Virtual- and Augmented Reality-Supported Teaching for Professional Caregivers

Anders Kalsgaard Møller(✉) and Eva Brooks

Department of Culture and Learning, Aalborg University, 9200 Aalborg, Denmark
ankm@hum.aau.dk

Abstract. Virtual reality is used to support teaching in the professional caregiver educations. Virtual reality can visualize the anatomical part of the body and provide interactive content that support and motivate students. This paper presents a preliminary study of an ongoing development of two new virtual and augmented reality applications with teaching material about leg ulcer and Chronic Obstructive Pulmonary Disease. We have conducted workshops and interviews with a total of seven teachers at a caregiver program who have provided information about the potential uses of virtual and augmented reality including their design ideas and feedback on a prototype of the applications. This have contributed to insights into how future solutions should be designed and how these may support teaching. The results indicate that virtual and augmented reality can be useful for achieving many different learning goals. It also indicates that it is not always an advantage to use immersive virtual reality or augmented reality, but it is possible to achieve at least similar results using a non-immersive version through mobile phones or tablets.

Keywords: Virtual reality · Augmented reality · Learning · Caregivers · Health · Vocational training · Teaching

1 Introduction

Virtual reality (VR) is a technology that is being used more frequently lately in connection with education and training as it offers options for creating 3D spatial representations, multisensory channels for user interaction, immersion of the user and intuitive interaction through natural manipulations in real time [11]. One of the areas where VR has been used is in vocational training and often related to medicine and healthcare applications [8]. For example, to train surgeons [3], in nurse education [5], medical professionals [6] or for health care training [7]. It has also been used in rehabilitation therapy and training [4] and has been deemed effective for both mental- and physical therapy [10].

At the Danish Vocational Education and Training Colleges (VET), VR has been introduced to support teaching at the professional caregiver education. VR applications such as Sharecare VR [2] is used in anatomy courses to visualize the different parts of the body and other VR applications are used to introduce students to assistive technologies or simulate symptoms of dementia [9].

E. I. Brooks et al. (Eds.): DLI 2020, LNICST 366, pp. 48–60, 2021.
https://doi.org/10.1007/978-3-030-78448-5_4

Many of the students at the VET colleges have reading difficulties, dyslexia, attention-deficit/hyperactivity disorder (ADHD) and similar conditions. They have trouble with learning and keeping focus from traditional teaching methods such as lectures and textbooks. However, the introduction of VR has had a positive effect on the students learning outcome, which in turn have led to a desire to develop additional solutions to support teaching. Thus, plans have been made to develop two new applications targeting leg ulcers and Chronic Obstructive Pulmonary Disease (COPD). It is planned to develop both a VR version and an Augmented Reality (AR) version of the applications.

The difference between VR and AR is defined by Azuma (1997) who describe AR as a variation of VR where the difference is that "Virtual environment technologies completely immerse a user inside a synthetic environment.

> *While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it* [1].

One of the reasons for also designing an AR option is the option of using the application while still being able to participate in group work or other class-related activities. If a student is immersed in VR the student will not be able to see and interact with other group members or follow class-related activities.

In this study we hosted workshops and interviews with teachers at VET colleges around Denmark. Based on the input from the teachers we look at the opportunities and perspectives for VR-supported teaching at the caregiver education. More specifically, the study focus on what kind of learning goals VR can support, how these are supported and how future solutions should be designed.

2 VR and Learning

First-order experiences, with direct non-symbolic interaction, size, transduction, reification, autonomy, and presence are according to [1] what contributes to positive learning outcomes in VR. The sense of presence is defined by [13] as *"The sense of being there"* which enhances a user' first-hand experience where the user interacts directly with the world [11]. Transduction, size and reification are terms used to describe how raw data from the world is transformed into information we can interact with or experience through our senses e.g. enabling a user to interact with tissue or moving around inside a human body [12]. VR can support training in safe environments and increase learner's motivation [8]. It can promote active participation, high interactivity and individualization [14].

Some users do, however, have greater benefit from VR than others because the individual traits and characteristics influence the experience of the users in VR [20]. Not all users enjoy VR [15]. Some feels unsafe entering the virtual world and others suffer from cyber sickness.

A distinction can be made between VR/AR presenting a 3D world through a screen and a fully immersive experience presented through either a head mounted display (HMD) or a CAVE environment [16] where the virtual environment surrounds a person providing a fully immersive experience. The first is referred to as non-immersive VR/AR or desktop VR/AR and the latter as immersive VR/AR [8]. Results from [17] show that users are more engaged when using HMD compared to non-immersive alternatives and that they take it more seriously, e.g. approaching dangerous situations with more care [18]. Furthermore, users report being more present in immersive VR which is important for the learning process and make them spend more time in the training environment [12].

VR can be used for different types of skill acquisition both cognitive, psychomotor and affective skills [15]. In a literature review, [15] it was found that VR using HMD was better for learning visual and spatial information than alternative options. This could for instance be spatial information and visual information about the organs. However, it was found that non-HMD options were better for remembering facts such as names.

While not much evidence exist, studies indicated that HMD-based VR is superior when it comes to learning affective skills - as they: *"are related to interpersonal skills, and here the ability of the technology to create a believable simulation of a virtual human or social situation is crucial"* [15].

For psychomotor skills it was not important how the VR was presented. The learning outcome where closer related to the perceived realism and the quality of the kinesthetic input and haptic output provided through e.g. a joypad and how it fits with bodily movements [15].

3 The VR/AR Prototypes

A prototype has been created of the solution based on initial feedback from teachers and coordinators at the VET colleges. The prototype has been built as a VR solution for different versions of Oculus glasses and an AR version for Microsoft HoloLens. For the HoloLens version it is possible to interact using finger gestures, e.g. press a virtual button with a finger. For the VR version a joypad is used.

The prototype supports interaction and visualization of the different parts of the body with a special focus on the organs. The prototype provides basic information about the different parts of the body such as, names and information about how they function. Different options exist for interacting with different body parts. For instance, simulate different types of illness, turn the 3D model around or divide the body parts into different layers. In Fig. 1, the main menu is presented where one can select different parts of the body for further interactions and visualizations. Once an item is selected in the menu a 3D model of the item is presented. In Fig. 2, the lungs have been selected and a screen with a 3D model of the lungs is presented along with an information box. The user can turn the 3D model and select different stages of COPD. The user can also select different layers of the lungs (Fig. 3). Figure 4 shows a leg ulcer with an option to simulate different stages of the illness.

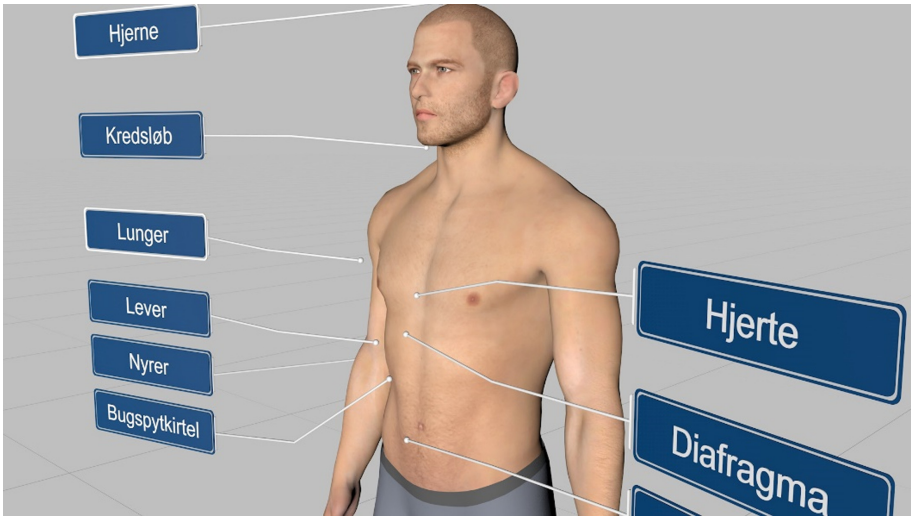

Fig. 1. The main menu of the AR/VR application where you can select different bodyparts/organs for further interactions.

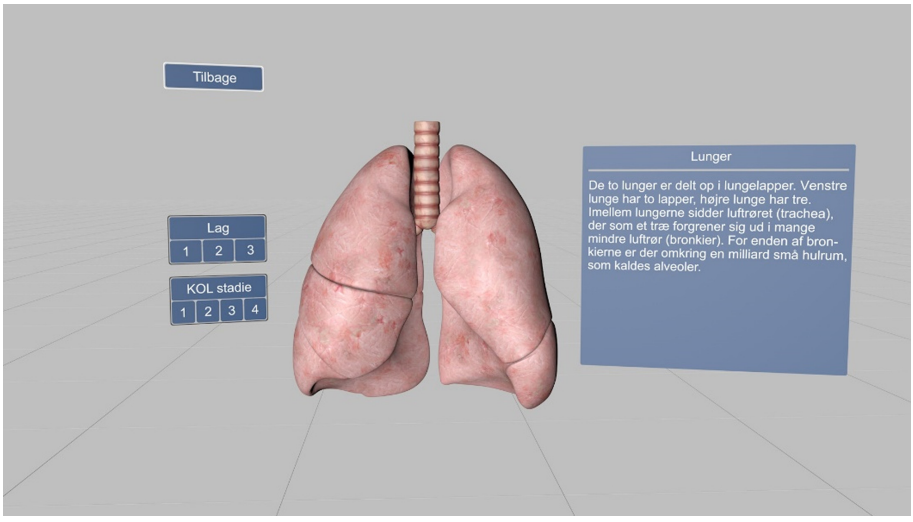

Fig. 2. 3D model of the lungs, a box with information about the lungs and buttons to select different stages of COPD and options for changing the layers this view is layer 1.

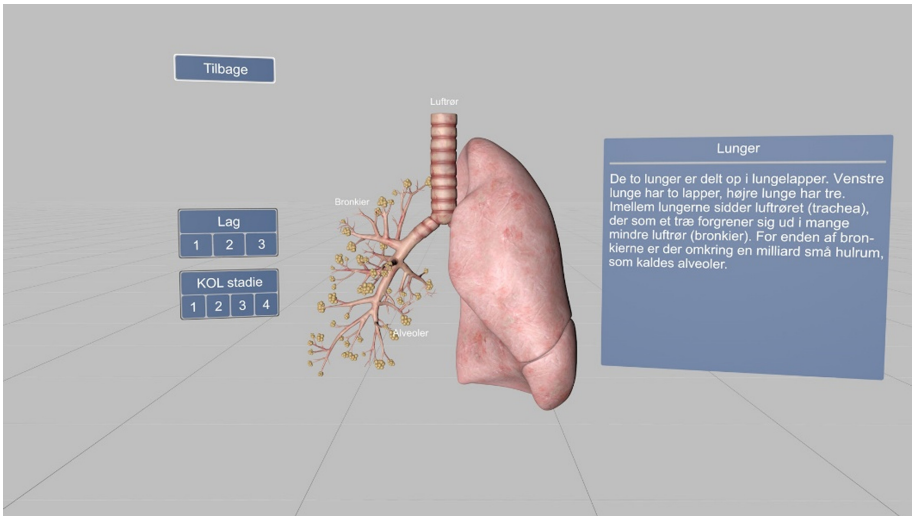

Fig. 3. 3D model of the lung with layer 3 selected where the bronchial and alveoli are visual.

Fig. 4. A model of a leg ulcer where one can change the severity of the leg ulcer by pulling the lever.

4 Method

It was originally planned to carry out a workshop with two groups of four teachers from the caregiver education. However, due to changed restrictions with Covid19 which occurred in the middle of the course, it instead became a workshop with three teachers and four single interviews with teachers. In total seven teachers participated in the study. The interviews were held online using Microsoft Teams. The teachers were all females

and educated nurses. They all taught in somatic illness, anatomy and pharmacology and had between 1–12 years teaching experience.

The workshop consisted of a group interview with questions regarding their teaching experiences, knowledge of VR/AR, how they currently taught classes about COPD and leg ulcers, and how they considered VR/AR to be used to support their teaching activities. They were also asked to draw and explain their best idea for a VR/AR solution that could be used to support their teaching. Finally, they were introduced to the prototype of the new applications and given a chance to comment on the content, design and options for interaction. The prototypes were introduced in the end to ensure an open-minded approach where they could come up with new ideas that were not affected by the knowledge of the prototypes.

The single interviews followed the same procedure as the workshop, except that they did not get the option of drawing the solution. Instead of experiencing the prototype first-hand they were instead presented with a video of the prototype.

The workshop was recorded with a camera and the online interviews recorded using the video-recording option in Teams. The workshop and the interviews were transcribed verbatim and analyzed with a thematized approach [19] resulting in three themes: 1) Students and motivation, 2) Learning activities and goals, and 3) The teacher's role. The themes are further elaborated in the below section. In addition, the teachers' feedback to the prototypes is presented as well as the solutions suggested by the teachers who participated in the workshop.

5 Findings

The teachers were all interested in using VR and AR to support their teaching. While some of the teachers had no prior experience with VR and only a few had been using it for teaching, they often introduce and use new technology as part of their teaching. They were therefore open towards using VR as part of the teaching.

5.1 Students and Motivation

In general, teachers noted that there was a need for alternatives to regular classroom teaching, as many of their students were challenged in terms of concentrating and understanding the material from textbooks. One of the teachers already had good experiences with VR and explained the following:

> *I have experienced students who are scared of technology who distance themselves from it, but I have experienced more students who are turned on academically. I support a curios behavior that makes them achieve a greater learning benefit than previous students have done in my teaching when I have run traditional class- and group work.*

While the teachers see a positive effect on most students, there are still some who find VR transgressive or experience cyber sickness. They also emphasize that it is not the same approach that works with all students. This is in line with the findings in the existing literature [15, 19]. VR should, therefore, not be a standalone option to teaching, but be

used as a supplement and be used in specific situations for specific learning goals. This way the different teachers can meet the different traits and characteristics of the students and use VR for students that are motivated to learn from VR as suggested in [19].

5.2 Learning Activities and Goals

One of the situations where the teachers see a potential in VR is for their simulation of diseases. Currently, they use video and pictures or use roleplays where the students or teachers act in the role of an ill citizen. In these situations, they lack a tool to show different diseases and the condition of the citizen which can be used to learn students how to provide the correct care and treatment. There is a general need to be able to visualize different parts of the body both the healthy body and when suffering from a specific disease.

The students often work with case-studies where the teachers present a case about an ill person, but the teachers are lacking visualization tools to support the story. It is easy to read vital signs, measure the weight of a citizen but they must also be able to make observations about the condition of a citizen and make conclusions about a potential treatment in their professional job. It is, however, hard to create realistic and meaningful learning activities that facilitate this type of learning. As expressed by one of the teachers:

> *We document and measure, but it is important that they can also make observations – see, feel, listen and touch. That is something they should practice more… How is the breathing? it is not just about numbers.*

They also talk about being able to have a more holistic understanding of specific conditions and how it affects the citizens e.g. what happens to citizens when they only have 40% lung capacity left due to COPD or what does a person look like with low body mass index (BMI).

Furthermore, the teachers underline the importance of including the affective part of learning, i.e. about understanding what a citizen with COPD goes through, so the student can react in an appropriate way. One of the teachers mention the mental and emotional part this way:

> *The psychological part in connection with having COPD is important and if you can connect that process, with what he looks like, what does he say... If you could get the emotional part involved, it would make really good sense.*

Today, the teachers use videos, along other tools such as a COPD simulation suit or exercises where the students experience reduced lung capacity by breathing through a straw. However, the teachers suggested a VR scenario where sound and the visuals of a citizen with COPD are combined, where the citizen's condition is either improved or worsened by the student's actions. The teachers want a safe environment where students can test different things without fearing the consequences.

5.3 The Teacher's Role

Teachers see themselves as facilitators who must support the students in their learning activities. As the teachers identify poor reflective skills in the students, they often have to assist them with asking questions that facilitate discussions about the new content and how it relates to their future role as caregivers.

Several of the students have difficulty relating to things like science and at times almost experience learning blockages. Teachers therefore feel that they must think alternatively and creatively when they convey part of the curriculum. This is elaborated in the following quote:

> *Some students have some unfortunate experiences from their primary school. If I start talking about the periodic table, then I lose half of the students. It is better to start with a different approach and slowly work around it. I often hear from the students that they prefer science when taught at the caregiver education. It is not because I lower the requirements, but because I convey it with a health professional angle.*

Instead of learning about physics and chemistry by talking about, for example, formulas, the teachers can show how the different physical and chemical reactions take place in the body using VR and thus students gain an understanding of it. This is what is referred to as non-symbolic interaction by [11]. Instead of learning an abstract symbolic system such as math to explain a chemical process the processes can instead be visualized using VR making it more accessible for the students at the VET colleges.

5.4 Feedback to Existing Prototypes

Overall, the teachers believe that the new solutions should motivate students to learn about the body's anatomy and different conditions from the newly developed prototypes. Many students have a hard time imagining how the different parts of the organs are connected from looking at a picture, as one cannot split the different layers and see what it looks like as with the 3D model in VR.

However, the teachers are not entirely satisfied with the level of detail on the models and the information that comes with it. It might be enough for students who had just started the education, but students later in the education will miss details about e.g. COPD. In the later stage of the education the students need to be able to recognize symptoms through observations and subsequently choose the right care approach and the visualizations in VR did not provide enough details to do so.

In addition, the teachers find that the text boxes contain too much text, and it appear as a wall of text, where the students typically want it to be divided in smaller pieces of information. Instead, they suggest that the students receive information continuously when they interact with the models. In general, they want the students to be more active when using the application.

For the three teachers who participated in the workshop and could try the prototype themselves, they quickly learned how to interact with the models and understood quite quickly how to use gestures and move around the menus.

Several of the teachers suggest having an AR version for phone or tablet that can be used for preparation or reflection before and after teaching, as part of their homework. It was also suggested that sound be used for, for example, to support the simulation of COPD, in which case one would be able to hear the breathing.

5.5 Solutions

Each of the participants in the workshop were asked to draw and describe their ideas to a solution on a piece of paper. Subsequently, they were asked to explain what they had drawn and their idea or concept. The three drawings are shown in Fig. 5, 6 and 7. All teachers chose to present a solution around a case description of a person with an illness. The solutions provided an opportunity to see a holistic picture of the citizen of how the disease affects the person. In all cases, emphasis was placed on the student being able to make choices or actions, which they would then receive feedback on through the system. If they made the right decision, they would e.g. see that the citizen got better. The solution should also include options for varying the level of difficulty. For the teacher with the drawing presented in Fig. 5, the starting point was a citizen with COPD. The student would see an avatar of the citizen indicating how he/she was affected by the disease along with vital sign information and a 3D model of the lungs. This to give a holistic view on how the disease affects the citizen and provides opportunities for the students to combine their knowledge from different courses such as anatomy, pharmacology and somatic illness.

Figure 6 represent a solution where three students are active. One in the role of a citizen, one as a caregiver and one as an observer. The student acting in the role of the citizen has been instructed in the role enabling him or her to answer questions about their wellbeing. Using AR technology, the student would look like an ill citizen when looking through the AR glasses. Thereby AR add a visual dimension to the roleplay that are typically used as part of the teaching to represent a job situation as professional caregiver.

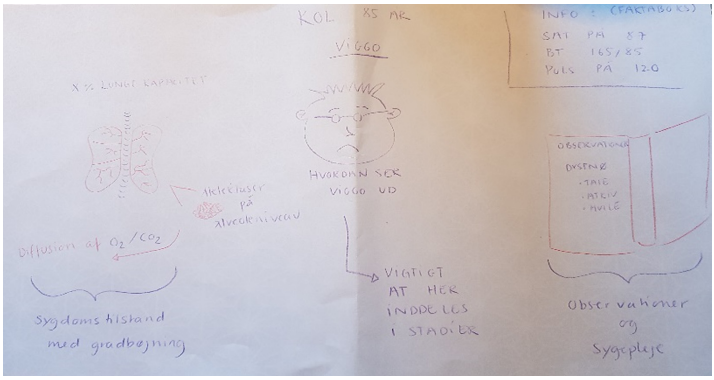

Fig. 5. Solution from the workshop. The student with an avatar of a citizen with COPD. The students can see how the disease effect the avatar, vital signs and an overview of the lungs.

The last solution is in Fig. 7. Again, the student interacts with an avatar of an ill citizen. Based on the interaction with the citizen the student must decide on an action through a multiple-choice menu and again receive immediate feedback on their action.

At some point the actions can lead to the student having a look at the lungs, including aggravations or improvements of the condition, based on the actions or based on the stage of the disease. Furthermore, it was suggested to create two versions of the application one that the students could use with VR glasses and one phone-based solution the students could use to practice at home.

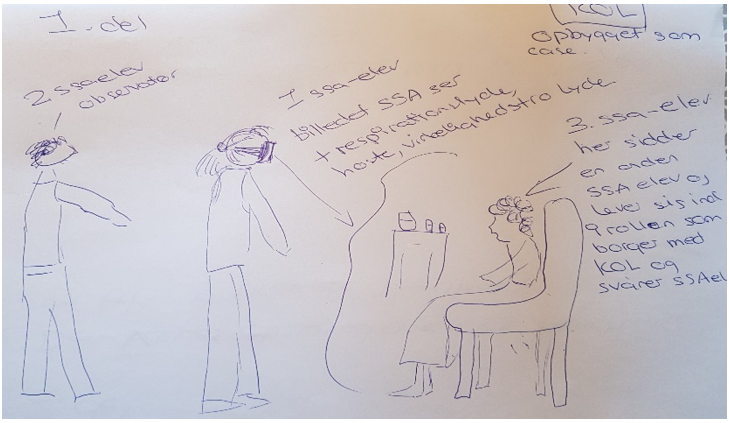

Fig. 6. Solution from the workshop. VR/AR solution that support the student in a roleplay where one student act as the citizen, one as the caregiver and one as observer.

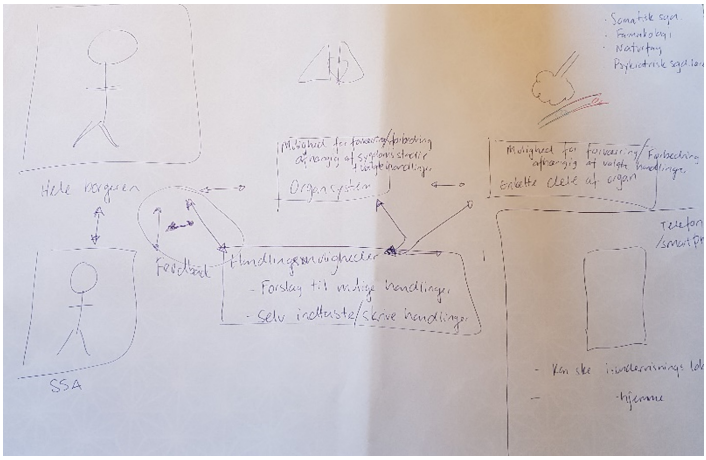

Fig. 7. Solution from the workshop. Again, the students interact with an avatar of a citizen through a multiple-choice menu.

6 Discussion

Several learning goals have been suggested by the teachers where they see a potential for using AR and VR solutions to support the teaching both for cognitive and affective skill training. The overarching learning goal for the students is to be able to observe a citizen's condition and decide on the care or treatment. This encompasses several sub-learning goals. First the students need to know the names of the different body parts and how they function. This include both the healthy body and how a disease progresses and affect the body. Then they must be able to recognize a disease. Understand how they treat and prevent disease, and how diseases affect the citizen both mentally and physically. Finally, the students need to be able to reflect upon these observations and decide on a set of actions to provide the necessary care for the citizen.

The teachers had different suggestions for how VR/AR could be used to support these goals. Firstly, VR/AR can help motive the students to learn by providing the content in a different way, as traditional classroom teaching often works poorly and can lead to learning barriers for many of the students. VR/AR provide options for 3D visualizations that can help students understand the body – how it functions and how diseases progresses. It can be used for homework and repetition training if implemented on a mobile or tablet. It can be used to provide a safe environment for the students to train real life scenarios with interactions and treatment of citizens.

When designing the VR/AR solutions of the future these learning goals should be considered. At the same time, it must be possible to adapt the content and level to the individual student depending on where he/she is in the educational process. It is also important that there is a progression in the solution, so that the degree of difficulty is continuously increased, so the students does not experience the same each time they interact with the system. Teachers put great emphasis on the importance of immediate feedback to guide the students and help them reflect on their experiences in VR/AR and how this could be used in a real-life scenario.

Interestingly the teachers suggested using non-immersive versions of the solution for specific learning goals. This indicates that immersive VR/AR is not always a better solution than non-immersive VR/AR but is highly dependent on the learning goal. Based on the teachers' recommendations and the existing literature on Immersive/non-immersive VR/AR. It seems like immersive VR/AR is more suited for situations that involve both affective and cognitive learning - where the user e.g. needs to understand how symptoms affect a citizen both physical and mentally. Immersive VR/AR is better for simulating social interactions [15], the students feel more engaged with the task [17] and they take the condition of the citizen more seriously [18]. Likewise, immersive VR/AR is recommended for learning how the body works considering the spatial and visual information. Non-immersive VR/AR versions displayed on a screen, mobile or tablet could, on the other hand, be used when only cognitive skills is involved such as learning or remembering the names of the organs or factual knowledge about diseases. This would enable students to use it for preparation and rehearsal as part of their homework.

This hypothesis is based on the assumptions and experiences of the teachers working with the students. Further research including the actual teaching situation in VR and AR – immersive and non-immersive is however, needed. Furthermore, this study did not

include the students. Including students in the research would be a next step to study if they achieve the learning outcome that teachers expect.

The research design has been altered due to Covid19. Ideally the initial prototypes should have been designed after gaining the initial feedback from the teachers but instead we choose to use it as a generative tool as part of the interview and workshop.

Due to the limitations of doing the online interview we gained limited feedback in terms of design ideas to the new solution from the teachers who participated in the interview compared to the teachers who participated in the workshop.

7 Conclusion

This study has identified several learning goals that can be supported by VR or AR both cognitive and affective learning goals. The study indicated that the specific learning goals should be considered before deciding on what type of virtual technology and application should be used when designing teaching material for the professional caregiver education. It is important that the solutions offer options for immediate feedback and that the content and difficulty level can be altered to match the educational goals of the student and provide the student with new experiences.

Acknowledgement. This project was partly financed by Videnscenter for Velfærdsteknologi Vestdanmark. The prototypes were developed by Takeawalk VR. Thanks to the teachers from the VET colleges who participated in the study.

References

1. Azuma, R.T.: A survey of augmented reality. Presence Teleoperators Virtual Environ. **6**(4), 355–385 (1997)
2. Sharecare. https://www.sharecare.com/pages/vr. Accessed 26 Oct 2020
3. Yoshida, S., Kihara, K., Takeshita, H., Fujii, Y.: Instructive head-mounted display system: pointing device using a vision-based finger tracking technique applied to surgical education. Videosurgery Miniinvasive Tech. **9**(3), 449 (2014)
4. Pensieri, C., Pennacchini, M.: Overview: virtual reality in medicine. J. Virtual Worlds Res. **7**(1), 1–34 (2014)
5. Green, J., Wyllie, A., Jackson, D.: Virtual worlds: a new frontier for nurse education? Collegian **21**(2), 135–141 (2014)
6. Ma, M., Jain, L.C., Anderson, P. (eds.): Virtual, Augmented Reality and Serious Games for Healthcare 1. ISRL, vol. 68. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-642-54816-1
7. de Ribaupierre, S., Kapralos, B., Haji, F., Stroulia, E., Dubrowski, A., Eagleson, R.: Healthcare training enhancement through virtual reality and serious games. In: Ma, M., Jain, L.C., Anderson, P. (eds.) Virtual, Augmented Reality and Serious Games for Healthcare 1. ISRL, vol. 68, pp. 9–27. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-642-54816-1_2
8. Freina, L., Ott, M.: A literature review on immersive virtual reality in education: state of the art and perspectives. In: The International Scientific Conference eLearning and Software for Education, vol. 1, no. 133, p. 10-1007 (2015)
9. Vidensportalen. https://videnscenterportalen.dk/vfv/2019/11/27/viva/. Accessed 26 Oct 2020

10. Khademi, M., Hondori, H.M., Dodakian, L., Cramer S., Lopes, C.V.: Comparing "pick and place" task in spatial augmented reality versus non-immersive virtual reality for rehabilitation setting. In: 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Osaka, pp. 4613–4616 (2013). https://doi.org/10.1109/EMBC.2013.6610575
11. Mikropoulos, T.A., Natsis, A.: Educational virtual environments: a ten-year review of empirical research (1999–2009). Comput. Educ. **56**(3), 769–780 (2011). https://doi.org/10.1016/j.compedu.2010.10.020
12. Winn, W., Windschitl, M., Fruland, R., Lee, Y.: When does immersion in a virtual environment help students construct understanding? In: Proceedings of the International Conference of the Learning Societies, pp. 497–503. Erlbaum, Mahwah (2002)
13. Slater, M.: Immersion and the illusion of presence in virtual reality. Br. J. Psychol. **109**(3), 431 (2018). https://doi.org/10.1111/bjop.12305
14. Pantelidis, V.: Virtual reality in the classroom. Educ. Technol. **33**(4), 23–27 (1993)
15. Jensen, L., Konradsen, F.: A review of the use of virtual reality head-mounted displays in education and training. Educ. Inf. Technol. **23**(4), 1515–1529 (2017). https://doi.org/10.1007/s10639-017-9676-0
16. Cruz-Neira, C., Sandin, D.J., DeFanti, T.A.: Surround-screen projection-based virtual reality: the design and implementation of the CAVE. In: Proceedings of the 20th Annual Conference on Computer Graphics and Interactive Techniques, pp. 135–142 (1993)
17. Loup, G., Serna, A., Iksal, S., George, S.: Immersion and persistence: improving learners' engagement in authentic learning situations. In: Verbert, K., Sharples, M., Klobučar, T. (eds.) EC-TEL 2016. LNCS, vol. 9891, pp. 410–415. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-45153-4_35
18. Reiners, T., Wood, L., Gregory, S.: Experimental study on consumer-technology supported authentic immersion in virtual environments for education and vocational training. In: Hegarty, B., McDonald, J., Loke, S. (eds.) Proceedings of the 31st Annual Ascilitite Conference (ascilite 2014): Rhetoric and Reality: Critical Perspectives on Educational Technology, 23–26 November 2014, pp. 171–181. University of Otago, Dunedin (2014)
19. Janßen, D., Tummel, C., Richert, A., Isenhardt, I.: Towards measuring user experience, activation and task performance in immersive virtual learning environments for students. In: Allison, C., Morgado, L., Pirker, J., Beck, D., Richter, J., Gütl, C. (eds.) iLRN 2016. CCIS, vol. 621, pp. 45–58. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-41769-1_4
20. Braun, V., Clarke, V.: Using thematic analysis in psychology. Qual. Res. Psychol. **3**(2), 77–101 (2006)