Use of an immersive virtual reality application to educate medical students in patient handover in medical students – Hand-O-VR

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Abstract

Background: Patient handover is a daily task for doctors and nurses alike and structured handovers have been proven to impact patient outcome positively. In order to teach the handover procedure different communication tools have been applied like the ISBAR (introduction, situation, background, assessment, recommendation) method.

Objective: This study aimed to assess the benefits of a supplementary training in virtual reality for medical students.

Methods: Handover training using the ISBAR method and patient actors is part of the curriculum in surgery of the eighth semester of human medicine studies in Mainz. Knowledge is tested via an OSCE (objective structured clinical examination) using patient actors. We developed an immersive virtual reality application using 360° video surroundings with structured patient cases. This application was offered as an optional supplementary training in groups of three with a peer tutor. Parameters evaluated included participants' characteristics, usability, and visually induced motion sickness. Furthermore, a survey of the whole semester was conducted about their experience using virtual reality and the personal enjoyment of studying. Last, the scores of the OSCE were collected and compared between groups.

Results: The study was conducted over two semesters and 92 of 385 (23.9%) volunteering students were recruited. Median age was 25 years and the majority was female (n= 61, 68.5%). There were little to no problems considering visually induced motion sickness and eye strain. Students felt significantly more confident in patient handover after the additional training (7 point Likert scale, mean (pre training) = 3.69, mean (post training) = 3.17, $P < .01$) and reported to have significantly more fun studying than their peers who did not participate in the additional training (mean(participants) = 2.8, mean(non-participant) = 3.69, $P < .01$). The points achieved in the OSCE did not differ between groups (median grade = 17 in both groups, $P = .619$).

Conclusions: This study shows that applications in virtual reality if implemented in a structured curriculum can be a helpful and safe addition in the teaching of communication skills. While overall points achieved in the OSCE did not differ, it has been shown, that knowledge retention is increased in enjoyable learning settings. Virtual reality applications should be considered as a time flexible, safe and fun educational tool suitable for numerous different settings.

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Key Words: virtual reality, medical education, head-mounted display, handover, gamification

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Abstract

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This study shows that applications in virtual reality if implemented in a structured curriculum can be a helpful and safe addition in the teaching of communication skills. While overall points achieved in the OSCE did not differ, it has been shown, that knowledge retention is increased in enjoyable learning settings. Virtual reality applications should be considered as a time flexible, safe and fun educational tool suitable for numerous different settings.

Introduction

Patient handover is part of daily work in hospitals around the globe. No matter if in-patient or out-patient, elective or emergency care all departments involved in patientcare must perform regular handover of patient cases. This involves all medical staff and includes intra- and interprofessional as well as intra- and interdisciplinary communication [1]. It has been shown that patient handover is a key element for adequate patient care, influencing patient outcome directly and yielding an important aspect of patient safety [2, 3]. In order for a handover to be easily understood by the receiving party it is important to have a clear structure, concise language and focus on essential information. Furthermore, patient handover comprises a variety of communication skills into one task, which can be taught and practiced. For all of these reasons the ISBAR concept was developed, tested and validated for different medical professions [4-6]. ISBAR is an acronym for Introduction / Identify – Situation – Background – Assessment – Recommendation, which provides a clearly structured backbone for every handover situation [7]. The details of the ISBAR concept are shown in *Figure 1*.

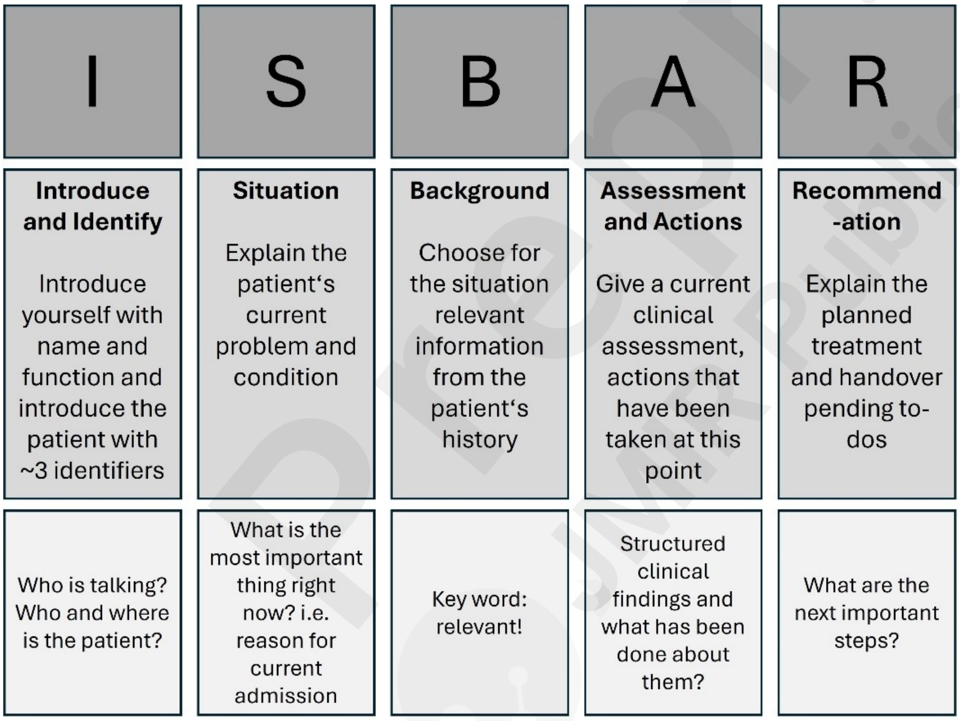

Figure 1: ISBAR method in schematic form. Row 1: abbreviation. Row 2: title and description. Row 3: Additional cues.

Teaching of communication skills is important for all medical professionals and has been incorporated more and more over the last decades [8]. In Germany, clear learning objectives for communication have been implemented into medical licensing regulations, challenging teachers and university settings alike [9]. Most medical professionals working today have not received formal communication training until years into their practice – if at all – because there had not been emphasis on training of these skills during their time studying or of training, yet [10]. Thus, the first step is to train the trainers, because a good clinician is not automatically a good teacher [11]. Furthermore “classical” courses, lectures and exams are not well suited for communication training. Effective communication training needs a good balance of theory and practice as well as self-reflection and teacher and peer feedback. The theoretical base is indispensable to create a reproducible result. Practical skills can only be trained effectively in practical courses, using the newly acquired skills [8]. This is often done employing actors as simulated patients, which are a valuable but also very costly asset [12]. Self-reflection is key for every communication skill to be learned. This might take extra time in or after class to reflect by oneself or in a small group, why certain situations were more difficult to handle or why some interactions were perceived to be more stressful than others. Feedback by teachers and peers is not only important to correct theoretical and contextual shortcomings but also to confront the student with how they are perceived by others. Many communication classes include the additional aspect of video review for the students to perceive themselves from the outside [13, 14].

Employing the concept of constructive alignment a practical skill like a patient handover cannot be tested using multiple choice or written exams, but much rather should be tested in an OSCE (objective structured clinical examination) [15]. This style of exam has been successfully used in the medical field for years [16]. In contrast to a written examination, which hundreds of students can take at the same time, students take turns at different stations of an OSCE, each performing their station by themselves. Thus, OSCEs are more time consuming and by default also more cost intensive.

Virtual Reality (VR) technology using head-mounted displays has grown in the past years to be easily available to the public especially in recreational computer science and has also been widely used for different research projects. Among many other uses, VR is an interesting addition to educational programs, facilitating learning in a safe environment on one’s own time and in one’s own pace [17]. Furthermore, learning in VR has been shown to be enjoyable to students and create autobiographic memory, which can be more easily accessible [18]. VR programs have been used for procedural and communication skills alike [19]. In recent years, VR has gained additional interest because of its ability to bridge the gap whenever direct contact i.e. with patients or peers was not possible, as we have experienced during the international COVID-19 pandemic [20]. While VR has so far not been able to replace contact to peers, patients and teachers, it is evolving to be a useful tool to enrich educational programs [17, 21, 22].

The aim of this study was to develop and test a supplemental educational tool for training of patient handover in VR in a curricular course for medical students.

Material and Methods

Study setting and conceptualization of the educational concept

In the University Medical Center of the Johannes Gutenberg-University Mainz Germany communication skills are taught in the longitudinal communicational curriculum, which encompasses a variety of different disciplines over multiple semesters. One of those is teaching patient handover within the framework of surgical practical training in the beginning of the 8th semester. Students are taught the ISBAR concept in a short theoretical overview and afterwards practice with patient actors. They receive feedback from a teacher as well as their peers. The unit is 45 minutes long and 4 to 6 students make up one group. Additionally, there are videos and texts available for review online. At the end of the semester students undergo an OSCE using patient actors again, complying with the concept of constructive alignment [15]. While other parts of the surgical practical training can be practiced at home or at the skills lab (i.e. surgical knot tying or suturing) patient handover is challenging to practice. Therefore, we developed a training suite in VR consisting of three cases of increasing urgency and employing patient actors and a suitable curriculum to accompany the VR program. During VR training, students are led through the scenario by short multiple-choice questions to obtain a patient history. They also receive a data sheet similar to a patient file. The training in VR is conducted by a peer instructor in groups of three, thus each student can perform one scenario. The training was conducted in the newly established VR training centre of the Rudolf-Frey-Lernklinik during the course of the semester.

Figure 2 depicts an overview of the course of the study.

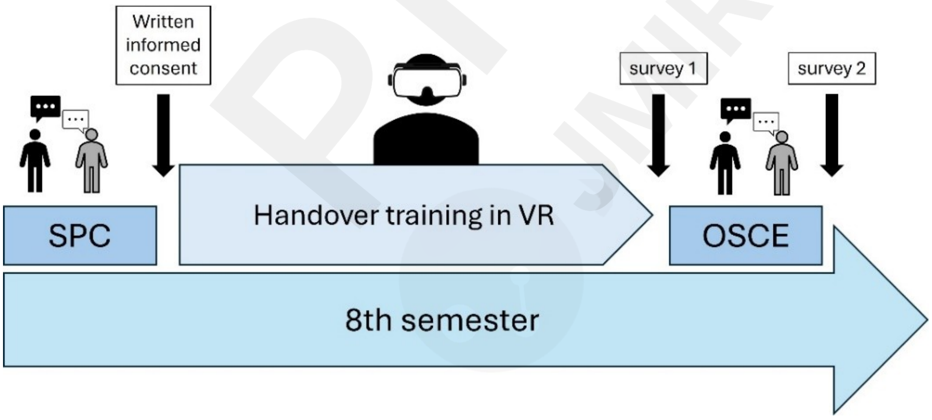

Figure 2: Course of the study over one semester. In the first week of the semester was the surgical practical course including the subject of patient handover taught with patient actors. Over the course of the semester there were multiple time slots for a one-time handover training in VR. In the last week of the semester was the OSCE including examination of the subject of patient handover using patient actors. Black arrows indicate time points of informed consent and survey of participants and non-participants in the same semester.

Conceptualization of scenarios and video shoot

An interdisciplinary team concepted the scenarios involving the same preoperative patient under Warfarin therapy before inguinal hernia repair with increasingly urgent need for medical attention.

Scenario 1: The participant arrives in the patient's room, who tells him that he has continued his daily medication of Warfarin up until this morning, despite undergoing inguinal hernia repair tomorrow. Shortly after, the attending physician arrives for the handover.

Scenario 2: The participant arrives in the patient's room, who tells him that he has continued his daily medication of Warfarin up until this morning and has noticed black stools in the past few days. He also reports to feel faint, as an additional information the participant is given lab results with decreased hemoglobin levels. Shortly after, the attending physician arrives for the handover.

Scenario 3: The nurse calls the participant to assist her, because the patient has fainted, and his bed is covered in bloody stool. His blood pressure is low, and heart rate elevated. Shortly after the medical emergency team and the attending physician arrive in the room for a handover.

The participants perform a quick history and then have to give a structured handover to the arriving doctor using the ISBAR concept. A detailed script of the scenarios is available in the supplementary material. The videos were shot using a 360° camera in 8k (Insta360 Pro 2; Insta360, Guangdong, China) in an actual patient room. The decision to use highly immersive video footage with actors and in the actual hospital setting over animated surroundings was supported by prior research, which showed that more realistic scenarios were preferred by participants [23]. The shoot was supported by the company Visual-Impressions, who are specialized in 360° video shooting (Visual-Impressions GmbH, Magdeburg, Germany).

Development of the 360° immersive VR environment

We utilized a game engine Unity (Unity Technologies, San Francisco, United States) version 2019.2.18f1 for immersive VR development environment. Virtual Reality Toolkit (VRTK) version 3.3.0 was used to provide basic user interactions in VR, including locomotion and UI interactions. The recording 360° videos were edited and stitched according to the scenarios using Shotcut video editing tool (Meltytech, LLC, United States). The stitched videos resulted in equirectangular format, which can be used for spherical projection mapping in VR. We incorporated the VIVE Media Decoder, a powerful video decoding plugin, to achieve high-quality video streaming in Unity. The VR headset used for this study was the HTC Vive Pro (HTC Vive Pro, Taoyuan, Taiwan) with the resolution of 1440 x 1600 pixels per eye (2880 x 1600 pixels combined), refresh rate 90 Hz, and field of view 110 degree. Furthermore, additional information regarding the scenarios was integrated under close medical and educational supervision and displayed with UI panels in VR. Participants were able to use their controllers with the ray casting technique to interact with those UI interfaces. We also implemented the interactive questionnaire using The Virtual Reality Questionnaire Toolkit, allowing the participant to answer questions directly in VR. If the participant answered the question correctly, the UI panel turned green and the scenario continued. If answered incorrectly the scenario stopped at the question until answered correctly. There were unlimited tries allowed.

Figure 3 gives an impression of the VR environment.

Figure 3: Screenshots from the VR environment. In a a nurse finds our patient, who fills dizzy and unwell. She checks his vital signs (b) which are depicted in the box above her head. Shortly after the emergency team arrives (c) and the patient is connected to monitoring (d). In e the attending arrives to receive a patient handover.

Recruiting and data collection

Over two semesters (summer semester 2023 and winter semester 2023/2024), we recruited volunteer participants, who underwent VR training in groups of three together with a student teacher, who all gave corrections and feedback after each handover. Students were made aware of the study via email and personal information during the curricular surgical practical course. Participants were asked to complete questionnaires at the end of VR training regarding demographic information, personal motivation and the immersion scale according to Nichols et al. [24] as well as rating how confident they were in the subject of patient handover. Furthermore, data regarding visually induced motion sickness and eye strain were collected [25]. At the end of the semester, after the OSCE, participants were questioned again, regarding motivation, confidence and preparedness facing the OSCE as well as their impression of VR as a useful tool for education. Participants were contacted directly via email for this second survey and reminded once. In addition, the whole semester was questioned as a control group. OSCE results for the handover examination and overall OSCE results were recorded for analysis. For data collection, the online platform lime survey was used (LimeSurvey GmbH, Open Source).

Statistical analysis and ethical approval

Statistical analysis was performed using SPSS 29.0 (IBM SPSS Statistics). Participants characteristics were analysed using descriptive parameters. Other questionnaire items were analysed using Mann-Whitney-U-Test and t-Test.

Ethical approval was sought before start of the study and acquired under the reference code 2023-17025.

Results

Overall, 92 participants of 385 students (23.9%) were recruited for the study, of which 3 (amounting to one group) dropped out because of exceptionally bad weather conditions, which made them unable to attend training. After written informed consent they were divided in groups of three and attended VR training. Data analysis was performed on the 89 participants, who attended training (per protocol analysis). Median age of participants was 25 years, the groups was comprised of 61 female (68.5%) and 28 male participants (31.5%). 40% (n = 36) of participants had prior experience in the medical field (i.e. nurses, physical therapists, paramedics). The second survey after the OSCE was answered by 81 of the 89 participants (91%).

Most participants had minimal to no experience using VR equipment or a head-mounted displays (never: n = 49, 55.1%; less than 5 times: n = 33, 37.1%). Eye strain and VIMS was reported to be minimal, with one singular outlier, who was able to complete the training despite dizziness (median(eye strain) = 1; Min(eye strain) = 1; Max(eye strain) = 9; median(VIMS) = 1; Min(VIMS) = 1; Max(VIMS) = 16). The majority of participants stated to feel present in the virtual world (scale of 1 – 7, 1 = not at all, 7 = very much, n(5 and more) = 60, 67.4%). The details of the results of the Immersion Scale questionnaire are shown in *figure 4*.

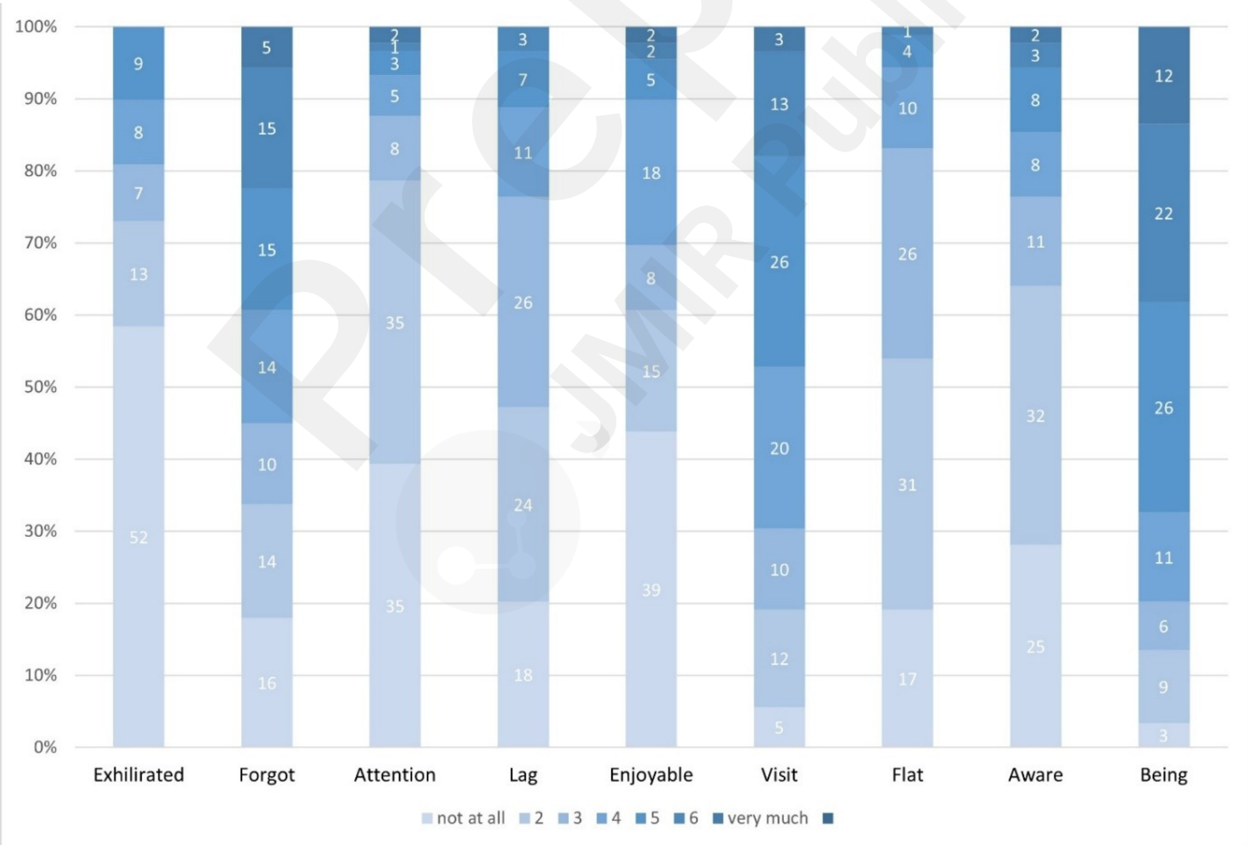

Figure 4: Result of the Immersion Scale as described by Nichols et al. as a 7-point Likert scale [24]. Results show high grade of presence with minimal lag and minimal exhilaration, fitting a high grade

of immersion.

Participants reported to feel significantly more confident to give a patient handover after the training (median(pre-training) = 4, median(post-training) = 3, $p < 0.001$). The majority stated that they enjoyed the handover training in VR and they had more fun than in other courses during the training (scale 1 – 7; 1 = a lot more fun and enjoyable than other courses; 7 = a lot less fun and enjoyable; n(1) = 47; 52.8%, n(2) = 24; 27%). Further results are shown in *figure 5.*

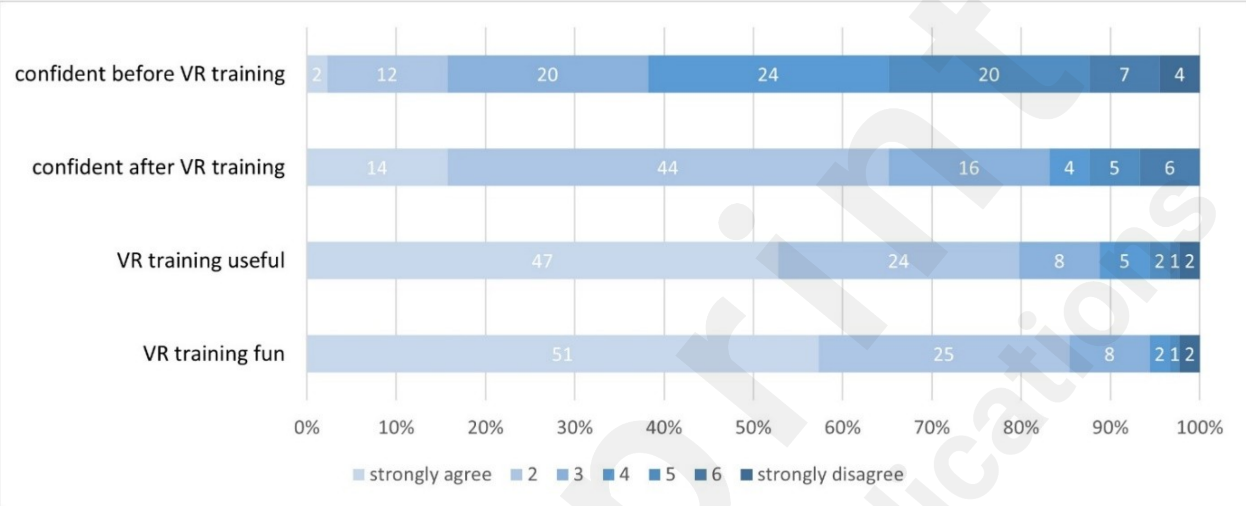

Figure 5: Results of pre- and post-training questionnaires. Participants felt significantly more confident to give a patient handover after VR training (rows 1 and 2) mean(pre training) = 3.69, mean(post training) = 3.17; $P < .001$). After experiencing the training, they deemed VR programs for medical education to be useful and stated that they had more fun in the VR training than in other courses (rows 3 and 4).

153 of 296 students (51.7%) of the whole semester, who had not participated in the training replied to the survey. Comparing survey results between VR-training participants (P) and non-participants (NP), there were a few significant differences to be noted. Students were asked if they felt, they were able to recall and use what they had learned about patient handover well in the OSCE (scale 1 – 7, 1 = very much, 7 = not at all; mean(P) = 2.75; mean (NP) = 3.29; middle rank(P) = 104.38; middle rank(NP) = 124.45; $P = .027$). Asked the question, if they had fun studying for the patient handover participants stated to have had significantly more fun (scale 1 – 7, 1 = very much, 7 = not at all; mean(P) = 2.8; mean (NP) = 3.69; middle rank(P) = 94.82; middle rank(NP) = 129.51; $P < .001$). Having experienced the training, significantly more participants deemed VR equipment and head-mounted displays as a useful supplement for medical education (scale 1 – 7, 1 = very much, 7 = not

at all; mean(P) = 1.56; mean (NP) = 3.03; middle rank(P) = 54.98; middle rank(NP) = 110.73; *P* < .001). It is to be noted that all students were highly motivated (scale 1 – 7, 1 = very much, 7 = not at all; mean(P) = 3.38; mean (NP) = 3.76; middle rank(P) = 107.84; middle rank(NP) = 122.61; *P* = .105) pointing towards there being no difference between groups. Further results of the second survey are shown in *figure 6*.

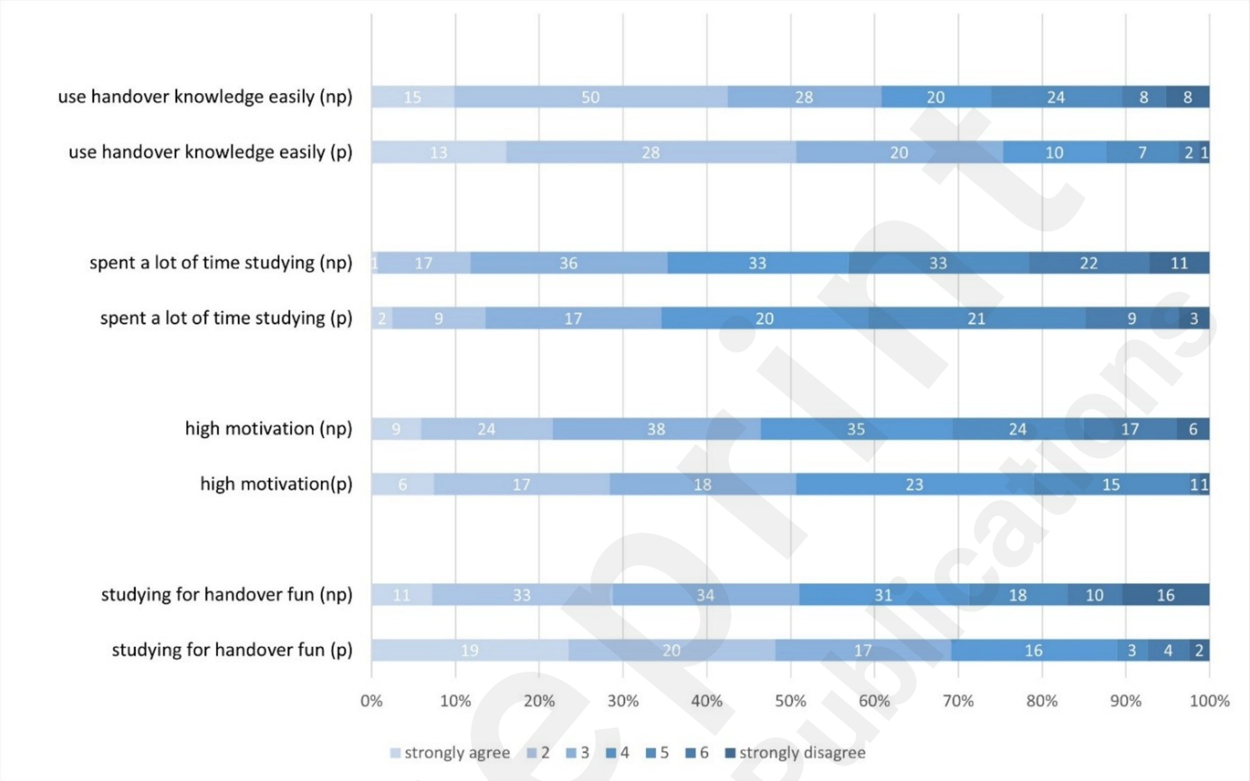

Figure 6: Comparison of np and p answers in the second survey. Rows 1 and 2: P stated more often than np to feel like they were easily able to recall what they had learned in the subject of patient handover and apply this knowledge in the OSCE (*P* = .027).

Rows 3 and 4: P and np spent a similar amount of time studying for the subject of patient handover, showing no significant difference between groups (*P* = .544).

Rows 5 and 6: Motivation between p and np was not significantly different (*P* = .105).

Rows 7 and 8: P stated to have significantly more fun than np studying for the subject of patient handover (*P* < .001).

It should be noted that there was no significant difference between results of the OSCE, neither in the handover station nor in the overall grade (median grade (p) = 17, median grade (np) = 17, *P* = .619).

Discussion

Patient handover is an integral part of clinical work with an evident influence on patient outcome. The ISBAR method provides a clear structure, which is easily remembered and reproduced [7]. However, practical skills call for practical training, which can be time and cost intensive [8].

Our study presents a novel VR training program for handover in a surgical context, which is customized to our didactic framework and easily used with a student tutor. Interest in our study was high and we were able to swiftly recruit participants. Asked for their motivation to participate, most of them stated that they were curious about new ways of studying. Our results show that our training program in VR was perceived to be a fun and enjoyable addition to other educational concepts without drawbacks like severe VIMS or eye strain. There was no significant influence on OSCE results, which is consistent with prior study results [26]. Participants felt more confident after handover training in VR, which is – especially in communication skills – an important aspect of presenting the skill.

To the authors knowledge, there is no similar study or program using 360° immersive virtual reality in a curricular setting currently available. Andreasen et al. described the comparison of a VR tool with traditional paper-based learning methods in 2023 [27]. However, the study used a desktop VR application without head-mounted displays and fully immersive 360° environment. Furthermore, the evaluation between groups was conducted as written test. We deliberately decided against this approach to respect the concept of constructive alignment [15]. In the past our group was able to show that VR simulation using 360° immersive video is preferred by participants, hence we chose this mode of demonstration over others [28]. Similar to our results the authors describe mainly similar outcome in the examination but students using the VR application reporting to find this way of learning more enjoyable [27].

Neher et al. presented a feasibility study for an interprofessional team training for medical and nursing students in VR in 2024 [29]. While this study is using immersive virtual reality with head-mounted displays, it is a computer-generated environment in contrast to the program we are presenting. Being a feasibility study, there is no implementation in curricular teaching or comparison with a control group as in our study.

While our study shows interesting results, there are some limitations to be noted. Oftentimes, programs using volunteer participants like the presented one draw highly motivated students' interest, which can form a bias in the results. Comparing participants and non-participants, there was no significant difference in how motivated they felt to study for patient handover or how much time they spent doing so. This suggests that this bias between groups was minimal. Our study compared additional VR training to no additional training. A further interesting comparison for future studies could be a third group of additional training with patient actors. However, we did not have the means to provide additional training with actors as simulated patient, which is costly in Germany.

While handover training in VR was perceived well, participants still had to attend a separate training slot at the University Medical Center Mainz in person. There were a multitude of different time slots to be more flexible than when using patient actors, but so far there is no possibility for training on short notice, like an at-home-application would provide. This type of flexibility is hard to achieve in communication training, because feedback from peers and tutors is integral for this type of training. Future applications may be able to assess human communication and give feedback, however, for the near future this is most likely going to primarily concern assessment of correct content and order of information (i.e. choice of relevant information, respecting the ISBAR method). Evaluation of tone, facial expressions and other "soft" aspects of communication demand highly sophisticated technical solutions, which are not widely available, yet [30, 31]. These types of additions would facilitate communication training without time constraints and will surely be subject of interesting research in the future. However, it should be critically evaluated, if communication training without human interaction is a goal we are trying to achieve.

Overall, our study was able to show that VR communication training can be a valuable addition to conventional educational programs leading to students feeling confident to give a patient handover.

Declaration

Acknowledgements

This publication is part of Patrick Schwoerers doctoral thesis. We thank Visual-Impressions GmBH from Magdeburg, Germany for their help during the 360° 8k Video shoot.

Ethics approval and consent to participate

All participants were volunteering medical students of the 8th semester in human medicine at the Johannes Gutenberg-University Mainz enrolled in the surgical practical course. Written consent was obtained in the beginning of the study. Participation was not reported to OSCE examiners. Ethical approval was obtained under the reference code 2023-17025- andere Forschung erstvotierend.

Consent for publication

All authors have read and approved the manuscript in its current form and consented to publication.

Competing interests

The authors declare no competing interests.

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Authors' contributions

LH and TH conceptualized the course of the study. LH and PS recruited and undertook the study. PS managed data collection. LH, FH, LV, KUS, CB, HB and TH conceptualized the script and carried out the video shoot. LH, KUS, HB and TH conceptualized the educational concept. LH and TH prepared the statistical analysis and the manuscript. PS, VC and CH created the virtual reality environment and program. HL and TH supervised the study and its conduct. All authors reviewed the manuscript.

Abbreviations

VR	Virtual Reality
ISBAR	Introduce and Identify, Situation, Background, Assessment and Action,

	Recommendation
OSCE	Objective Structured Clinical Examination

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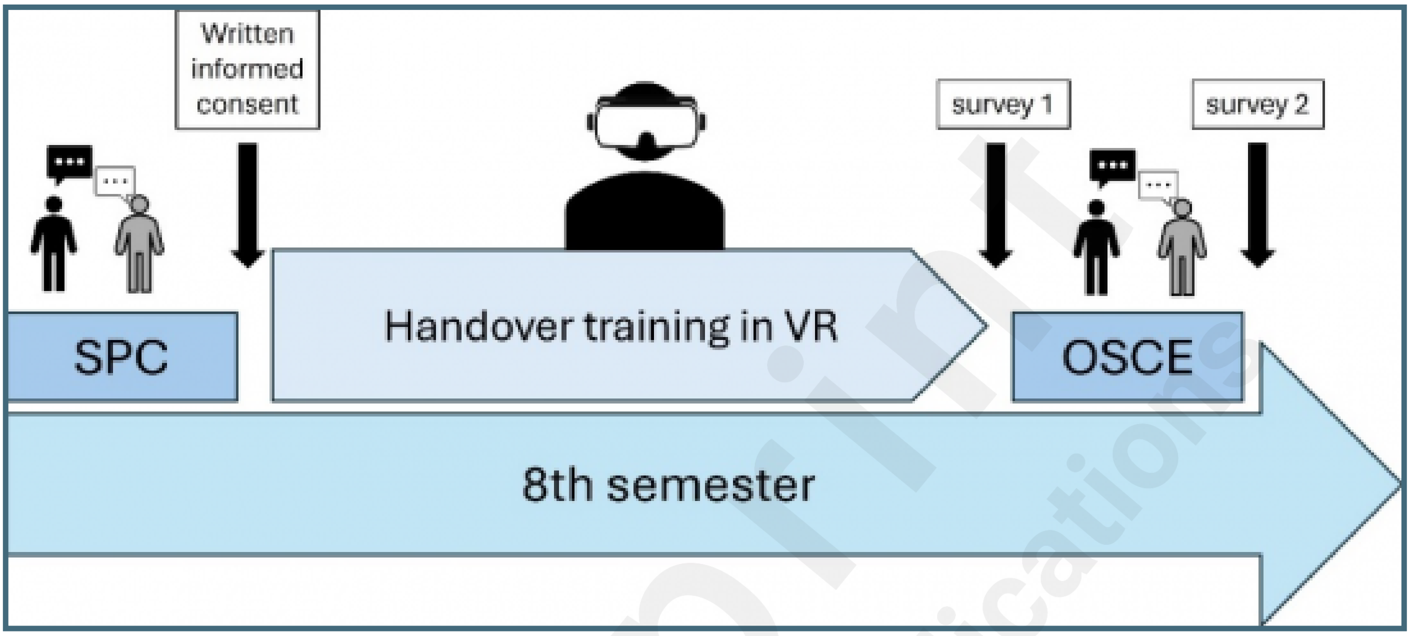
Supplementary Files

Figures

ISBAR method in schematic form. Row 1: abbreviation. Row 2: title and description. Row 3: Additional cues.

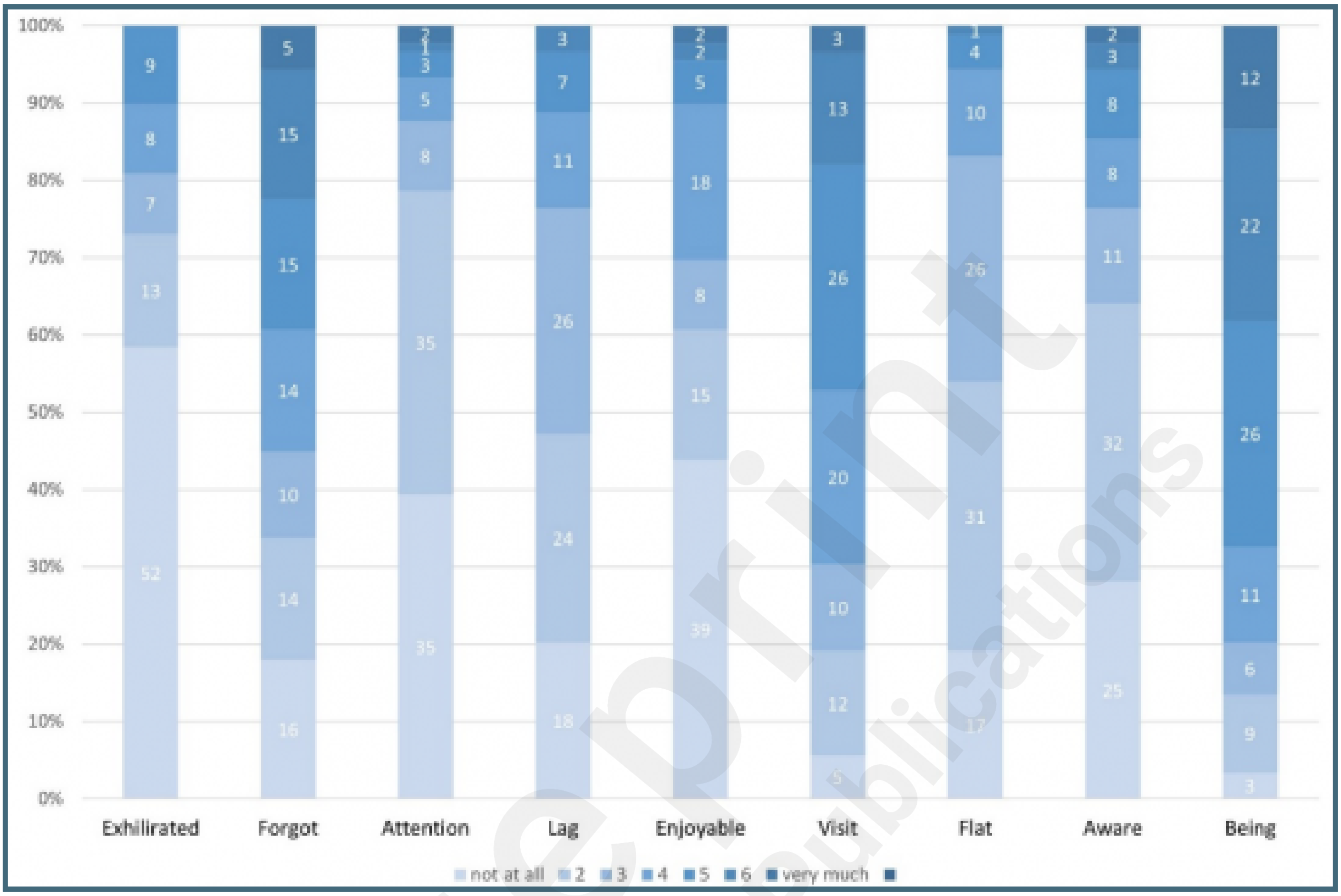
I	S	B	A	R
Introduce and Identify Introduce yourself with name and function and introduce the patient with ~3 identifiers	**Situation** Explain the patient's current problem and condition	**Background** Choose for the situation relevant information from the patient's history	**Assessment and Actions** Give a current clinical assessment, actions that have been taken at this point	**Recommend -ation** Explain the planned treatment and handover pending to-dos
Who is talking? Who and where is the patient?	What is the most important thing right now? i.e. reason for current admission	Key word: relevant!	Structured clinical findings and what has been done about them?	What are the next important steps?

Course of the study over one semester. In the first week of the semester was the surgical practical course including the subject of patient handover taught with patient actors. Over the course of the semester there were multiple time slots for a one-time handover training in VR. In the last week of the semester was the OSCE including examination of the subject of patient handover using patient actors. Black arrows indicate time points of informed consent and survey of participants and non-participants in the same semester.

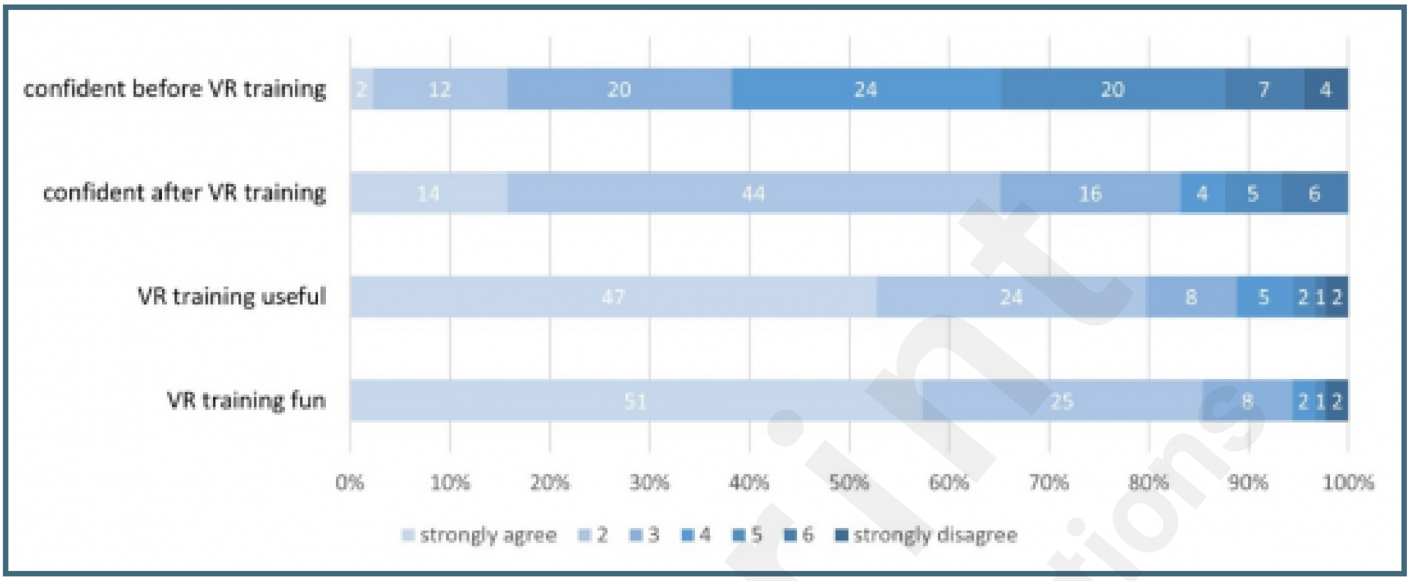


Screenshots from the VR environment. In a a nurse finds our patient, who fills dizzy and unwell. She checks his vital signs (b) which are depicted in the box above her head. Shortly after the emergency team arrives (c) and the patient is connected to monitoring (d). In e the attending arrives to receive a patient handover.

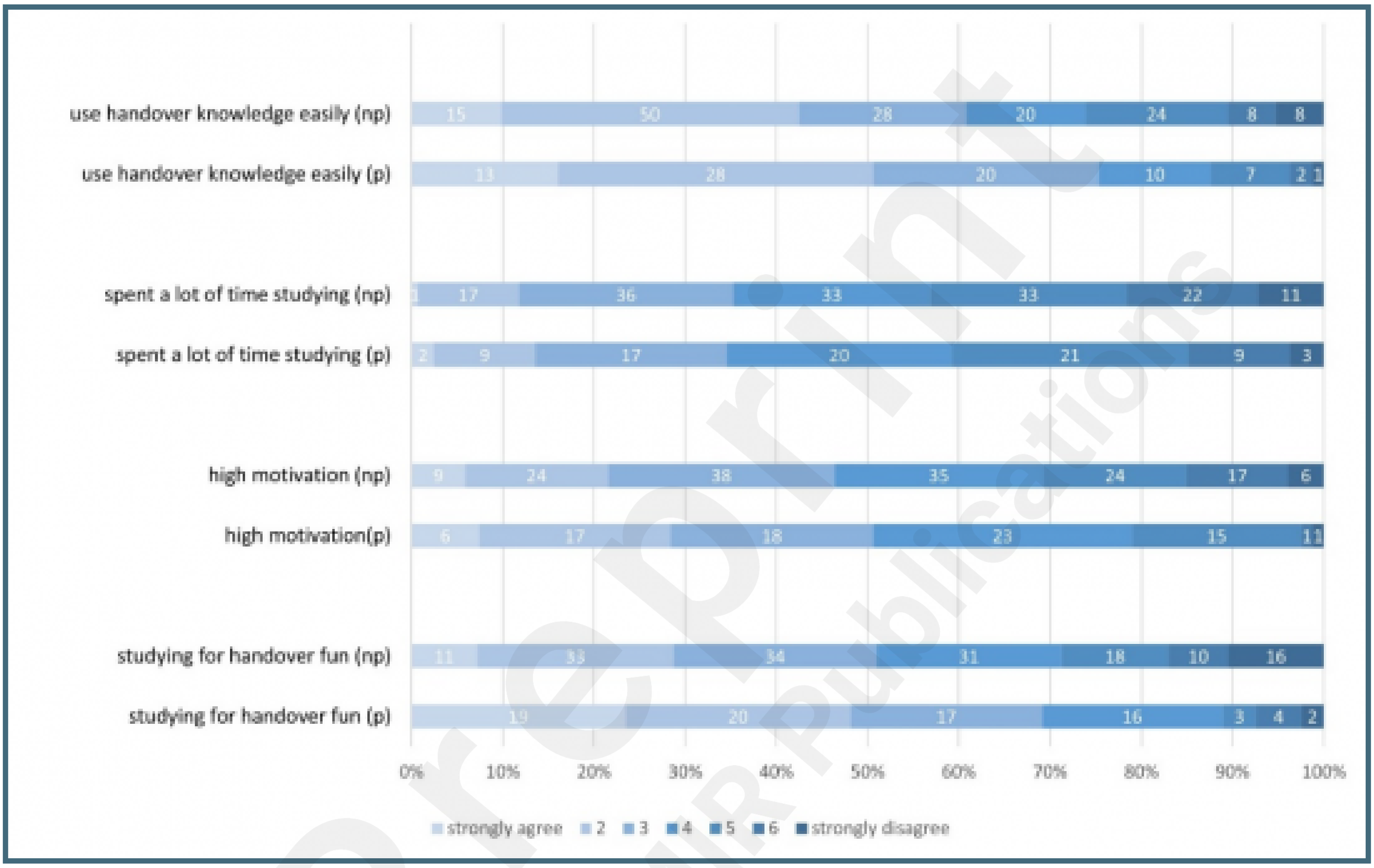
Result of the Immersion Scale as described by Nichols et al. as a 7-point Likert scale [24]. Results show high grade of presence with minimal lag and minimal exhilaration, fitting a high grade of immersion.



Results of pre- and post-training questionnaires. Participants felt significantly more confident to give a patient handover after VR training (rows 1 and 2) mean(pre training) = 3.69, mean(post training) = 3.17; $P < .001$). After experiencing the training, they deemed VR programs for medical education to be useful and stated that they had more fun in the VR training than in other courses (rows 3 and 4).



Comparison of np and p answers in the second survey. Rows 1 and 2: P stated more often than np to feel like they were easily able to recall what they had learned in the subject of patient handover and apply this knowledge in the OSCE (P = .027). Rows 3 and 4: P and np spent a similar amount of time studying for the subject of patient handover, showing no significant difference between groups (P = .544). Rows 5 and 6: Motivation between p and np was not significantly different (P = .105). Rows 7 and 8: P stated to have significantly more fun than np studying for the subject of patient handover (P < .001).



TOC/Feature image for homepages

Untitled.