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Published in:
Computers & Education: X Reality

DOI:
10.1016/j.cexr.2024.100058

Published: 29/02/2024

Document Version
Publisher's PDF, also known as Version of record

Computers & Education: X Reality 4 (2024) 100058

Contents lists available at ScienceDirect

Computers & Education: X Reality

journal homepage: www.journals.elsevier.com/computers-and-education-x-reality

Advantages of virtual reality childbirth education

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ARTICLE INFO

Keywords:
Virtual reality
Childbirth education
Learning effectiveness

ABSTRACT

Many expectant parents do not prepare enough for childbirth, and not getting a tour of the birthing hospital is causing them unnecessary stress. We enhanced childbirth education with an online virtual reality program for the users to experience what it might be like to give birth in a hospital. In this paper, we report a study that included observational user testing with a virtual reality headset and autonomic testing with the device of the user's choice. Data was collected with a pre-questionnaire, observations from the user tests, a semi-structured interview with the expecting parents, a post-questionnaire, and a follow-up questionnaire. The program improved learning outcomes and offered realistic and concrete birthing examples. Usability was good with the virtual reality headsets, while other devices need more research.

1. Introduction

1.1. Childbirth education

The main goals of prenatal education are to coach families on birth, breastfeeding, baby care, upbringing, and parenting (Declercq et al., 2013; Klemetti & Hakulinen-Viitanen, 2013) and to meet others in the same situation (Fabian et al., 2005). Prenatal education includes childbirth education (CBE[1]), which should provide up-to-date, evidence--based information, enable a positive childbirth experience for the expectant parents, and support the birthing person's capabilities (Klemetti & Hakulinen-Viitanen, 2013). Most countries do not have a centralized body to define the requirements for CBE. In Sweden and Finland, the governments have defined prenatal education as an integrated part of public healthcare prenatal care (Fabian et al., 2005; Klemetti & Hakulinen-Viitanen, 2013). Finnish prenatal education is based on the Finnish Health Care Act (Finlex, 2010), which defines the well-being services in each county as responsible for providing free pre- and postnatal services for families.

Prenatal education programs can vary in many ways: by the size of the group, the number of lessons, the length of each lesson, and the lesson format, such as face-to-face, hybrid, or online. During the 1970s in Sweden, the suggested classes consisted of 8–10 group sessions, which have now been reduced due to cost and structural changes in the healthcare sector (Fabian et al., 2005). In Finland in the 2010s, the most common childbirth class series consisted of five classes taught by the public health nurse and a hospital tour with a midwife. The hospital tour usually included a 30-min lecture and a 30-min tour of the triage, birthing, and postnatal wards. However, there was a significant variation between the different counties of what was offered. When inquiring about the current situation, we discovered that in some counties, the CBE currently consists of only one 1-h online meeting without the possibility to ask questions with no hospital tour. The entire CBE is sometimes only an email or even to the point that some parents do not get any CBE (Siivola & Leinonen, 2022). This was the situation with the CBE program in 2019 before the COVID-19 pandemic, during and after which CBE programs further deteriorated. According to the study, the learning goals were not fulfilled even with the families who reported receiving childbirth education (Siivola & Leinonen, 2022). Therefore, based on the inconsistencies in the education received in childbirth, there is an obvious need to improve childbirth education, and online learning tools should be studied (Klemetti & Hakulinen-Viitanen, 2013; Siivola & Leinonen, 2022).

1.2. Negative birth experiences and fear of childbirth affect future reproductive decisions

Negative birth experiences and Fear of Childbirth (FOC[2]) are both

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[1] CBE Childbirth Education.
[2] FOC Fear of Childbirth.

https://doi.org/10.1016/j.cexr.2024.100058
Received 9 December 2023; Received in revised form 19 February 2024; Accepted 19 February 2024
Available online 29 February 2024

increasing (Haapio, 2017; Joensuu et al., 2023; THL, 2023) and, if left untreated, could result in severe health-related issues, challenges with the ability to bond with the baby, and even avoidance of new pregnancies (Dencker et al., 2019; Joensuu et al., 2023; Kido & Uemura, 2023; O'Connell et al., 2017; Sorsa et al., 2023; Vaajala et al., 2023; Wijma & Wijma, 2017).

In Finland, the FOC diagnoses have increased from 1,9 percent in 2010 to 11,0 percent in 2021 (THL, 2023). For first-time mothers, FOC has been associated with fear of the unknown, pain, and loss of control (Størksen et al., 2013). For subsequent pregnancies, the most common reason for FOC is a previous birth experience (Størksen et al., 2013), and a negative birth experience would then prolong the time for new pregnancies and influence reproductive decisions (Joensuu et al., 2023; Sydsjö et al., 2013).

Based on experts around the world, it is becoming evident that it is essential to develop interventions to prevent FOC and negative birth experiences (Haapio et al., 2017; Moghaddam Hosseini et al., 2018; Størksen et al., 2013). For example, many educational interventions have successfully reduced FOC through additional family group training (Haapio, 2017; Haapio et al., 2017; Karabulut et al., 2016; Uçar & Golbasi, 2019). For instance, Haapio et al. (2017) extended Finnish prenatal education for first-time mothers with a more extensive CBE lecture in the hospital by a midwife. However, despite the promising results, our inquiries suggested that the extent of CBE offered by the birthing hospitals in Finland has decreased to what it was set up to be in the past.

1.3. Virtual reality

Virtual reality (VR) is a computer-generated three-dimensional graphical representation of the natural or imaginary environment in which users are immersed through a dedicated headset or an array of display walls (Chittaro et al., 2018; Gagnon, 2022; Renganayagalu, Mallam, & Nazir, 2021). VR can help users feel immersed in another environment, and it can help users transfer knowledge to the real world better than traditional study material (Chittaro et al., 2018; Renganayagalu et al., 2021). Specifically, a VR tool can improve participants' self-efficacy (Chittaro et al., 2018) and users' emotional responses during learning (Ulrich et al., 2021). Overall, VR can be a promising technology for enhancing learning through experiential learning (Renganayagalu et al., 2021).

However, VR in education has its challenges. Cybersickness and user interaction problems have been reported in previous studies, as are struggles with VR hardware (Ramaseri Chandra et al., 2022; Renganayagalu et al., 2021). For example, the hardware is not designed for prolonged usage (Oculus, 2023). Studies on the use of VR in education need to consider usability since usability standards for VR are still developing (Ramaseri Chandra et al., 2022; Renganayagalu et al., 2021). For example, the VR experience can face usability issues like space limitation, fatigue, accessibility, and predictability, which can all be improved with design techniques (Meta, 2023).

Beyond usability, learning theories, and equipment availability must be considered to get generalizable findings on the benefits of VR in education (Renganayagalu et al., 2021). Learning theories should be an integral part of the studies, though they are often overlooked when technology is studied (Renganayagalu et al., 2021). Equipment availability has also slowed down the use of VR in education. However, the gaming industry has accelerated the publication of consumer market VR hardware, which will benefit the education industry (Renganayagalu et al., 2021).

Since the current Finnish CBE does not meet the users' needs (Siivola & Leinonen, 2022) nor reach the needed level of learning (Klemetti et al., 2018; Siivola & Leinonen, 2022), we developed an online flipped classroom CBE program. In addition to the online course and meetings, the program utilizes VR to give the user a more realistic feeling of what it could be like to give birth (Siivola et al., 2023).

1.4. Research questions

This paper presents the user study of the VR CBE program we developed with the following research questions (RQ[3]):

1. How did users use the VR CBE program?
   1.1. How much of the VR content did they follow?
   1.2. Did the participants use the program independently after the testing session?
2. How do users experience VR CBE?
   2.1. Is the VR CBE easy to use?
   2.2. Are users satisfied with the program?
   2.3. Would they recommend the program to others?
3. What was the impact of VR CBE?
   3.1. Is the program improving learning outcomes?
   3.2. Does the VR CBE program affect FOC?

The following sections detail how we built the VR CBE, followed by the user studies and a discussion of the findings according to Kirkpatrick's learning theory.

2. Material and methods

The VR CBE was developed using a user-centered design process ISO 8241-210 (ISO, 2019). It is an iterative design process based on understanding users, their tasks and environment, and user evaluation. First, our VR program was tested by previously pregnant users (Siivola et al., 2023) and, in this current study, by pregnant users. The program is further developed after each user testing cycle in the iterative process.

The program content included 360° videos, images, text, and sound clips. Due to the software restrictions, only 360° videos were visible in the VR headset. Fig. 1 presents the content and the flow of the program. The program can be used with different devices, creating distinctive user experiences. Using the program with a VR headset, the immersion level is higher than in other devices. Smartphones and tablets use a gyroscope functionality where the image moves with the device's movement, and the user can thus "look around." The immersion is improved by placing a smartphone on a cardboard headset. The 360° view can be explored on a computer by moving the image with a mouse. A desktop computer or laptop provides less immersion but offers the advantage of a larger screen and broader accessibility for the user group. Being useable with different devices makes the program more accessible.

The program was developed based on the previous user studies. In a previous program version, the content was placed close to the visual location in the main panorama image. For example, the fetal heart rate monitoring video was placed next to the equipment in the panorama, and the birthing ball video was next to the ball (Fig. 2.).

The users reported being confused when the videos from different stages of labor were in mixed order. End-of-labor videos were alarming when viewed at the beginning of the program. For this test, we lined up the videos according to the flow of labor from the start (left) towards the end (right) (Fig. 3.).

The program was filmed with an Instra360Pro camera, the final videos were compiled in Premiere Pro, reduced in size with Handbrake (HandBrake, 2022), and the final program was developed with Pano2VR (Garden Gnome, 2022). The finished program is hosted on a website accessed with VR headsets, tablets, smartphones, and computers. VR headset shows only VR content (360° videos and panorama) due to the limitation of the software. A more detailed presentation of the content, structure, and technology used can be found in the article by Siivola et al. (2023).

Inspired by the article "Measuring the effectiveness of virtual training: A systematic review" by Strojny and Duzmanska-Misiarczyk

[3] RQ Research question.

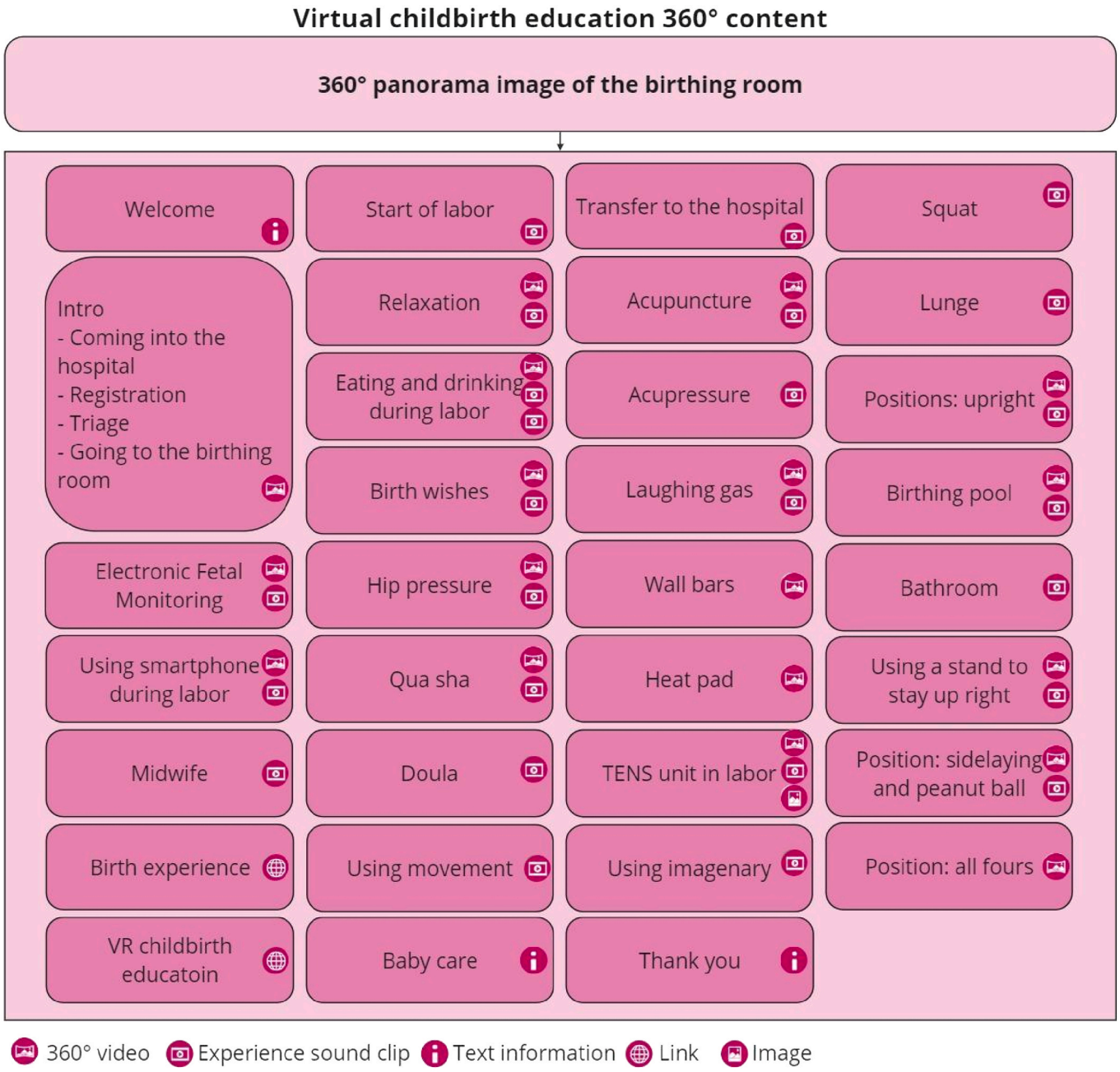

Fig. 1. The organization of the 360° videos in the tested VR CBE.

(2023), we set out to study the learning effectiveness and advantages of the VR CBE program that would take into account the usual limitations found in their systematic review. In this study, we looked at all four levels of learning from Kirkpatrick's model, which is a tool for evaluating and analyzing the results of learning programs and training in four levels of evaluation: reaction, learning, behavior, and results (Kirkpatrick & Kirkpatrick, 2006). Kirkpatrick's model is widely utilized for training evaluations and was proposed for use in the VR training research by Strojny and Duzmanska-Misiarczyk (2023). The reaction includes engagement and satisfaction with the program. For example, how the users interact with the program, how much content they use, and whether they recommend it. Learning and results levels include following the learning results and whether the program increases the user's ability to give birth. Behavior is followed by how the users revisit the program in the self-paced use, whether they visit it on their own, and for how long.

The learning goals were derived from the official CBE documentation for prenatal clinics (Klemetti & Hakulinen-Viitanen, 2013). The following goals were selected for this study:

Expectant parents:

- o Understand the stages of labor
- o Know how to make a birth plan
- o Can take responsibility for their birth
- o Understand the benefits of a support person
- o Have enough knowledge of the physiological birthing process
- o Know and understand the most common birth interventions (e.g., fetal monitoring, induction)
- o Have enough knowledge of non-medical pain relief
- o Understand the stages and situations suitable for different pain relief methods

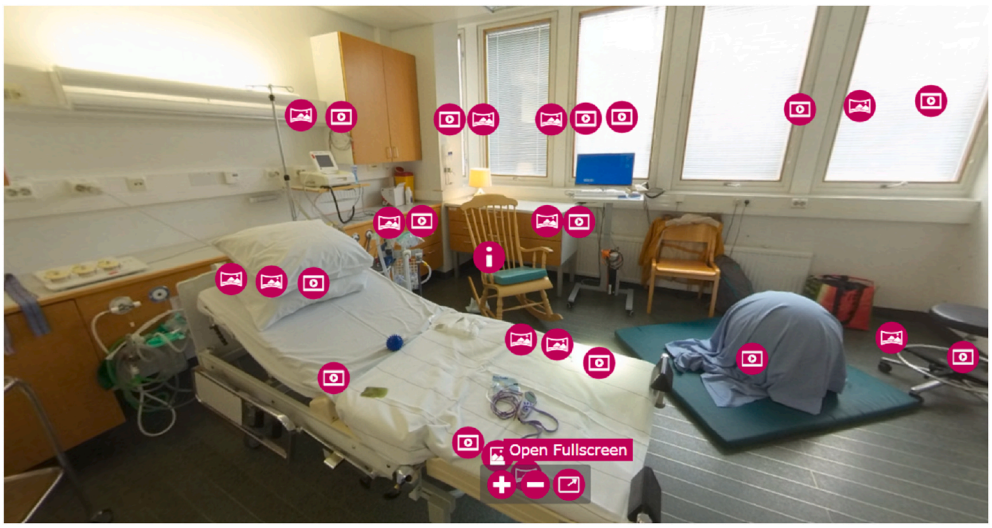

Fig. 2. The organization of the content in the previous version of the VR CBE on a computer screen. The corresponding videos were located next to the location where they were used. The introduction video length was 4:20, and the others were between 0:49 to 2:28.

Fig. 3. For this test, the content was organized according to the flow of birth from left to right. This image is from the VR headset with only 360° videos.

- o Know why fetal heart rate is monitored and what interventions come with it
- o Have enough information about childbirth
- o Get updated, evidence-based information about childbirth according to their needs
- o The CBE is enough to prepare them for childbirth
- o The CBE increased their resources for childbirth
- o Trust their ability to give birth
- o Have enough information to participate in the decision-making
- o Know their rights during birth
- o Have enough information about the birthing environment.

Most of these learning goals were reported in previous research (Siivola & Leinonen, 2022), allowing us to compare the results. Other learning goals were not used in this study since the content of the VR program is still limited. For example, we do not have content for the postnatal period or breastfeeding.

The usability of the system was measured using a Positive System Usability Scale (PSUS[4]) (Sauro & Lewis, 2016) and its translation to Finnish (Jokela, 2013). PSUS originated from the System Usability Scale, initially developed by John Booke in 1986, and it consists of ten statements. Initially, it had five positively and five negatively worded statements. Later, Sauro and Lewis (2016) modified the scale to have ten positively worded statements, making the tool more reliable. The statements were translated into Finnish.

The study procedure is presented in Fig. 4. In the first part of the study, the program was used with a VR headset one user at a time with the researcher. Before the user test, the participants completed a pre-questionnaire with background information (Appendix A). In the user

[4] PSUS Positive System Usability Scale.

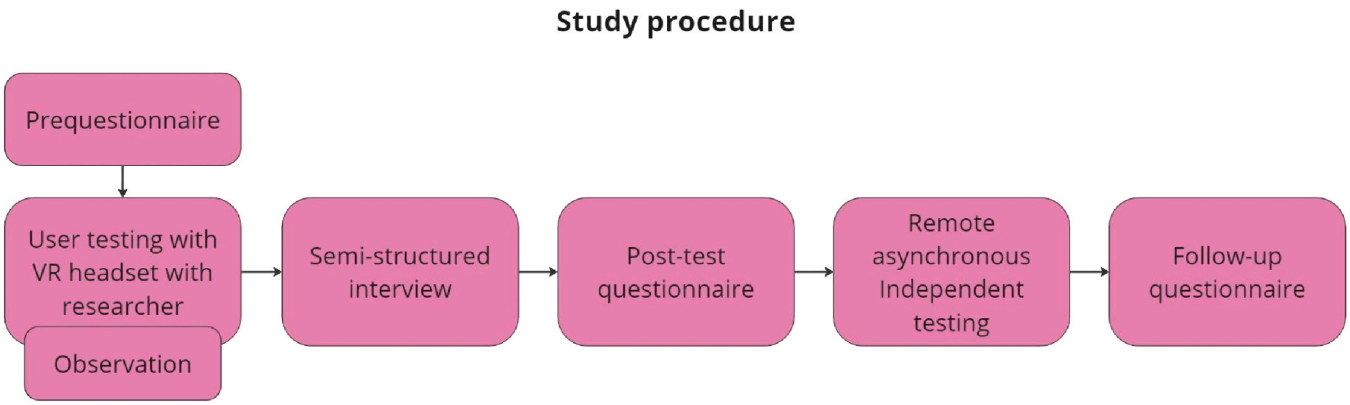

Fig. 4. Study procedure for the user study.

testing, the participants used the program with Oculus Quest 2 while observed by the researcher (Appendix B). A cognitive walkthrough was used for the observation (Mahatody, Sagar, & Kolski, 2010). A semi-structured interview (Appendix B) and post-test questionnaire (Appendix C) were completed immediately after the test. Only the participant and the interviewer were present. The interview started with the user describing their feelings about the program and their experience with the VR headset. The interviewer facilitated the discussion with the questions in Appendix B to ensure all the topics were covered. The researcher took notes from the interview since the ethical approval did not include recorded material. Finally, the users received a link to the website, giving them free access to the program.

In the second phase, remote asynchronous testing (Alhadreti, 2021) was used in which the participants had free access to the content using a device of their choice. They could use the program as much as they wanted during multiple sessions. After two weeks, they completed a follow-up questionnaire (Appendix D).

The session length and used content were observed during the user testing, and the independent testing results were self-reported in the follow-up questionnaire (RQ 1). The user experience was studied using observation, semi-structured interviews, and post- and follow-up questionnaires (RQ 2). The learning goals and FOC were studied using pre-, post, and follow-up questionnaires and interviews (RQ 3). We report the length of the use of VR, the number of single sessions, and the timeline as requested by Strojny and Dużmańska-Misiarczyk (Strojny & Dużmańska-Misiarczyk, 2023).

To participate, the users needed to be pregnant, understand Finnish, have been offered the public prenatal clinic CBE before attendance, and were able to come to the research location for the first phase. The questionnaires were implemented with Google Forms, and the links to the pre-test and follow-up questionnaires were sent to the user by email. A content analysis approach (Krippendorff, 2004) was applied to analyze the collected data. The open-ended data was coded into groups and categories. Notes were taken by hand and later transferred to Google Docs by a Lamaze-certified childbirth educator. Trustworthiness was checked by redoing the coding. The study has ethical approval from the Aalto University Research Ethics Committee.

3. Results

This user study aimed to test the VR CBE program with five pregnant users before large-scale testing. The study sample was 5. The characteristics are presented in Table 1. One was pregnant for the first time, and others had previously given birth. They all were fluent in Finnish and had taken the CBE offered by the prenatal clinic but had yet to be offered a tour of the hospital or CBE at the hospital. Two users had attended private childbirth education. Three users did not have FOC, one had FOC without diagnosis, and one had been diagnosed with FOC.

Table 1
User characteristics and user study data.

	User 1	User 2	User 3	User 4	User 5
Fluent in Finnish	Yes	Yes	Yes	Yes	Yes
Pregnant	Yes	Yes	Yes	Yes	Yes
Had given birth before	No	Yes	Yes	Yes	Yes
Had official CBE	Yes	Yes	Yes	Yes	Yes
Tour to the hospital	No	No	No	No	No
Private CBE	No	Yes	No	Yes	No
Had FOC	No	No	Yes, not diagnosed	Yes, diagnosed	No
Motion sickness	Sometimes	No	No	Yes	No
Age	40	35	40	41	31
Had tried a VR headset	Yes	No	Yes	Yes	Yes
Had seen 360° videos	Yes	No	No	No	Yes
Length of the user study with VR in minutes	30	34	33	37	31
Felt being in the birthing room	3	5	4	4	5
Number of independent sessions (1–5)	1	3	1	1	3
Independent us in minutes	20	40	30	10	55
How satisfied with the VR CBE? (1–5)	5	4	3	2	3
Would recommend	Yes	Yes	Yes	Yes	Yes

Three reported not having motion sickness, one had sometimes, and one reported having motion sickness. The average age of the participants was 37 years (ranging from 31 to 41 years). Four users tried VR headsets before the user test, and two had seen 360° videos.

3.1. The use of the VR CBE program (RQ 1)

The users were given the VR headset with the CBE program running. They were instructed to browse freely and consume the content they wanted without further instructions. All the users watched the intro video first and then followed the order that the program suggested to them. Four users watched all 18 videos, and one user skipped four videos since she was familiar with the topics. The average time for the testing was 33 min, ranging between 30 and 37 min.

The users were happy with the length of the videos. The intro video length was 4:20, and the others were between 0:49 and 2:28. User 6 mentioned, “The length of the videos was good. The length should be

visible when selecting the video."

During the independent testing, the users visited the content one to three times and self-reported using the program for an average of 33 min (between ten to 55 min). In addition to the VR headset, they used the program with smartphones (3) and computers (1). Users 3, 4, and 5 preferred VR headsets, and 1 and 2 preferred a computer. Users who preferred VR noted that the experience was most immersive, the program was easier to follow, and it had the best usability. Those who preferred the computer stated it was easy to use and available at home.

3.2. User experience of the VR CBE (RQ 2)

Fig. 5 presents the results on satisfaction and usability. Users found the program easy to use, consistent, and intuitive. They needed very little technical support and felt confident using the program. The Positive System Usability Scale score was 87 after the VR testing and 76 after the independent testing. According to Sauro and Lewis (2016), these scores can be interpreted as A+ and B.

The users felt they were in the birthing room (average rating 4,2 on a scale of 1–5) (Fig. 6). The users felt 360° videos added value to the program (average of 4,6), while the VR brings only a small added value (average of 3.6). The user's satisfaction with the program varied between 2 and 5, with an average of 3.4.

None of the users mentioned anything about the weight of the VR headset, and none had difficulties using the hand controllers. None of the users felt motion sickness during the testing. One user had astigmatism in her eye, and after the test, she noticed her eye was tired. For one user, the VR headset tickled her nose, and when she touched her nose, the Oculus turned into see-through mode. The researcher helped her to double-tap the headset to return to the program. This problem was corrected by adjusting the VR headset.

Four of the users had given birth before, and they reflected on what they had experienced. User 4 got goosebumps while watching the birth pool video, remembering her experience: "Similar to my birthing pool experience." User 3 reflected on her past trauma experience and stated, "Difficult to prepare for vaginal birth after emergency cesarean, and I do not even know if I will have one now."

Several users commented that the video flow was good and supported the labor progression. User 3 mentioned, "The flow of labor was visible. It had different pain relief methods for different stages of labor."

Users also commented a lot about the midwife being present most of the time. The narrator mentioned "your midwife," but user 4 commented that there were eight midwives during her long birth. Some commented that the midwife was not present so much during their birth, and the midwife did not have time to guide them during the birth. They worried the program would give false information about the midwife being always present during birth. User 3 mentioned it was great to see such an active midwife who had time to guide, but user 2 considered the program to be led too much by the midwife. Instead of the midwife offering the pain relief, user 2 hoped to see the birthing person requesting the pain relief.

The narration worked, and there were no comments on the male voice. When asked about the male voice, user 1 stated: "The narration was natural. I did not even think of it during the program," and user 5 stated, "Did not even think of it."

Users mentioned the length of the videos to be good and some technical improvements for the 360° videos. The height of the floor was different from the real world, which bothered a few users at the beginning. User 1 stated: "The length of the videos was good. The floor height was weird, but I got used to it". The online videos were reduced in size, and user 5 mentioned that the quality of these videos could be better. The actors' spatial distance from the camera was found to be important. User 4 mentioned, "The person came close a few times, and I felt I needed to move away." When people in the 360° video came too close to the camera, the users physically moved away from them in the real world.

On the follow-up questionnaire, the independent testing results were not as good as the VR testing. The program had more content (sound clips, text, images), but none of the users mentioned the extra content positively in the open-ended questions. Some commented that the program was more challenging to use with other devices. User 4 stated that the program was clumsy on a smartphone. User 2 would like first to use the program on a computer to get the program's overall feeling, and then she would like to use it with a smartphone. User 4 iterated that there was too much content to be used with a smartphone. However, user 1 liked that the program would be available anytime on a computer.

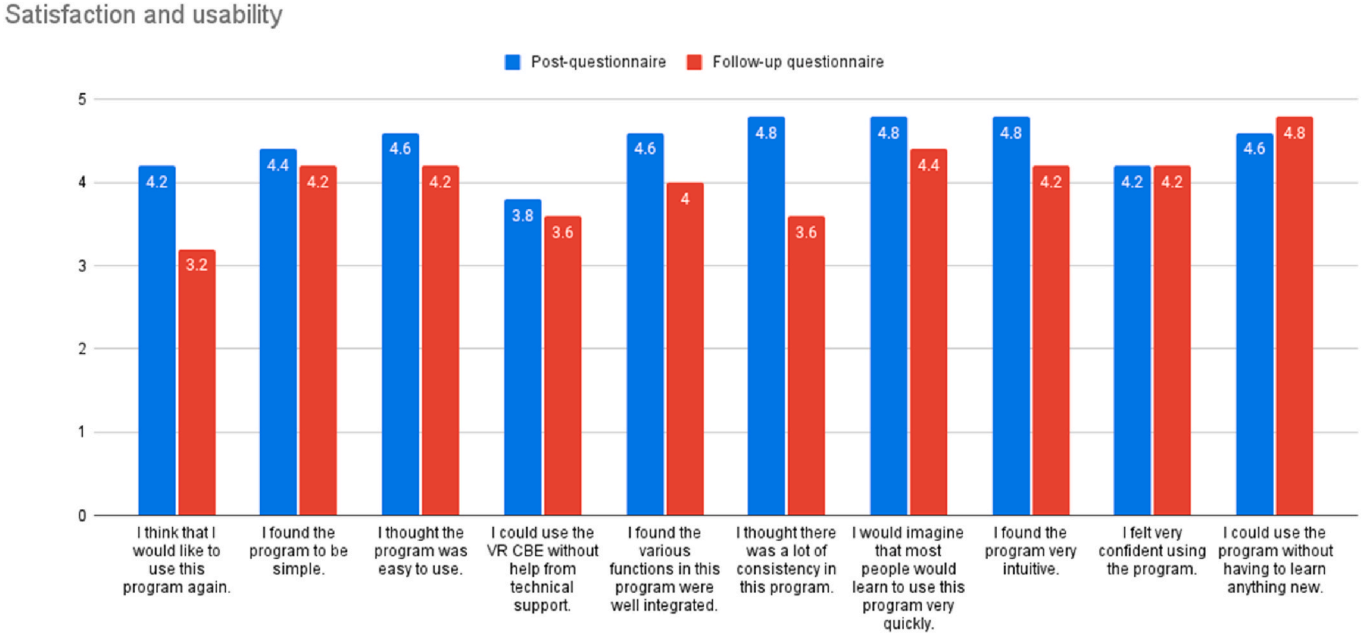

Fig. 5. Satisfaction and usability with the VR program (left) and after independent testing (right). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

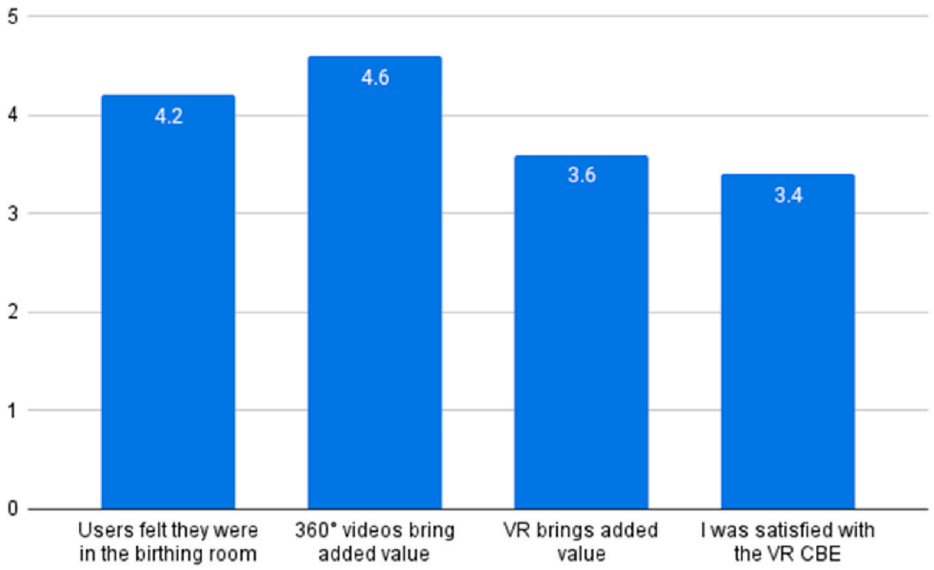

Fig. 6. The users felt they were in the birthing room during the VR testing. In the follow-up questionnaire, they agreed that the 360° videos bring added value.

3.3. *The impact of VR CBE (RQ 3)*

For the learning goals, we had three points of measurement: the pre-, post-, and follow-up questionnaires (Figs. 7 and 8). All learning goals received higher ratings after the VR testing than in the pre-questionnaire. However, the results after the independent testing were mainly lower than after the VR testing, mostly between the pre-questionnaire and the results after VR testing.

Experiencing what birth is like is essential, and the program offered them a great experience. The users were pleased with the real-looking and realistic content, which helped them understand what they had been taught before (Fig. 9). User 5 stated, "I empathized with the person giving birth. It felt realistic." User 1 said, "This brought to life the list from the PowerPoint slide about non-medical pain relief." User 3 echoed this sentiment: "First, this felt like a training video, but then I forgot it since it felt so realistic." They mentioned specific pain relief methods that they learned to use, and they will remember to use them during birth due to visual memory. Seeing the hospital environment was also important. User 4 stated: "Good to see concrete methods and how I can use them in reality.", and user 3: "Felt more realistic than previous material I have seen." The program was a new, exciting way to have CBE.

It is also important to note that one user had a prenatal appointment before the testing. She had an undiagnosed FOC, and she was confronted by a new professional who did not correspond to her previous trauma in a sensitive way, which triggered her trauma just before the user test. During the semi-structured interview, the user reported being upset about what had happened in the prenatal appointment. Her trauma was connected to the hospital and respective personnel. Before testing, her undiagnosed FOC was confirmed, but she did not report her distressing meeting beforehand. This event did affect her VR testing and the results. For satisfaction, she gave 2. She reported that VR testing increased her

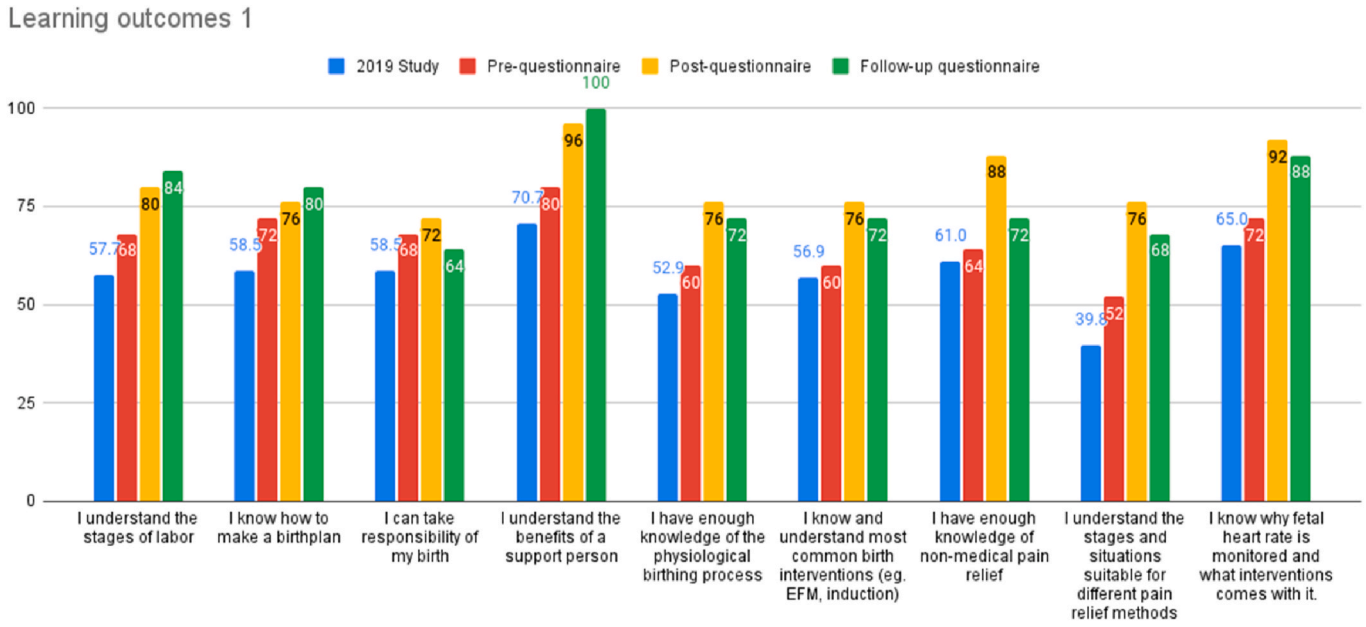

Fig. 7. Results of the self-reported learning goals part 1. VR CBE improved the level of learning compared to the pre-questionnaire results. With this understanding, the users know the stages of labor, the benefits of the support person, non-medical pain relief, and why the fetal heart rate is monitored.

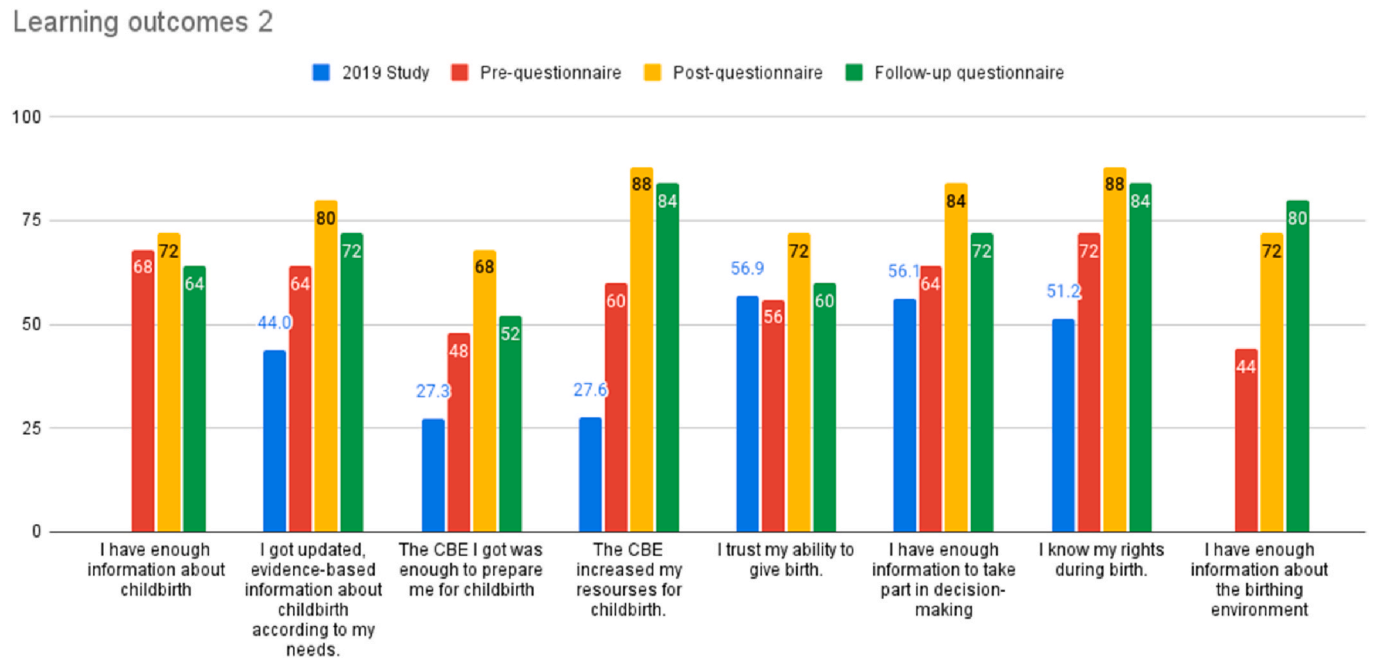

Fig. 8. Results of the self-reported learning goals part 2. The users reported getting improved resources for childbirth, having enough information to participate in the decision-making, and having knowledge of their rights during birth. They can improve their childbirth experience by being part of the decision-making process.

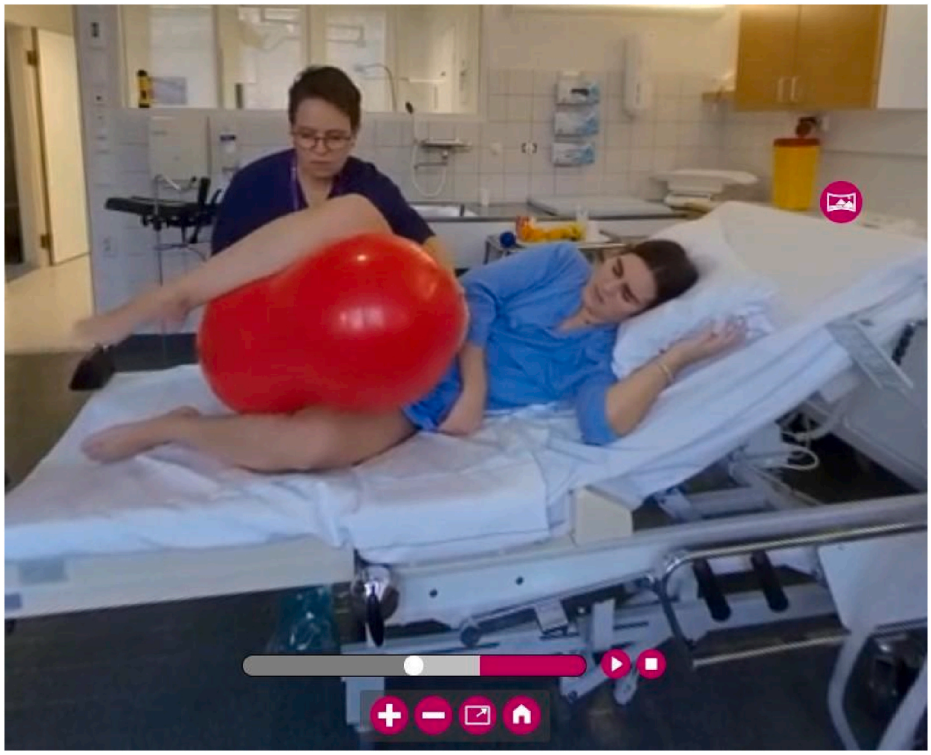

Fig. 9. *"I thought a peanut ball was a ball of peanuts. It was perfect to see it and how it is used,"* one user laughed.

FOC, but independent use did not affect her FOC. The other user with diagnosed FOC reported that the VR testing did not affect her FOC, and the independent testing decreased her FOC.

A positive outcome was that users started brainstorming ideas for future content, like birthing at home with a support person and medical pain relief. User 2 asked for "more information on what the support person can do during labor," and user 4 thinks the program "should have information on what to do at home before transfer to the hospital" and "pushing phase and what happens after birth." Furthermore, this was a good recap of the previous training for those who had childbirth education. User 3 mentioned this as "A good reminder of the birthing ball and tens unit, which I have at home."

Generally, the users like the concept of VR CBE. The users felt the experience was concrete and realistic, and the CBE content came to life with this program. Some users mentioned that the VR CBE should be available for all pregnant parents, especially first-time parents.

4. Discussion

In this paper, we presented the VR CBE program user study and laid out the technological foundation and the development process addressed in the Renganayagalu et al. review (2021). We designed the study according to the guidelines set by Strojny and Duzmanska-Misiarczyk (2023).

During the VR testing, four users watched all the videos, and for the one who skipped some videos, the content was familiar to her. The users used the headset for 31–37 min, close to the safety recommendations of a maximum of 30 min (Facebook Technologies, 2021). We got all the replies to the follow-up questionnaire, and they all used the program independently.

The implementation of this program was improved from the previous user test by Siivola et al. (2023). The new video distribution as a timeline of the birthing process instead of by location improved the flow of the program. The video quality, floor height, and the actor's closeness are issues that need to be reconsidered in future development. Testing with the VR headset was done in a chair with wheels. Seated positions improved accessibility (Oculus, 2023), and all the users used the chair's motion. No one mentioned anything about the weight of the VR headset, nor did they get motion sickness, which is promising for future use. The PSUS usability results were good, especially with the VR testing. In a previous user test (Siivola et al., 2023), a concern was raised about the end-of-labor contraction videos. However, none of the users mentioned that those could be intimidating this time. This might be due to the videos being organized based on the progression of labor.

The users are satisfied with the VR CBE program and recommend it. According to the users, all expectant parents, especially first-time expecting parents, should have this training to get this realistic view of birth, with concrete examples of how pain relief is used.

The learning results were increased from the baseline data after VR testing. However, the independent testing results decreased, staying mostly above the baseline. The decreased results require more research and program development when the goal is to use it independently. When we compared the results to the study of Siivola and Leinonen (2022), the learning outcomes were better with the VR CBE than with the standard training.

Based on the interviews, the users were excited and happy they got the VR CBE training. The users highlighted that seeing concrete examples of pain relief will help them utilize them during their birth, and this will help their ability to stay longer at home before transferring to the hospital and to cope with labor.

Fear of childbirth can arise for different reasons (Slade et al., 2019). We encountered a user who had a traumatic birth experience that caused her fear. In these situations, the source of fear should be discussed beforehand to determine if the CBE program based in a hospital will help to alleviate the fear rather than increase the fear. Alternatively, at least, the users need to be fully informed about the content to make an informed decision whether to use the program. Our two users with FOC had different reasons for their FOC, and they both reacted in the opposite way to the program. The program's effect on FOC will need more research with a more extensive user group with different reasons for FOC. The user with increased FOC after the VR testing received additional care from the childbirth educator.

As mentioned in the introduction, negative birth experiences and FOC are both increasing and, if left untreated, could result in challenges to bond with the baby and even avoidance of new pregnancies. VR CBE can help parents by improving learning outcomes, their understanding of childbirth, setting realistic expectations, communicating with the staff, and making it possible to participate in the decision-making process during birth, which can improve the birthing experience and satisfaction (Hodnett, 2002; WHO, 2018). Testing with wider target groups is needed to confirm this, and the program's independent use with tablets, smartphones, and computers should be studied.

5. Limitations

The main limitation of this research is the small user group. The users were recruited through social media, and previous experience with VR most likely affected their application to participate in the study. This might make the results more favorable toward the VR program. The users were over 30 years old, and younger users could give different results. A small user group was proper for the pilot stage of this program before large-scale tests. Since the user group, expectant parents, are considered to be vulnerable, all action needs to be taken not to harm the users.

Only a few users had FOC, so the effect on FOC cannot be determined. This study guided that the reason for FOC needs to be addressed, and the program content should be presented before offering the VR program for expectant parents with FOC.

The learning outcomes were self-reported. Since there is no standard testing for childbirth education, it is difficult to measure learning outcomes in another way. An important aspect of adult learning is how people think they have learned and feel they can utilize the information.

The analysis was done only by the first author. The author is, in addition to being a researcher, a Lamaze certified childbirth educator LCCE, a birth doula, and a doula trainer with much experience working with pregnant families. She is also a certified professional adult teacher and elearning specialist.

6. Conclusions

Klemetti & Hakulinen-Viitanen (2013) suggested using the Internet to enhance childbirth education, and this study presented one way to implement it. Using online VR tools can increase the level of learning. VR brings the content alive, lets the parents experience childbirth, and gives a realistic and concrete view of what birthing can be like. The VR CBE provides expectant parents knowledge about what it is to give birth in a hospital and use different pain relief methods during birth at home and in the hospital. We still need to consider the amount of presence from the midwife and bringing a support person to the program.

This study was part of a user-centered design process, following ISO 8241-210 (ISO, 2019), with iterative testing of the VR CBE with users, including testing, observations, interviews, questionnaires, and follow-up, providing the users with immersive and engaging educational experiences. The usability of the VR user interface was generally good, and all the users could use the VR CBE on their own with minimal introduction. A seated position was needed for comfortable use of the program. The narration and the length of the videos worked well. The distribution of the content according to the flow of birth worked better than the spatial distribution of the content previously used. However, according to the feedback and interaction analysis, we still need to consider the usability and the amount of content presented with devices other than the VR headset, the floor height, and the actor's spatial distance to the camera. We should make the length of the videos available in the main panorama and need to study the optimal resolutions for the videos. We got minimal information about the program's effects on FOC, which require further studies.

Ethical approval

The study has ethical approval ETHICS-000057 from Aalto University. The diary number is in SAHA D/598/03.04/2023.

Statements on open data and ethics

The participants were protected by hiding their personal information in this study. They were voluntary and knew they could withdraw from the experiment at any time. The data can be provided upon request by sending an e-mail to the corresponding author.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Marjaana Siivola: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Conceptualization. **Teemu Leinonen:** Writing – review & editing, Supervision. **Lauri Malmi:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Thank you to Maxi-Ann Campell and Crystal Vauhkonen for proof-reading the article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cexr.2024.100058.

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