

First aid training in virtual reality

Effects of a virtual refresher course on self-efficacy, knowledge, and transfer

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1 PROBLEM STATEMENT, MOTIVATION & NOVELTY

Practical first aid courses enable people to act precisely and effectively in emergency situations. The time after an emergency is crucial for saving lives. According to studies, around 59% of fatalities could be prevented if the population had better first aid skills [Heard 2020]. However, in many emergency situations, people hesitate to provide first aid. Only just under 52% of participants feel confident that they would actually help in a first aid situation [Steichele-Biskup 2021]. According to a study by the ADAC, the reasons for this are fear of making the situation worse for those affected or doubts about one's own self-efficacy, which persist even after completing a first aid course [Steichele-Biskup 2021]. With the help of virtual reality (VR), first aid training can be enriched with immersive scenarios and realistic training situations can be created. This could help people feel more confident about actually helping in an emergency situation [Philippe 2020]. Initial findings on VR training are promising [Strojny 2023; Wu 2020], but also show the need for meaningful empirical studies on the effectiveness of virtual first aid training [Chirico 2020]. In this paper, VR is specifically examined as a supplement to traditional first aid courses and various measures of learning success are considered.

2 THEORETICAL BACKGROUND

The use of VR training has increased significantly in recent years, and studies have demonstrated the advantages of immersive learning environments in many contexts and to varying degrees [Wu 2020; Philippe 2020; Makransky 2021]. The focus is on learning success, but this is defined differently depending on the study: Key constructs for evaluating effectiveness are self-efficacy, transfer learning, and procedural knowledge, which will be discussed in more detail below.

2.1 Self-efficacy

Self-efficacy is an individual's confidence in themselves and their own abilities to organize and execute certain procedures. This confidence enables them to independently accomplish certain tasks or solve problems [Bandura 1977]. Specific self-efficacy can be changed by various influences, the most important determinants for increasing it being individual, active, personal achievements. These can be achieved through practice [Heslin 2006]. To date, the effects of VR training on self-efficacy have rarely been investigated [Abich 2021], which is why further insights are being gathered in this work. Practicing in VR

Simulations can help individuals experience learning success in scenarios comparable to those that may occur in reality. Learners internalize the structure of such situations and are thus able to apply what they have learned to similar real-life situations: as a result, those who have undergone training feel more self-effective in real-life situations. This increases the likelihood that they will actively engage as first responders [Philippe 2020]. VR scenarios can therefore be used to achieve individual learning success, which increases self-efficacy so that more people dare to act as first responders in serious emergencies [Abich 2021].

2.2 Transfer performance

Transfer refers to the ability to apply knowledge already acquired in a specific situation to another context [Perkins 1992]. However, this transfer can only take place if the tasks or situations have significant similarities and these are also noticed by the learner [Gick 1987]. Transfer performance is one of the most important learning objectives. Although transfer assurance is highly valued in education, few studies have examined this factor in depth in the application of VR training [Wu 2020]. This paper therefore focuses on achievable transfer performance. According to the "transfer-appropriate processing approach," the more overlap there is between the learning situation and the practical challenge in terms of the acquisition method, the more successful the transfer of acquired knowledge will be [Morris 1977]. According to the "encoding specificity theory" [Tulving 1973], targeted information retrieval is further facilitated if the original learning environment has many similarities with the application situation. Since participants deepen their knowledge in a realistic first aid simulation, they should then be able to apply it to similar real-life emergency situations. There should be sufficient overlap between the VR training and real-life circumstances.

2.3 Procedural knowledge

Procedural knowledge encompasses the knowledge of how something is done. This primarily includes process flows and practical applications [Salaberry 2018]. In the context of using VR in education, procedural knowledge in particular seems to benefit and achieve better learning outcomes than traditional learning methods. This is shown by a study by Andreasen et al. [Andreasen 2019]. In this study, participants learned about specific genetic techniques either through a video or through VR. When the participants then had to explain what they had learned to another person, the VR group showed significantly better results in procedural knowledge acquisition than the video group [Andreasen 2019]. This advantage is particularly evident when previously learned knowledge has to be applied in new situations [Conrad 2024]. This is precisely where VR could be used to supplement conventional teaching methods. Knowledge is imparted in normal lessons, and VR scenarios can be used to consolidate and automate the sequence of actions on an individual basis. Despite these findings, the current state of research on the use and effectiveness of VR in a first aid context is still very rudimentary. The few studies that do exist focus primarily on the development of VR applications. Subsequent reviews of effectiveness are rare [Al-Hiyari 2021; Girau 2019; Phatichon 2024]. Nevertheless, existing studies provide initial noteworthy findings in this field. They found that VR can effectively promote procedural knowledge of first aid procedures, so that the sequence of sub-steps is better internalized [Bucher 2019; Park 2022]. At the same time, other studies show that VR scenarios are not universally suitable for building motor skills and are not suitable for learning chest compressions, for example: it is not possible to adequately convey the force and frequency required for chest compressions [Nas 2021; Schmidt-Polończyka 2024].

3 RESEARCH METHODOLOGY

In this study, a quantitative experiment was conducted with company first responders and other participants who had taken a first aid course more than a year ago. Using a mixed design (mixed between within design), the study examined whether completing a VR first aid course with several VR scenarios had a positive effect on knowledge, transfer, and self-efficacy. The VR training took place either shortly after the participants had completed their last traditional first aid course or more than a year later.

The experiment consisted of two separate VR sessions and an integrated pre- and post-questionnaire. The first session (15 min) served as an introduction to virtual reality and to learning how to use the VR headset (Meta Quest 2). The main session (60 min) began with an explanation of the procedure. This was followed by a written pre-test (knowledge, attitudes, demographics). Then came the actual VR training with the "First Aid Training" software (V. 1.2.19) from OneBonsai, consisting of the scenarios "severe bleeding" and "burn injury," which was conducted in English. Between and after the scenarios, items were queried to gauge the mood. Finally, the written post-test was conducted to check knowledge and VR perception. $N = 24$ subjects participated in the study ($n = 15$ women). Their ages ranged from 19 to 64 ($M = 33$, $SD = 12.5$).

4 RESULTS

Compared to the pre-questionnaire, the post-questionnaire showed higher mean values for subjectively measured self-efficacy (0-100%), procedural (0-20 points) and declarative knowledge (0-12 points) measured using objective tests, and transfer to a novel situation (0-23 points) in the descriptive statistics.

The results of the Wilcoxon rank test show significant increases in declarative knowledge ($W = 35.5$, $p = .043$, $rb = -.478$) and self-efficacy ($W = 0.00$, $p < .001$, $rb = -1.00$). This confirms the hypotheses regarding the increase in declarative knowledge and self-efficacy from the pre- to post-survey.

Further assumptions were confirmed by t-tests for paired samples. Significant changes were observed between the pre-test and post-test in procedural knowledge ($t(23) = -7.73$, $p < .001$, $d = -1.58$) and transfer ($t(23) = -7.69$, $p < .001$, $d = -1.57$). Therefore, the hypotheses regarding the increase in procedural knowledge and the increase in transfer performance in the post-test compared to the pre-test can be confirmed. The significant results are shown graphically in the box plots in Figure 1.

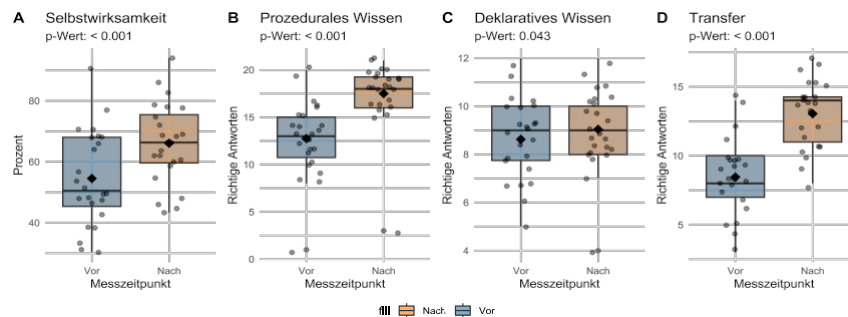


Figure 1: Box plots of the pre- and post-survey of self-efficacy, procedural knowledge, declarative knowledge, and transfer

5 DISCUSSION

The VR training conducted had a positive impact on learning success. Increases in specific self-efficacy, declarative knowledge, procedural knowledge, and transfer performance were observed. The test subjects also found the virtual scenarios to be immersive and realistic, allowing them to actively apply theoretical first aid techniques in a practical setting. The most effective factor in building specific self-efficacy is the accumulation of individual learning successes—the individual successful completion of realistic scenarios presumably contributes significantly to this, regardless of whether the learning experiences actually take place in the real or virtual world. In both cases, procedural knowledge benefits from active learning. The decisive factor for active processing is the individual relevance of the respective information and stimuli [Leung 2018]. The immersive nature of virtual training increases the general subjective relevance of the exercise situation. Because the virtual environment appears authentic and real, what is learned is linked to subjective emotional experience and one's own actions, which, according to studies, leads to holistic learning experiences [Makransky 2018] and the certainty of being able to successfully cope with emergency situations. In VR, participants experience control over their actions in realistic emergency situations and successfully overcome them [Heslin 2006], whereas traditional first aid courses are primarily based on vicarious experiences. According to Bandura [Bandura 1977], these also have a positive influence on self-efficacy, but do not achieve the same effect as individual learning successes. Thus, VR training is superior to other learning formats in this respect.

VR training also enables participants to better recall the correct sequence of first aid methods. This is reflected in both an increase in procedural knowledge and transfer performance. According to Guided Learning Theory [Kirschner 2006], structured, action-oriented instructions simplify step-by-step learning by reducing cognitive load.

The immersive experience specifically promotes context-related learning and, according to the Cognitive Affective Model of Immersive Learning (CAMIL), has a positive effect on the sense of presence [Makransky 2021]. This helps learners to immerse themselves more deeply in the emergency situation. The realistic depiction, e.g., splattering blood, was perceived by the test subjects as stressful, which made the situation seem real and created a high degree of congruence between the learning situation and the potential application situation. This level of realism and immersion cannot be achieved by typical exercises in a traditional first aid course, as much of the content is only taught theoretically or practiced on static dummies. The virtual world enables learners to process content interactively and emotionally through various sensory channels, which is likely to promote the formation of holistic and precise mental representations that facilitate the targeted, timely retrieval of knowledge in real-life scenarios [Mayer 2014].

Company first responders in particular could benefit significantly from additional VR training. The results of the master's thesis show that commercially available VR training courses can be a useful addition to existing courses. They promote practical application and increase transfer performance. This can help to break down barriers to actively helping in emergency situations and strengthen individuals' confidence in their first aid skills. VR training can be used as a practice measure, refresher course, or learning progress test and may help to address current weaknesses in existing first aid courses. This can effectively improve the overall quality of first aid training. Overall, we believe that well-designed VR training courses are innovative solutions in the field of civil protection, ensuring a high level of training among the population in the long term and saving more lives.

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