Journal of Problem Based Learning in Higher Education

VOL. 10, No. 1, 2022 – Page 101-112
10.5278/ojs.jpblhe.v10i1.7097

360 VR PBL: A New Format of Digital Cases in Clinical Medicine

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ABSTRACT

In this paper, we present and discuss an explorative study on the use of a social 360° virtual reality (360VR) for supporting case-based Problem Based Learning (case-PBL) in clinical medical education. In the context of case-PBL, we argue that our social 360VR learning space extends the design and application of cases in medical education by including elements from project-PBL. Three groups tested the learning design as a part of the clinical exercises in their 5. Semester bachelor course. After the social 360VR activity, the students performed a physical examination of the collateral and cruciate ligaments of the knee like the one in the training material. Our preliminary findings indicate that the students immersed in social 360VR collaboratively establish a mutual understanding of how to perform the examination through identifying problems related to the examination and by taking responsibility for their own and the other group members learning.

Keywords: Problem Based Learning, Social Virtual Reality, Social 360VR, Medical Education, Digital Learning, Covid-19

INTRODUCTION

Case-Problem Based Learning (case-PBL) is traditionally characterized by well-defined problems and teacher-led learning designs (Servant, 2016; Stentoft, 2019). In contrast,

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project-PBL is organized around “open-ended and student-centered projects running over extensive periods of time” giving the students a higher degree of responsibility for their learning processes (Stentoft, 2019, p. 960). As argued by Stentoft (2019), case-PBL and project-PBL should be viewed as complementary in medical education not as mutually exclusive. In this paper, we introduce and explore how social 360VR can be used as a digital platform for case-PBL in medical education. Virtual Reality (VR) is not a new medium for learning in medical education, but it is generally used for training of specific skills (Matzke et al., 2017) and less on elements associated with project-PBL (e.g. responsibility for own learning, team-based learning, self-directed learning, identification of problems, etc.). Our aim is to explore how a 360° video of medical students examining the collateral and cruciate ligaments of a knee (training video) can be used as a case for other medical students in social 360VR, who will have to perform the same type of examination on a person as in the training video. This case-design is open-ended without designed “problem triggers” (Stentoft, 2019) and the students in social 360VR will have to negotiate how to perform the knee examination. Further, the students will perform the examination in pairs to stimulate reflective dialogues between the students.

Our work with 360VR PBL is a consequence of the Covid-19 pandemic, where teachers had to experiment with new digital formats of PBL (Lyngdorf et al., 2021). In their research, Lyngdorf et al. (2021) found that elements of active learning had been under pressure as the existing digital tools did not support interaction and feedback in very advanced and sophisticated ways. While theory and facts are easier to present in online lectures, it is more difficult to integrate practice-based elements in online teaching formats (Dodds, 2021). Gaur et al. (2020) argued that medical educators should develop innovative solutions to foster students’ experience of the “immersive nature of medical education” (p. 1995). In the context of medical education this includes getting access to real patients, seeing and experiencing how an examination or operation is performed – not just how to perform a specific skill.

In this paper, we explore how 360° video can be used in clinical exercises in Higher Education (HE) medical education as an extension of case-PBL (Stentoft, 2019). With social 360VR teachers and students are no longer confined to viewing a video on a flat screen, instead the 360° video is projected in a Head Mounted Display (HMD) (McIlvenny, 2020a) providing a more immersive social experience. With social 360°VR new opportunities for bringing authentic cases into PBL arise and new formats for collaboration is emerging (Davidsen & McIlvenny, 2022). We consider our work as an innovative extension of how PBL cases are usually used in clinical medicine (Barrows, 1996; Stentoft, 2019) and an addition to the longstanding commitment for using technologies in medical education (Helle & Säljö, 2012). The preliminary findings indicate that the students see 360VR PBL as a great supplement to the ordinary clinical exercises and that they actively use what they learn in social 360VR in later clinical examinations.

VIRTUAL REALITY IN MEDICAL EDUCATION

There is a growing body of research on 360VR (Pirker & Dengel, 2021), however, the dominant type of VR in education is still the use of computer-generated 3D worlds (Bailenson, 2018; Radianti et al., 2020). The argument for using computer-generated VR is that students can practice new skills in a simulated environment that enables corrections, repetition, non-dangerous failure and interaction with expensive laboratory facilities or far-away environments (Jensen & Konradsen, 2018). The use of VR-simulated surgical training enables individual students to learn surgical skills in a risk-free environment and increases their technical competencies. It also improves the individual students' performance and decreases operating time in, for example, laparoscopic procedures (Frederiksen et al., 2020). Further, the students can develop their skillset at their own pace, which would not be possible with a real patient. Research has also shown that the use of simulated training helps the students develop their non-technical competencies, including communication skills and teamwork (Lungu et al., 2021).

Different studies have investigated the differences between using 360VR videos and 2D videos in medical education with individual students. One of the positive outcomes in 360VR is a higher level of involvement while watching the video and it is also suggested that the use of 360VR prepare the students for dealing with real-life situations (Arents et al., 2021). According to Pirker & Dengel (2021) the use of 360VR has potential in educational activities focusing on factual learning, but also in relation to a change of attitudes, emotional value, increasing interest, and engagement. They only found some studies reporting major disadvantages and challenges with the use of 360VR videos, such as increased cognitive load, problems with integrating the immersive media in the every-day teaching sequence and negative learning affects due to the low embodiment in 360VR videos (Pirker & Dengel, 2021). Pirker and Dengel (2021) also noted that 360VR could "prove to be a game-changer for the future of distant learning" (p. 86), which we are exploring in this paper in relation to case-based PBL.

DESIGNING A PBL CASE IN SOCIAL 360VR

With the case-PBL learning design, we aim to support collaboration between the students and a higher degree of responsibility for their learning in social 360VR. Instead of exposing individual students to the training video, we have used a social 360VR platform called CAVA360VR developed by the BigSoftVideo group at Aalborg University

(Davidsen & McIlvenny, 2022; McIlvenny, 2020b). In CAVA360VR (picture C in Figure 1) students can play and annotate a 360° video together with other students distributed between different locations. In CAVA360VR each participant in represented with an avatar head following the movement of the head and a pair of hands synced with the movement of the controllers. At the moment the CAVA360VR supports up to 20 users working together at the same time and it is also possible to participate using a windows computer without a HMD. In addition, to the technological platform used in the case design, we have also used a training video with students being tasked to examine a knee for the first time (see Figure 1 picture A). In the training video, we witness some failures and uncertainties about how to perform the examination, which we believe can promote learning for other students working with the data in social 360VR (Tawfik et al., 2015). In a way, the training video is showing how two students are identifying problems and learning goals in relation to a knee examination. They address the problems they face together, which is then acting as the learning design for the student groups in social 360VR.

Figure 1. (A) Picture from the original 360° video. (B) The technical setup outside of the CAVA360VR space. (C) The technical setup inside the CAVA360VR space.

The basis for the PBL activity in 360VR is a 17-minute-long non-scripted video showing a professor and two students. The 17 minutes is from a longer session on 100 minutes, but we decided to focus on this part to limit the time in social 360VR. In the training video, one of the students is performing a physical examination of the collateral and cruciate ligaments of the other student's knee and the professor is providing feedback and stimulating questions during their examination. In Figure 2, we have visualized the elements and process of the case-design.

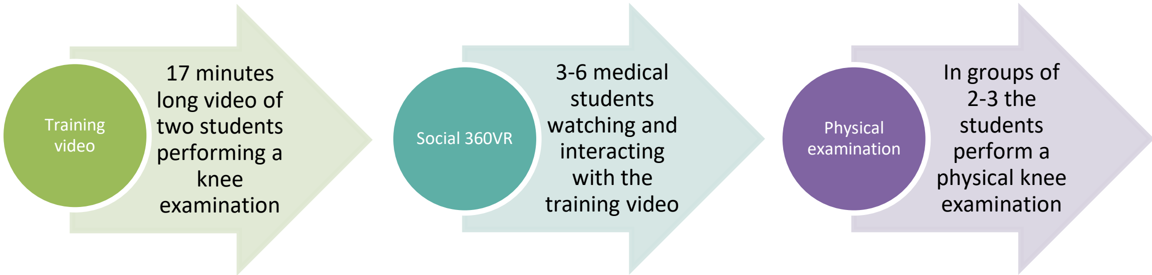

Figure 2. Visualization of the case-PBL design.

In our instruction to the students participating in the social 360VR tests, we explained that each of the students should wear a headset in separate rooms watching the 360° training video together immersed inside CAVA360VR and use the tools to collaboratively learn how to conduct the examinations (see Figure 1 picture B and C). They did not receive any direct instruction on how to annotate inside VR – they had to figure that out for themselves. We also informed them that after they finished being in social 360VR they should be able to perform the same examination on a human subject as in the training video. We did this in order to identify the level of transfer from social 360VR to situated practice (Dohn et al., 2020), which we will analyze in detail in another paper. This also meant that the students were not only tasked with retaining the knowledge provided in the training video, but also had to transfer the knowledge to physical examinations performed in dyads, meaning that the students had a shared responsibility for learning how to perform the examination. Table 1 is providing an overview of the three tests – the duration of the social 360VR activity (we are not evaluating effectiveness in terms of time spend in 360VR), a short description of the conditions and the time spend on the physical examination afterwards and the student's prior knowledge and experience in clinical examinations.

	Time spent in immersive 360°VR	**Conditions in 360VR**	**Time spent on the physical examination**	**Prior knowledge and experience in clinical examination**
Group 1 (3 students)				
Student A	40 min. 17 sec.	Unscripted 17-minute video clip in social 360VR	5 min. 45 sec.	No prior knowledge No experience with clinical examinations of the knee
Student B				
Student C				
Group 2 (6 students)				
Student D	36 min. 28 sec.	Unscripted 17-minute video clip in social 360VR	4 min. 54 sec.	Prior knowledge No experience with physical examinations of the knee
Student E				
Student F			4 min. 30 sec.	
Student G				
Student H			3 min. 42 sec.	
Student I				
Group 3 (5 students)				
Student J	49 min. 28 sec.	1 student seeing reflection prompts while playing the training video – no other students were able to see the prompts.	16 min. 21 sec.	Prior knowledge No experience with physical examinations of the knee
Student K				
Student L				
Student M			7 min. 17 sec.	
Student N				

Table 1. Overview of the three tests.

The tests were conducted in the end of 2021 and follow the GDPR regulations provided by the university – and the data is stored in servers provided by the university. Informed consent was obtained from all students who participated in the tests. The sessions in social 360VR were recorded with video cameras and a screen capture tool. This dual setup allows us to see both what the participants do inside 360VR and how they use the controllers in the physical space. The knee examinations were also recorded. This data has been watched and an initial logging of the material was performed (Davidsen & Kjær, 2018) using DOTE (McIlvenny, Davidsen, et al., 2022).

PRELIMINARY FINDINGS

In this case description, we focus on how the students in social 360VR organize their learning activity and how they use the tools in CAVA360VR to negotiate their understanding of the problems that are affiliated with the examination of the collateral and the cruciate ligaments of the knee. There were no problem triggers embedded in the case-PBL, and we are interested in finding out whether the students can learn how to perform the various tests.

Inside 360VR, the students used the various tools provided by the software to identify and define the problems occurring in the video and to structure their learning in the 360VR environment. The students frequently used the laser point to mark specific objects as relevant for each other (see Figure 3). The students also used the drawing tool to highlight and "freeze" these markings, for example drawing an arrow to indicate the motion in which the student pulled the knee. The drawing tool was also used for taking notes in 360VR (this proved troublesome for some due to the smoothing feature of the draw tool). A second strategy was to rewind the video which allowed the students to repeat sections of the video to further enhance their understanding of the procedures of the various tests.

Figure 3. Screenshots of (A) students pointing and (B, D) drawing using CAVA360°VR and (C) writing.

Another strategy the students used was to pause the video inside 360VR. The video would then be paused for all the students, which meant that all were "frozen" in the same moment of the video. During these pauses the students either summarized the knowledge they just heard or helped each other to understand what was going on in the training video.

While watching the training video, the students also began answering the professors' questions. By doing so they engaged with the dialog between the professor and students in training video. Some of the students mentioned in the subsequent feedback session that they had a feeling of standing physically in the room in the training video, which this shift in roles can be an example of.

In test 3, one of the students had several prompts appearing in front of her in 360VR (see Figure 4). These prompts guided the students to reflect on and discuss the information given to them in the training video. The students afterwards explained that it had a positive effect on them and helped them to understand what was going on in the training video. Only one of the students was prompted with the questions and the four other students were dependent on the fifth student to communicate the questions and the fifth had another responsibility in session compared to the others.

Figure 4. Scripted question.

Our preliminary findings also indicate that for the students to be able to perform the clinical test they are dependent on the use of different strategies for learning about the examination. Above we described their use of the technology to support their learning, but we also see how important the use of other skills and competencies related to communication, collaboration and problem-solving are for establishing a shared understanding. For example, we see that the design of the avatar only gives the students few nonverbal cues such as head and hand/controller movement. They then have a sort of handicap that forces them to rely on other resources – such as verbal communication. They must rely on their communicative ability of using words to visualize and describe their understandings. Their communicative abilities thereby play a fundamental role in situations where the technology or nonverbal cues from the avatar is not enough.

In our data we also see that when there is missing information in the training video, e.g., how a test is performed, the students who had prior training in the clinical examinations were able to use that knowledge when they performed the test, whereas the students without the prior training had to improvise on how to perform the test. At the same time the missing information, (e.g. when a certain medical term was used) allowed the students to build on each other's knowledge showing the importance of the collaborative learning space. It became a strength for the students to work together as a group because otherwise they might not be able to reach the correct understanding.

The ability to work together and analyze the training video inside the social 360VR using different learning strategies enabled the students to perform the two clinical tests (test of the medial and lateral collateral ligament and the anterior cruciate ligament) afterwards (see Figure 5). Our preliminary findings show that all of the students who perform one or more of the tests are able to do it despite they never tried it before and only seen it be done (the students' performances have been assessed by a doctor with expertise in clinical examinations). In the physical examination not all the students performed all the tests, and one student did not perform any of them. But they still participated in the examination by guiding and helping the other student(s).

Figure 5. Examination of a knee.

The design of the case-PBL that we present here thereby construct a learning space where the students not only learn to take responsibility of their own learning but also are encouraged to take part in the responsibility of the group and ensure that the other student(s) also reaches a positive learning outcome. It is also a design that enables the students to train other skills and competencies related to communication, collaboration and problem-solving – competencies that creates the fundament of becoming a competent doctor.

DISCUSSION AND FUTURE WORK

With our explorative study on using social 360VR as a platform and learning design for case-PBL in medical education, we bring a fresh perspective on the longstanding commitment to supporting and facilitating ”students' mutual learning, sense-making and collaborative engagement” (Bertel et al., 2021) with digital tools in PBL. Instead of designing specific problem triggers, we gave the student's a higher level of responsibility to figure out how to perform the different examinations. The explorative study shows that social 360VR can offer a more advanced and sophisticated platform supporting students PBL practices, not just an individual student's repetition of a task. In addition, the explorative study also indicates that students can learn from watching other students' failures and mistakes (training video), which is also prompting mutual learning and sense-making for the students. Based on our explorative study, we envision that social 360VR could support case-PBL practices for students and teachers in novel ways. The next step for us is to work with implementing social 360VR as design and environment supporting digital PBL cases in medical education.

ACKNOWLEDGEMENTS

We would like to thank all the students taking part in the experiments.

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