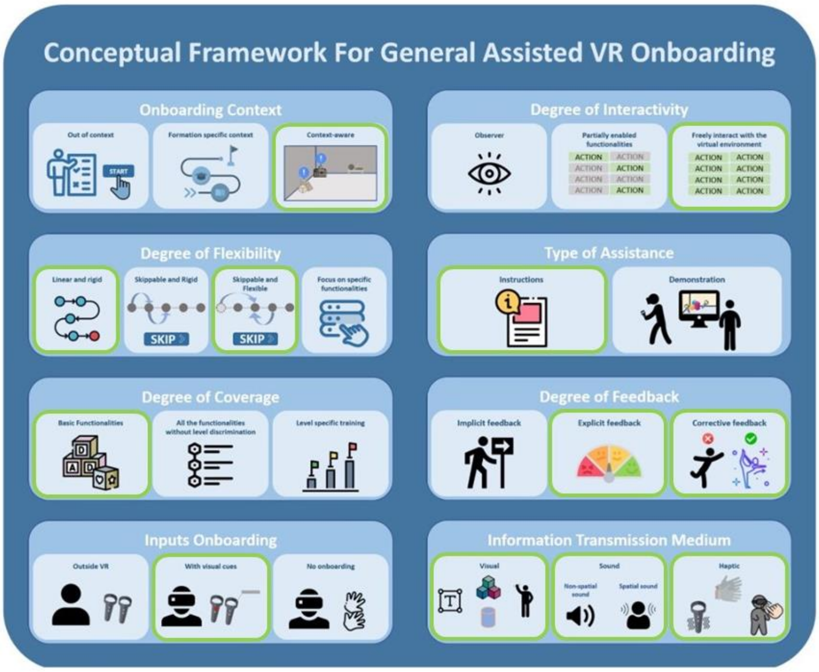
The design process started with the exploration of ENGAGE, the collaborative VR platform chosen for the study, and the mode of instruction in VR through the participation in Q&A sessions organized by the ENGAGE staff and autonomous exploration.

4.4.1.2. First design

An onboarding activity was prototyped to address the lack of a tutorial suitable for the educational context. A storyboard (see Appendix 2) was created that paved the ground for the design of an onboarding activity prototype. The designed activity should be understood as an integration of Tutorial Island rather than its replacement. The selected environment for the proposed onboarding activity was the Tropical Stage. This environment has been used by the ENGAGE staff to organize Q&A sessions to showcase the features of ENGAGE. This environment includes a stage with seats and a big screen but also an emptier area with space to place new objects. The provided flexibility makes it the optimal environment for the showcasing of the features. In the figure below (Figure 11), a variation of Chauvergne et al.'s (2023) conceptual framework is provided, which includes the characteristics of the designed onboarding session.

Figure 11

Designed tutorial's characteristics (adapted from Chauvergne et al.'s Conceptual framework for general assisted VR onboarding, 2023)



Note: The characteristics of the specific design are circled in green.

Participants joined the private session from the ENGAGE menu and accessed it with the provided password. They were welcomed with a handshake to trigger haptic feedback at the spawn point (see the first image in Figure 12). Nearby, a model of the controllers was placed to review the controls [P1 - handshake design]. The researcher disabled all the user's actions that are optional (3D drawing, sticky note placement, IFX placement) and eabled them one by one while learning about them.

Figure 12

Screenshots from the first designed activity in ENGAGE

Note: The first image shows the spawn point in the Tropical Stage, the second one shows the whiteboard with drawings and sticky notes, the third one shows a user making 3D drawings, the fourth shows several IFX placed in the VE and the fifth shows the gizmo toolset in ENGAGE.

After a quick reminder of the controls with the help of the model, the researcher and the participant moved to the stage area. There, participants learned how to write and draw on the whiteboard and how to create sticky notes (see the second image in Figure 12). The participants then learned how to use the 3D pen (see the third image in Figure 12) and share the drawings with other users [P1 - 3D drawings design]. Lastly, participants learned how to open the IFX library, how to place IFX in the VE (see the fourth image in Figure 12), and how to use the gizmo to move the assets, resize and rotate them (see the fifth image in Figure 12).

4.4.1.3. First testing

The first testing phase took place between the end of March and the beginning of April 2023 after trying it with a pilot participant to ensure smooth and successful execution. Six participants took part in the first data collection, and each session lasted approximately two hours.

To ensure participants' familiarity with the VR system, they completed the First Steps tutorial before the data collection. Participants completed the tutorial individually and autonomously. The participants' view was mirrored on the researcher's laptop, allowing the researcher to monitor their progress. As the main aim of this tutorial was to ensure all participants have a basic understanding of the hardware and software aspects of the VR system, data was not collected during this phase.

After a short break, the participants accessed and completed Tutorial Island in ENGAGE. During this tutorial, participants had the autonomy to follow the instruction provided in the tutorial or explore and navigate within the virtual environment freely. The researcher intervened only when participants encountered difficulties that hindered them from continuing. The participants' view and audio captured through the HMDs were recorded for later analysis, but these were not mirrored on the researcher's laptop. Following a brief break, the participants engaged in the onboarding activity guided by the researcher. Both the participants' and researcher's HMD views and audio were recorded during this activity, providing a double perspective and comprehensive representation of the interaction. Finally, to gather insights into participants' experiences, semi-structured interviews were conducted. The interviews allowed participants to express their thoughts, opinions, and feedback regarding the VR experience. The questions that prompted the interview can be found in Appendix 4.

After a quick review of the data, a few days later, some missing information was identified. The participants were therefore contacted again, and a few follow-up questions were asked, which are also found in Appendix 4.

4.4.2. Analysis and results

The video data from the first data collection comprised over 95 minutes for the second tutorial, Tutorial Island, and 190 minutes for the designed onboarding activity. For the latter, both the participant's view and the researcher's view were recorded, resulting in double the amount of video data. Additionally, around 115 minutes of interviews were recorded. First, the data was cleaned and optimized for review and then analyzed through thematic analysis to get an in-depth understanding of the participants' experiences. The results from the thematic analysis were compared with the ones from the observations of the video-based data. The dataset provides a source of information for analyzing the participants' interactions and experiences during the onboarding activity. In the table below (see Table 2) the results of the triangulation of the interview data and the observation data are presented.

Table 2

Results of the first triangulation of the observations and interview thematic analysis

Theme	Subtheme
Technical bugs	Firefly
	Exit button
Instructions	Misunderstanding
	Language barrier
	Multi-platform instructions
	Confusion
Feedback	Suggestions
	Positive feedback
	Criticisms
Difficulties	Sitting and teleportation
	Touch functionality on the tablet & whiteboard
	Gizmo usage
	Dizziness & strain
	Other & uncommon difficulties

Note: The subthemes highlighted in grey are issues that only pertain to the Tutorial Island.

Below, an explanation of the themes is provided including participants' comments examples as well as links to excerpts from the collected video data. In some cases, it is difficult to explain what was going on in words, therefore video excerpts were added to help shed some light on these occurrences.

The first theme, "Bugs", pertains to known issues in the application that are not attributable to user error. One subtheme, "Firefly", highlights a bug where participants were instructed to follow a firefly on Tutorial Island. At the beginning of the tutorial, the instructions suggest following a firefly with the gaze, but there is no firefly present, causing confusion for all participants as they searched for it (P2 looks around to find the firefly [P2 - firefly bug]). Another subtheme, "Exit button", refers to a malfunctioning button. In Tutorial Island, under the last screen with instructions on how to exit a session, there was a button that was supposed to allow users to exit a session. The button, however, did not function correctly, leading to frustration and confusion for most participants as they attempted to use it (P4 tries to click the *Exit* button [P4 - exit button bug]).

The second theme, "Instructions," focuses on issues related to the mode of instruction provided either by the researcher or the tutorial itself. The subtheme "Misunderstanding" indicates situations in which participants misunderstood the provided instructions (P2 presses the arrows icon instead of the actual arrows on the object [P2 - misunderstanding]). The subtheme "Confusion" depicts instances where participants experienced uncertainty during the onboarding process, expressing not knowing what to do or how to proceed (P5's confusion with the information buttons [P5 - confusion]). The subtheme "Language barrier" reveals that participants faced language challenges as instructions were not provided in their native language. P2, for example, mentioned:

> "Maybe this doesn't count for maybe native speakers. I'm not sure if it's like a language barrier, but for me, when I listen to something I need also a moment to actually like, think about what he [the instructor in Tutorial Island] said."

The subtheme "Multi-platform instructions" refers to participants facing challenges with multi-platform instructions, as they cater to various hardware types, such as PCs, mobiles & tablets, and VR headsets, leading to difficulties in understanding and focusing. P6 in this regard said:

> "Yeah, 'cause he also explained not only the VR but the, like, mobile and... and the computer also. Well, I was just focusing on, like, waiting for the VR headset. But you know, it's still like [clicking sound] when he's talking a lot."

The third theme, "Feedback," encompasses participants' expressions of opinions regarding the onboarding process. Under the subtheme "Suggestions," participants provided feedback for improvements to the tutorial. P2, for example, said:

> "I think it could be a bit more instructive maybe. I think, like, someone would appreciate more, like, having you on the side and showing. Like of course you did that. … But for example, when I went to the joystick and stuff, it would have been also cool to have you there."

"Positive feedback" illustrates participants expressing satisfaction and praise regarding their experience with the tutorial. P1, for example, expressed:

> "Yeah, taking different things, trying different things, like writing and using the tablet. That was really fun, and I think that's really good as well, especially if you're like at a distance with someone, but you can be together in a… in a virtual reality or something."

Conversely, "Criticisms" involves participants expressing dissatisfaction or critiques regarding their experiences, P3 describes her experience in the Tutorial Island as "boring". P3 then elaborated: "You know, because uh, because uh, he talked, uh… and I, I wanted to explore by myself."

The fourth theme, "Difficulties," delves into the struggles participants encountered while performing specific tasks in the onboarding process. Under the subtheme "Sitting and teleportation," participants faced difficulties with teleportation (movement) or sitting in a virtual chair (performed through teleporting to a chair) (P3 struggles to operate the controller in order to teleport [P3 - teleportation issue]). The subtheme "Touch functionality on the tablet & whiteboard" showcases issues with the touch function on the tablet and drawing function on the whiteboard, affecting the interaction process (P1 experiences issues while pressing buttons within the tablet menu [P1 - touch issue]). The "Gizmo usage" subtheme reveals challenges with the gizmo function of the IFX (3D assets), potentially affecting their interactions within the virtual environment (P1 can't move an IFX upwards because a smaller sensitivity was accidentally selected [P1 - gizmo]). Additionally, the subtheme "Dizziness & strain" highlights participants reporting feelings of dizziness or strain during the virtual reality experience, possibly due to the immersive nature of the environment. P3, for example, mentioned:

> "When I walked, I used the walking [with the joystick instead of teleporting]. It was kind of dizzy. And just the heaviness."

The final theme, "Other & uncommon difficulties," captures additional challenges that occurred less frequently, less than twice and were not covered by specific subthemes. P1 encountered difficulties when getting too close to avatars. One example of such issue is when P1 gets too close to other avatars [P1 - other difficulties].

Additionally, most participants expressed that the Tutorial Island could be skipped and that they required the researcher's help to complete it in a reasonable time. Five out of six participants thought the Tutorial Island could be skipped, while one mentioned that the access to the subject-specific tutorials were confusing and suggested shortening it and organizing it in a linear, sequential manner. When asked if they would have completed it on their own, four participants replied they would have figured it out, but the assistance made the process faster and smoother. One participant said they would not have completed it on their own while another participant mentioned they could have completed it, but it was boring and did not feel motivated to do it.

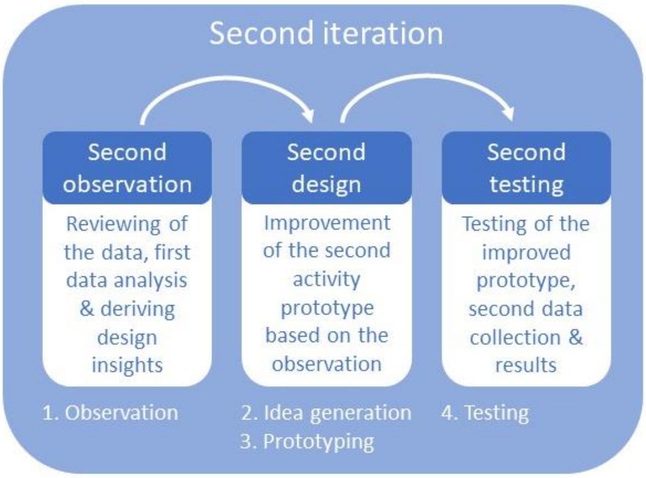
4.5. Second iteration

4.5.1. Procedure

To aid the understanding of this section, below is an overview of the steps in the second iteration (Figure 13) adapted from the iterative design process described by Norman (2013).

Figure 13

The steps of the second iteration



4.5.1.1. Second observation

The observation of the participants highlighted several challenges regarding Tutorial Island. First of all, several participants experienced difficulties with teleportation. Despite the instructions, some participants seemed to teleport in a different spot than they intended to. Additionally, a few participants could not make the teleportation work at all and required the researcher's assistance. Teleportation in ENGAGE, if done properly, is easy to master, suggesting that the instructions were not clear enough.

Participants often expressed confusion during the session in Tutorial Island, especially regarding the organization of the access to the tutorials. As can be seen in the second image in Figure 9, the participants could autonomously select the tutorial in which they are interested. For a newcomer though, who does not know what the platform's functionalities are, it can be confusing. Some participants were looking for an order; most participants started from the tutorial on the left and proceeded towards the right in order. By setting the order in which the subject-specific tutorials are accessed, scaffolding could be leveraged. For example, as sitting is done by teleporting to a chair, it should come after to learning how to teleport.

Contrary to the expectations, the presence of multiple languages was not mentioned as a barrier by participants and did not seem to cause any frustration. However, the multi-platform instructions were often mentioned as a limitation. As the instructions that relate to VR were given amidst superfluous instructions for other platforms, participants had to pay attention for prolonged time in order to extract the relevant information that apply to them. One participant noticed that the order of the platforms is not consistent, making it even harder to identify the VR instructions. The lack of action-based tasks might have reduced participants' motivation; several participants described Tutorial Island as "boring," with one participant who did not even complete it. Additionally, the substantial amount of instructions raise issues of cognitive overload, and it is possible that the participants' challenges are a consequence of the abundance of information. Participants had to use their mental capacity to identify the relevant information, potentially hindering their capacity for assimilating the pertinent notions.

Lastly, the instructions also included a section about changing the user's visual (as seen on the left screen in the first image in Figure 9). As Bailenson (2018) argued, looking around with an HMD happens naturally and therefore does not require instructions. The presence of this section of the tutorial is probably a consequence of the multi-platform nature of the tutorial as the visual controls require explanations on other devices.

In regard to the prototype of the designed activity, besides some misunderstandings between the researcher and the participants, participants expressed being mostly satisfied with it. They did, however, make a few suggestions. Several participants highlighted the need to have time to explore on their own and put into practice what they have learned. A few participants suggested adding a task with a clear objective in this regard.

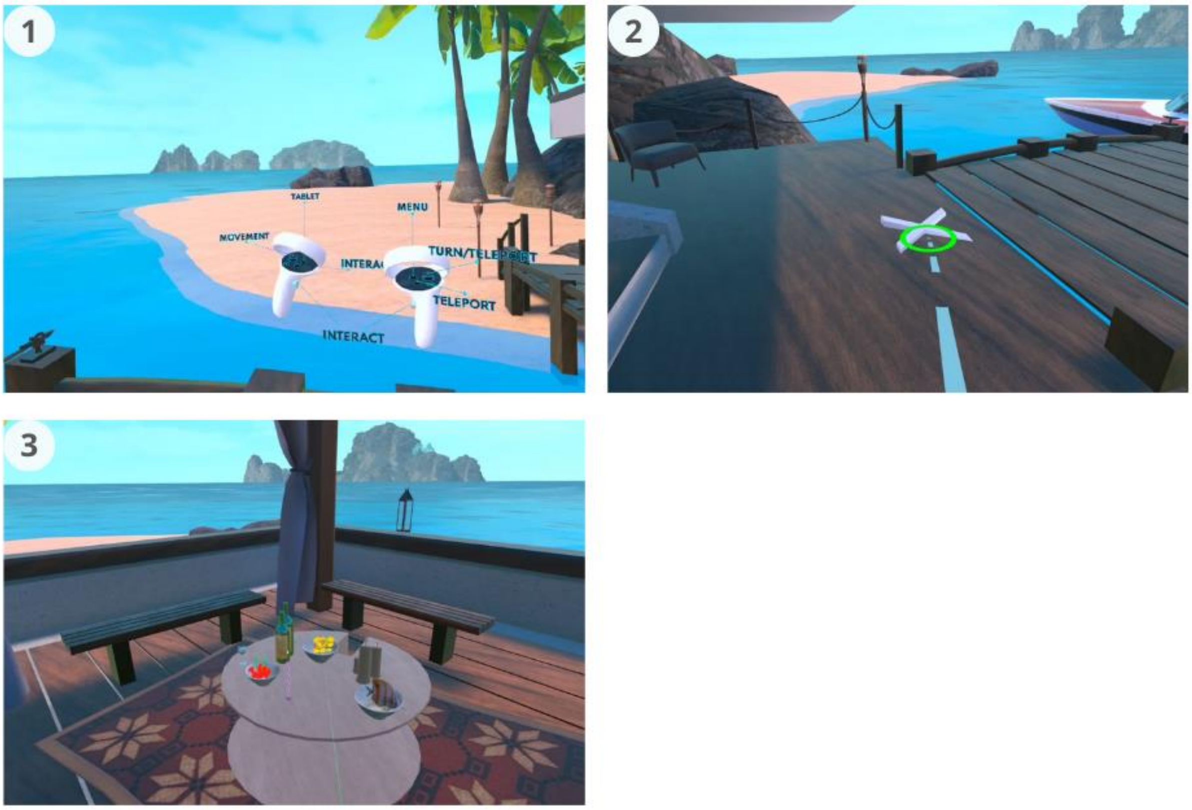
4.5.1.2. Second design

First, a storyboard (see Appendix 3) and then a prototype were created of the improved designed activity based on the findings of the first iteration. As it is impossible to modify Tutorial Island, it was completely removed, and the relevant functionalities from it were addressed and integrated into the designed activity. As in this case the participants had no experience in ENGAGE, before participating in the guided onboarding they were taught how to move and use teleportation as soon as they entered the session. Groups of IFX were previously prepared and saved to facilitate the preparation of the VE. The first group of IFX included a model of the controllers placed by the participants' spawn point, a cross on the floor by the researcher, and an armchair in the vicinity (see the first two images in Figure 14). The researcher disabled all the user's actions that are optional (3D drawing, sticky note placement, IFX placement) and eabled them one by one while learning about them.

Participants were first introduced to the controls with the help of the model and then tasked to teleport to the cross on the floor. Then they were tasked to sit on the chair, which builds on their prior knowledge of teleporting. Next, a second group of IFX was placed, with an arrow leading the participants to an emptier area, signified by a cross on the floor. A whiteboard was placed in front of the cross. The participants learned how to draw and write on the whiteboard and how to create sticky notes and share them. The participants also learned how to create 3D drawings and place and interact with IFX. When the participants grasped the essentials, they were led to a gazebo area and tasked to decorate it and prepare it for a picnic using all the functionalities they learned (see third image in Figure 14).

Figure 14

Screenshots from the second designed activity in ENGAGE



Note: The first image shows the first group of IFX in the designed onboarding activity, while the second image shows the created picnic area in the designed onboarding activity.

Participants looked for relevant IFX in the IFX library and moved, rotated, and resized the selected IFX to fit the scene. Additionally, they used 3D drawing to add assets that are not present in the IFX library. The researcher lastly placed a skybox IFX, an asset that replaces the sky's aspect to change the atmosphere to nighttime, placed a firework IFX to congratulate the participants, and ended the session.

4.5.1.3. Second testing

The second testing phase took place in the first half of May 2023. Five participants took part in the second data collection, and it took each participant between one hour and one hour and a half to complete. The procedure of the second data collection followed a similar structure to the data collection conducted in the first iteration. After the First Steps tutorial, however, participants went directly to the redesigned activity.

4.5.2. Analysis and results

The collected data underwent the same level of preparation, scrutiny, and methods of analysis. First, the data was cleaned and optimized for review and then analyzed through thematic analysis to get an in-depth understanding of the participants' experiences. The results from the thematic analysis were compared with the ones from the observations of the video-based data. The results from the triangulation are presented in the table below (See Table 3).

Table 3

Results of the second triangulation of the observations and interview thematic analysis

Theme	Subtheme
Instructions	/
Feedback	Suggestions
	Positive feedback
	Criticisms
Difficulties	Touch functionality on the tablet & whiteboard
	Dizziness & Strain
	Other & uncommon difficulties

The video data from the second data collection comprised of over 215 minutes. Both the participant's view and the researcher's view were recorded, resulting in double the amount of video data. Additionally, around 35 minutes of interviews were recorded. The data was grouped into similar themes as in the first data collection. The emerging themes, however, were more limited as Tutorial Island, was removed. The first theme, "Instructions," is centered around issues related to the mode of instruction provided by the researcher (P8 having difficulty understanding a question related to issues with the touch functionality of the menus [P8 - misunderstanding]).

The second theme, "Feedback," encompasses participants' expressions of opinions regarding the onboarding process. The subtheme "Suggestions" highlights participants offering valuable suggestions for changes and improvements to enhance the tutorial. P7, for instance, recommended:

> "Or maybe you can have another person helping you. Then I can interact with another person in the ENGAGE and then you can see both of us, and you can, at the right time, see that I have pressed the wrong… for example, button."

In the subtheme "Positive feedback," participants provided praise and expressed their satisfaction with the tutorial. P11, for example, when describing her experience mentioned:

> "I think that is a really nice platform, and the way you have done it is very well organized because in my case, I had no experience in those types of environments so it was new for me, and I could follow all the instructions."

On the contrary, the subtheme "Criticisms" encompasses participants' expression of dissatisfaction or critiques about certain aspects of the tutorial. P7, for example, expressed that the tutorial activity felt excessively long.

The third theme, "Difficulties," revolves around the struggles participants encountered while performing specific tasks during the onboarding process. Under the subtheme "Touch functionality on the tablet & whiteboard," participants encountered issues with the touch function on the tablet or faced challenges in using the drawing function on the whiteboard. P11, for example, found it difficult to adjust the brush thickness while writing on the whiteboard [P11 - brush slider]. P11 recalled the episode during the interview:

> "The only thing is when you try to make… when you are writing on the Whiteboard, and you try to move the brush to make it thicker. I would say it's the hardest thing on the whole activity."

Under the subtheme "Dizziness & Strain," participants reported feeling dizziness or strain, possibly due to the immersive nature of the virtual reality experience. P11 recalled feeling dizzy while moving with the joystick:

> “I would only say it was a bit dizzy when you move, but because you told me not to move [with the joystick], then it was fine.”

Lastly, the theme “Other & uncommon difficulties” captures additional challenges that occurred less frequently and were not categorized under specific subthemes. For instance, P8 was not able to find the post-it in the virtual environment due to being too close to the whiteboard. The post-it appeared behind the whiteboard [P8 - Sticky note]. P8 commented the episode in the interview:

> “… I was like, why is it not working? And you knew it was because I was too close to the board. Because then I feel like if you were alone in that situation, you wouldn’t really know what to do next.”

5. Discussion

The aim of this research project was to address the gap in the onboarding process in collaborative VR platforms for educational purposes and design an instructional activity to address encountered difficulties and aid this process.

5.1. RQ1: What kind of issues do newcomers encounter during the onboarding process in collaborative VR?

To address the first research question, we explored the challenges encountered during the onboarding process. The findings revealed several challenges related to the mode of instruction in Tutorial Island. These challenges underscore the necessity for clear and contextually relevant instructions. Firstly, several participants experienced difficulties with teleportation. Despite the instructions, some participants seemed to teleport to different spots than intended. A few participants could not make teleportation work at all and required the researcher's assistance. Teleportation in ENGAGE, if done correctly, is easy to master. The struggles faced by these participants indicate that the provided teleportation instructions were not intuitive or clear. The verbal instructions are delivered extremely fast, and the visual ones can be misunderstood. As seen on the right screen of the third image in Figure 9, the correct button is highlighted, but the second figure shows a beam of light coming from the front of the controller, where the trigger button is located. One participant expressed several times that the drawing shows the wrong button. Additionally, instructions are provided for all the hardware in which ENGAGE is available with no distinctions for the hardware the platform has been accessed with.

Multi-platform instructions were often mentioned as a limitation. VR-related instructions were mixed with superfluous instructions for other platforms, requiring prolonged attention to extract relevant information. Some noticed inconsistent platform orders, further complicating the identification of VR instructions. The abundance of instructions may have reduced motivation and user engagement, with several participants finding Tutorial Island "boring," and one not completing it. This situation raises cognitive overload concerns. Participants had to use their limited working memory to identify relevant information, potentially hindering assimilation, and retention in long-term memory according to cognitive load theory (Kirschner & Hendrick, 2020). Makransky & Petersen (2021) suggest immersive VR leads to higher cognitive load than less immersive media due to its design with multiple visual and auditory stimuli (Zhong et al., 2022). The need for direct and concise and contextually relevant instructions to avoid cognitive strain and sustain user engagement becomes evident here given the already substantial risk of user overload due to platform-related distractions.

Furthermore, participants often expressed confusion during the Tutorial Island session, especially regarding tutorial access organization. As seen in the second image in Figure 9, participants could autonomously select tutorials in which they were interested. However, for newcomers unfamiliar with the platform's functionalities, this non-linear approach could be confusing. Participants often engaged their problem-solving skills to make sense of the tutorial's organization. From a cognitive load perspective, the confusion participants experienced may be attributed to the cognitive effort required to decipher the organization of the tutorials. However, from a situated learning perspective, the confusion may also reflect the need for a more authentic and sequential introduction to functionalities, mirroring the way people naturally learn in real-world situations. Most participants started from the left tutorial and proceeded towards the right. This observation could be indicative of users' preference for a sequential approach, with functionalities being introduced in a gradual and ordered manner. Chauvergne et al. (2023) suggest that the increased efficiency shown in tutorials rather than in non-guided explorations is due to the fact that novices are not aware of the contents importance and consequently explore them inefficiently. Tutorials, on the other hand, indicate and guide the users to the relevant functionalities. Limiting available options and introducing them one by one, especially during onboarding, could be a strategic design choice to build on acquired knowledge. For instance, since sitting is accomplished by teleporting to a chair, it should come after learning teleportation.

According to Chauvergne et al. (2023), sensory-motor and cognitive abilities about how we interact with the world transfer to the virtual world. The authors argue, therefore, that tasks in the VE that mimic the ones we are used to naturally performing in the real world do not need instructions or training. This is the case for moving the head around to change the visual as the transfer is straightforward. The Tutorial Island in ENGAGE includes a section on the head movement, most likely to accommodate the other available platforms in which the controls do not come naturally.

Another aspect that emerged from the exploration is physical contact between instructors and users. Chauvergne et al. (2023) recommends adjusting HMDs correctly for a comfortable and effective learning experience. However, the authors warn that it is not recommended to touch the participant to avoid breaking their personal boundaries and invading their personal space. As they are not familiar with the controllers, they needed assistance in wearing the headsets and grabbing the controllers in the right orientation. If they put the headset first and then took the controllers, they would not see them and know how to grab them. Consequently, we had to readjust them in their hands. We also tried the opposite, so they would get the controllers and we would help place the headset, but they would naturally help place it and release the controllers, resulting in the same difficulty with the controllers mentioned above. Touching the face and head is also an even more intimate physical contact. Because of this, we opted for readjusting the controllers in their hands and always notifying them of my actions before touching them.

5.2. RQ2: What instructional activity can be designed to facilitate onboarding in collaborative VR?

Turning to the second research question, an instructional activity aimed at facilitating onboarding was developed. Participants generally expressed satisfaction with the prototype, despite some misunderstandings between the researcher and participants. These misunderstandings were likely a consequence of the novel instruction mode and limited shared visuals (Chauvergne et al., 2023). It is essential to acknowledge that in a virtual environment, not all user actions are visible to others. For example, menus and the actions contained within them are not displayed to other users, introducing an additional layer of complexity to the instructional process. The lack of a shared view, leading to a disconnect between users' experiences and what they can see, can hinder the effectiveness of instructions. To illustrate, in certain cases, the researcher gave directions such as "Now exit the menu by clicking the X in the right upper corner," but the participant had not even opened the menu. This resulted in confusion for both the researcher and the participant, as the participant inquired about which "X" to click since none were visible to them.

Two participants mentioned that participating in the onboarding process with peers would be beneficial as having someone on the same level around them to discuss and compare would be helpful. Participants in Jin et al. (2022)'s study identified the potential of VR in fostering a lifelike social setting conducive to collaboration. Similarly, Han et al.'s (2022) participants highlighted the beneficial impact of HMDs in promoting group collaboration. These positive social interactions and engagement underscore the significance of shared experiences, particularly in the context of distance learning. Furthermore, one participant proposed a future concept of a second instructor monitoring participants from outside the VE with a mirrored view, thus potentially addressing the visibility limitations. Being able to see participant's view would definitely be beneficial; during this study, though, the quality of the mirrored view and the frame rate were too low to effectively monitor users. Additionally, the HMDs have speakers close to the user's ears which might make it difficult to be heard. Unless the audio is set to the maximum volume, outsiders cannot hear what the user is listening to too. Consequently, participants were often given instructions synchronously with the recorded Tutorial

Island instructions, which can be very confusing for the participant as they are hearing two voices speaking at the same time.

Situated learning theory places a strong emphasis on the significance of learning within authentic contexts (Lave & Wenger, 1991). VR provides flexibility in the customization of the learning environment easing the adoption of authentic learning environments. ENGAGE, for example, provides the capability to replicate a wide range of environments; some can be chosen from a library while others can be manually constructed. This platform serves as an avenue for immersing users in scenarios that might otherwise be impractical to recreate (Bailenson, 2018). This alignment between the principles of situated learning theory and the capability of ENGAGE supports the notion that effective learning occurs when learners can apply their knowledge in contexts that closely resemble real-world situations.

Several participants stressed the need for time to explore on their own and practice what they learned. Some recommended adding a task with a clear objective in this regard. This desire for autonomy aligns with the principles of situated learning theory, which emphasizes the importance of involving learners in genuine tasks within authentic contexts (Lave & Wenger, 1991). In accordance with the principles of situated learning theory, the process of acquiring knowledge takes place within genuine real-life situations and is profoundly influenced by the surrounding social and physical environment (Greeno et al., 1996). This theory underscores the imperative of involving learners in authentic contexts tasks and offering them opportunities to put their knowledge to practical use. The integration of tasks that prompt autonomous exploration and application of acquired skills allows users to participate in instructional activities that can better emulate real-world situations, which is a key aspect of situated learning theory. After introducing a task for autonomous completion to review their learning, feedback was entirely positive.

Collaborative platforms facilitate situated learning by providing an authentic setting, cultivating a community of practice, and enabling active engagement and peer exchange. The outcomes of this study, when viewed through the lens of situated learning theory, provide a deeper understanding of how users can learn and collaborate on the platform. This understanding establishes connections to broader educational and learning theories, offering a holistic perspective on effective educational design within virtual environments.

The implications of this research are substantial for the design of collaborative VR platforms for educational purposes. In summary, the findings underscore the pivotal role of clear and contextually relevant instructions, and the need to minimize cognitive load. To practically apply these insights, the onboarding process in collaborative VR platforms should prioritize user-friendly instructions and gradually introduce functionalities during onboarding. Additionally, it is critical to allocate time for users' autonomous exploration and practice. Collaborative VR platforms can provide newcomers with more engaging and effective onboarding experiences by implementing these design improvements. The significance of authentic contexts, active participation, problem-solving, and social interaction is recognized in this research as a contributing factor to a successful design of virtual environments as an educational tool.

6. Limitations and future research

While the findings have provided valuable insights into the onboarding process and its impact on VR learning experiences, there are several limitations that should be acknowledged. Han et al. (2022) state that early decisions regarding the instructional approach for students play a pivotal role in leveraging the potential of VR for educational purposes and ensuring the successful integration of VR technology. Their study suggests that familiarity with VR technology is a crucial factor in determining the success of VR learning experiences and stresses that it is therefore essential to prioritize practice-based training. In fact, although VR is becoming more popular and accessible, it is still a novel medium and users need to adapt to it. The authors recommend an open and exploration-based structure where students can move, teleport, create, and interact freely with the VE. Only when students are proficient in using VR can they fully immerse themselves and learn within the virtual environment. Providing training time to help students become accustomed to the medium is therefore imperative.

The findings in Han et al.'s (2022) study suggest that a single training session is insufficient to foster adequate VR skills. To overcome this challenge, sufficient time must be allotted for students to adjust to the technology. Although not recommended, this study consisted of a single training session. The onboarding activity was deliberately designed with time constraints in mind. In the future, it should be implemented accordingly and divided into manageable chunks. This poses a second limitation, the amount of time spent in VR as prolonged exposure can induce sickness. DeVeaux and Bailenson (2022), for example, limited participants' use of VR to 30 minutes per session. The amount of time spent in VR was far from optimal and several participants expressed slight discomfort during the data collection.

It is worth considering certain limitations and drawbacks associated with the methods employed in this study. While observations and semi-structured interviews were effective in exploring participants' experiences and perceptions of the onboarding activity, the absence of quantitative data does not provide statistical generalizability and information on the extent of the observed trends and patterns. The generalizability and outcome of the study could also have been influenced by the included sample. The purposive and convenience sampling methods adopted in this study are useful for targeting specific expertise but do not guarantee an appropriate representation of the study population. Additionally, the sample size was also small because of the limited time to conduct the study. Future studies should use larger and more realistic samples in order to generalize the findings to the study population. Despite their comments not being generalizable, these methods allowed us to reach participants who meet the specific requirements, thus acquiring in-depth information from those capable of providing it.

Another limitation of the study is the absence of a comparative analysis. This study examined the onboarding activity within the chosen VR platform, ENGAGE, but did not provide a comparison with other collaborative VR platforms. In the future, a comparative analysis may be of value in determining the relative effectiveness and advantages of ENGAGE in comparison with other collaborative VR platforms.

The proposed onboarding activity involves highly individualized learning as it centers around a single student. However, it is important to mention that this approach may not be feasible within the education system due to its time-consuming nature. Consequently, it cannot be directly compared to an automated tutorial. During the study, one of the participants suggested the inclusion of peers in the onboarding activity while the instructor monitors the users' views. Exploring the possibility of having two instructors, one in the virtual environment and one monitoring users externally, could potentially expand the instructor-to-student ratio. Further research in this area is necessary to assess the practicality and benefits of such an approach. Moreover, longitudinal studies should be conducted to investigate how the number of participants affects the learning outcomes and identify an optimal or recommended number of participants.

It is important to acknowledge also that a single researcher may not be able to catch all potential usability issues compared to a team of evaluators. Ideally, this task would have been done with a second coder, and intercoder reliability checks would have been conducted. However, the findings can still be valuable in uncovering major problems and providing actionable recommendations for improvement. According to Braun and Clarke (2021, p. 38), the “themes cannot exist separately from the researcher.” The authors recognize coding as a subjective process that can encompass a deeper sense-making of the data if done reflectively, acknowledging, and embracing the researcher’s bias.

To sum up, this study enabled the design of a user-friendly onboarding activity to prepare students for collaborative virtual environments. However, the use of a single and individual training session presents challenges in real-world educational settings. The limited number of participants and the absence of quantitative data limits the study’s generalizability. Moving forward, it is of utmost importance to explore more feasible and scalable training methods that can be seamlessly integrated into existing educational systems. Exploring more practical and scalable training methods that can be seamlessly integrated into the existing educational system will help advance the field of VR education.

7. Conclusion

This study highlights the challenges associated with VR onboarding and proposes a comprehensive onboarding activity to mitigate the identified issues. The employment of design thinking enabled the refinement of the approach across two iteration cycles. The first cycle laid the foundation for developing a prototype targeting the gap between the existing tutorial and ENGAGE's more advanced collaborative features. At the same time, it explored the challenges faced by novice users. Participants faced challenges related to navigation, coordination, and cognitive load associated with VR interactions, revealing the specific pain points educators and learners may face during the initial stages of using this technology. The second cycle further validated the effectiveness of the designed activity.

This research contributes to the body of knowledge in the field that recognizes the need for efficient onboarding for novice users in VR education. It bridges a gap in the existing research by emphasizing the significance of onboarding specifically for novice users within the context of collaborative VR education. The identified challenges emphasize the significance of designing and testing effective VR onboarding activities as these difficulties can lead to frustration and hinder users from fully harnessing the advantages of VR (Chauvergne et al., 2023; Khojasteh & Won, 2021). By targeting the identified pain points, the onboarding activity aims to reduce barriers and enhance the user experience during onboarding. Additionally, it should serve as a pragmatic solution to ease the onboarding process in collaborative VR and enhance the overall user experience.

Furthermore, the study contributes to the broader goal of leveraging the educational potential of VR. By preparing newcomers to confidently navigate the virtual environment, the instructional activity aims at facilitating the transition to this technology, ultimately benefiting both educators and learners. This research sets the stage for further exploration and implementation of onboarding strategies in the context of collaborative VR, leveraging VR's full potential for education. While the current study has identified important insights and designed an instructional activity, it is essential to acknowledge the limitations and that the forthcoming research should build upon these findings to develop more feasible and scalable training methods.

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Appendix 1: Informed consent form

Consent form

Title of the study: Getting ready to learn in VR – The onboarding process in collaborative virtual reality

Master's student: Alice Zupančič
Supervisor: Dr. Géraldine Fauville

Purpose of the Study: The purpose of the study is to investigate the onboarding process in collaborative virtual reality. We aim to understand how users experience the onboarding process in collaborative virtual environments, how people go from VR novice to mastering the physical and virtual environment in order to start collaborating in VR and identify areas for improvement in the onboarding process.

Procedures: During the study, you will be asked to wear a head-mounted display and follow a series of brief tutorials. First, you will take the *First Steps* tutorial to learn about the controllers. Then you will complete a tutorial in *Engage* and lastly, you will complete our proposed tutorial. Between each tutorial, we will take a brief break. After that, we will hold a brief discussion about the experience. The study will take between 60 and 90 minutes.

Risks and Benefits: Some participants may experience discomfort or motion sickness while using the head-mounted display. If you feel any discomfort, notify the researcher, and remove the headset as soon as possible. The benefits of participating in this study include the opportunity to contribute to the understanding of onboarding processes in collaborative virtual reality.

Confidentiality: We will not record you during the study, however, we will record your view in the head-mounted display and sound. All collected data will be kept confidential and will only be accessed by the researchers involved in the study and will only be stored on a password-protected computer for the time necessary to analyze it. Your personal information will not be disclosed to anyone outside of the research team.

Voluntary Participation: Your participation in this study is completely voluntary. You may choose not to participate or withdraw at any time without penalty. If you choose to withdraw, any data collected up to that point will be deleted.

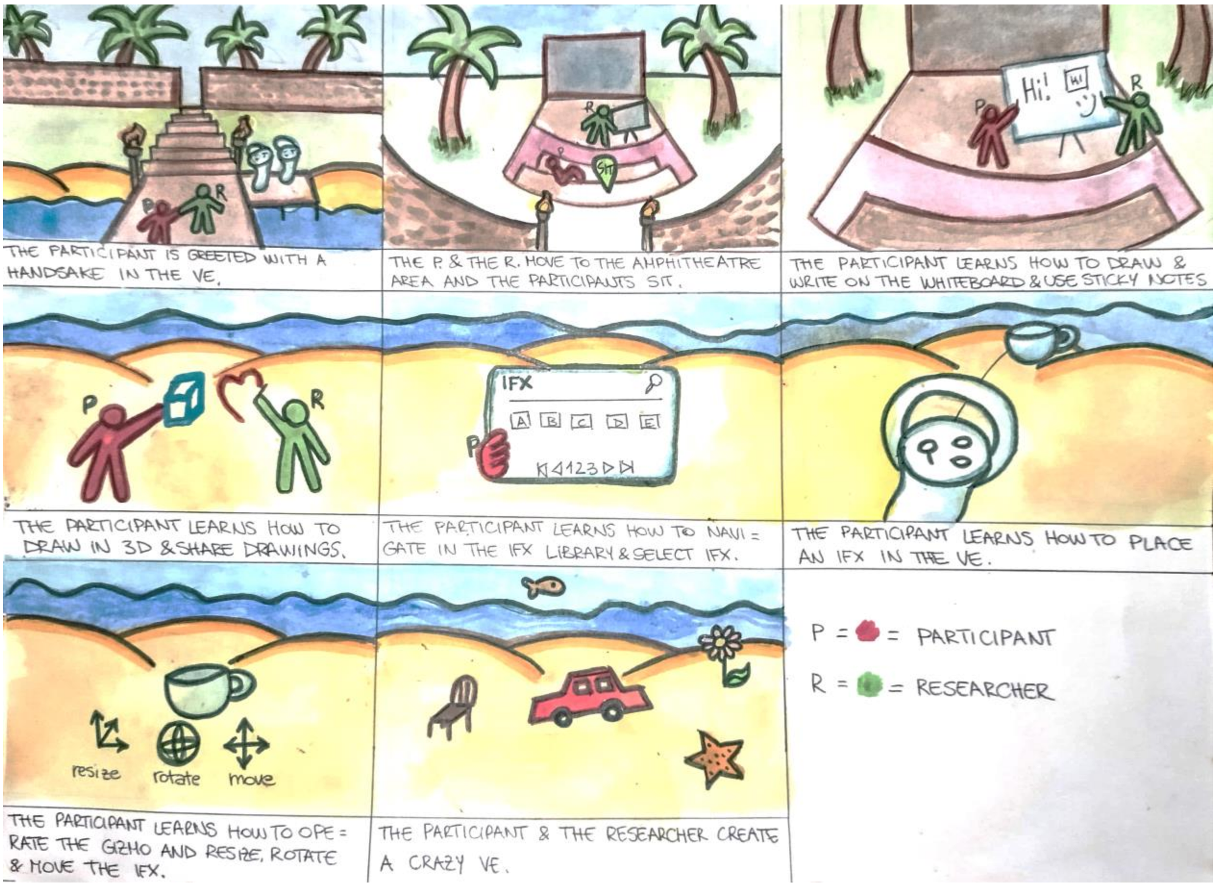
Contact Information: If you have any questions about the study or your rights as a participant, please contact Alice Zupančič (guszupal@gu.se).

Consent: By signing below, I confirm that I have read and understood the information provided above and I voluntarily agree to participate in this study. I understand that I may withdraw from the study at any time without penalty.

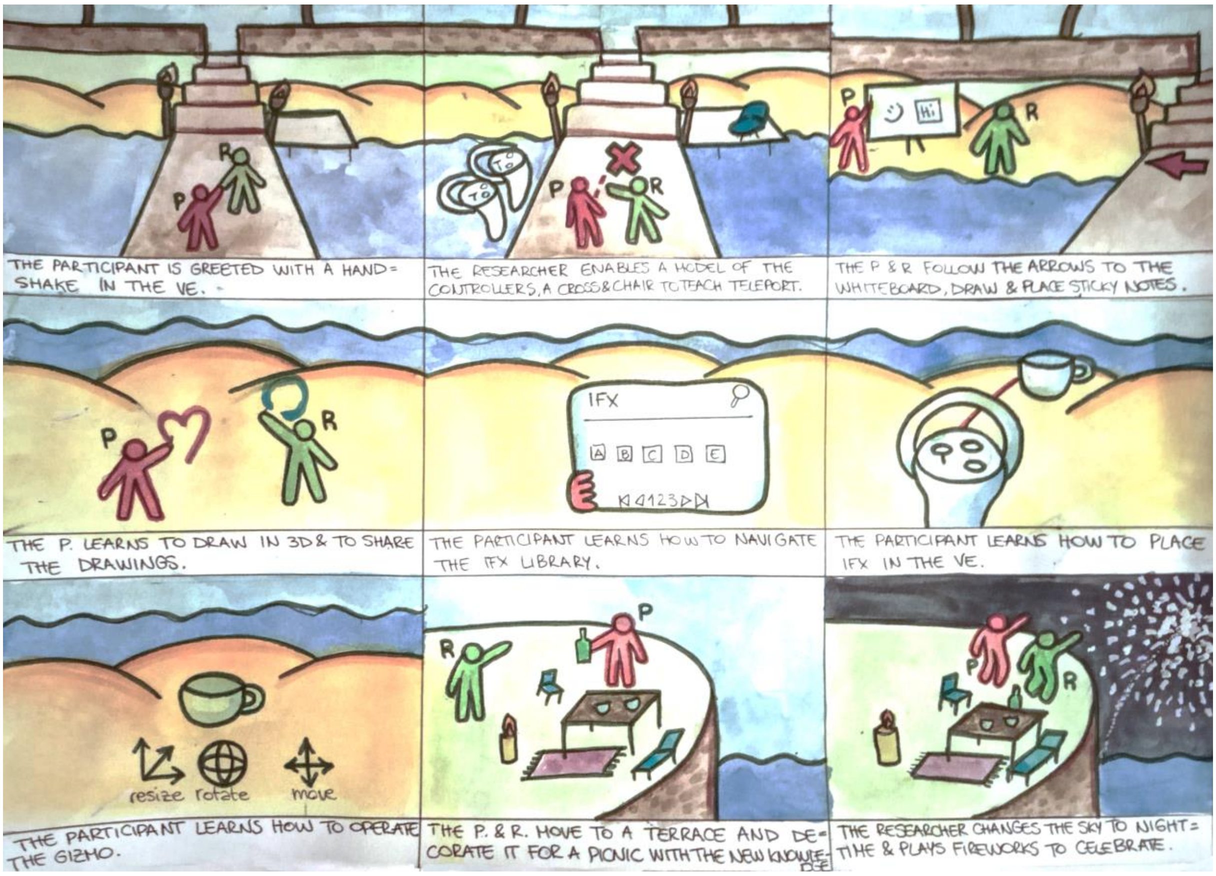
Signature: ___________________________

Date: _______________________________

Appendix 2: Storyboard of the first designed activity



Appendix 3: Storyboard of the improved designed activity



Appendix 4: Questions for the semi-structured interview

First iteration:

1. Have you ever used VR before? What is your experience?
2. How did you find the onboarding process in Engage in general? What aspects did you find easy or difficult?
3. Was Tutorial 2 user-friendly and easy to navigate? Were there any parts that were unclear or confusing? If so, can you describe them?
4. Was Tutorial 3 user-friendly and easy to navigate? Were there any parts that were unclear or confusing? If so, can you describe them?
5. How did you feel about the pacing of Tutorial 2? Was it too slow, too fast, or just right?
6. How did you feel about the pacing of Tutorial 3? Was it too slow, too fast, or just right?
7. Was there anything you enjoyed particularly or found particularly useful? Were there any features that you found confusing or frustrating?
8. Is there any specific feature you remember and would like to discuss?
9. Do you have any suggestion to make Tutorial 3 better?
10. Do you have any other suggestion or comment?

After the interview participants were contacted and asked to clarify their pronouns to avoid making wrong assumptions when referring to them and they were additionally asked whether they think they could have completed the second tutorial autonomously.

Second iteration:

1. What are your preferred pronouns?
2. Have you ever used VR before? What is your experience?
3. How did you find the onboarding process in Engage in general? What aspects did you find easy or difficult?
4. Was the tutorial user-friendly and easy to navigate? Were there any parts that were unclear or confusing? If so, can you describe them?
5. How did you feel about the pacing of the tutorial? Was it too slow, too fast, or just right?
6. Was there anything you enjoyed particularly or found particularly useful? Were there any features that you found confusing or frustrating?
7. Is there any specific feature you remember and would like to discuss?
8. Do you have any suggestion to make the tutorial better?
9. Do you have any other suggestion or comment?