It's All about Saving Lives: Towards a Virtual Learning Environment for the Rescue Chain

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Abstract: Simulating road accidents in a virtual reality (VR) environment and making the rescue chain experienceable is valuable because it allows users to practice their behaviour and react more confidently and effectively in an emergency. Following the Design Science Research Methodology (DSRM), we present the different steps needed for the development of the VR demonstrator. Since the links of the rescue chain (cordon off the accident scene, send an emergency call, provide first aid and hand over to the paramedics) will be simulated realistically, potential first responders can practice their behaviour and learn from their mistakes. The aim is to impart competencies sustainably and thus to save lives.

1 INTRODUCTION

Every year, approximately 1.35 million people are killed in road traffic crashes worldwide. Between 20 and 50 million more people suffer non-fatal injuries (Organization, 2018). In Europe an estimated 18,800 people were killed in a road crash in 2020 (Keersmaecker & Meder, 2021). The absence of first aid was judged to have contributed to the death in 4% of the cases (Henriksson et al., 2001). When a traffic accident with personal injury occurs, immediate medical care is of great importance. Other road users are the first link in the rescue chain and thus the first indicator of whether a person involved in an accident will survive or not. One example is the deficiency of oxygen. While the injured person loses consciousness after about two minutes due to a lack of oxygen in the brain, irreversible hypoxic brain damage occurs after only five minutes (Lacerte et al., 2021). Mell et al. (2017) describes that it takes 7 minutes from the time the emergency call is made until the ambulance arrives at the scene in urban areas. This median value rises to more than 14 minutes in rural areas. At the same time, every tenth patient waits almost half an hour for the arrival of the ambulance service (Mell et al., 2017).

To save lives, it is crucial that everyone can provide adequate first aid and to ensure the necessary care of the accident victims ("rescue chain") (Pawłowski et al., 2018; Sánchez-Mangas et al., 2010). In Germany the rescue chain thereby includes the links: cordon off the accident scene, send an emergency call, provide first aid and handover to the paramedics (Deutsches Rotes Kreuz, 2020; Johanniter, 2020). To ensure that German drivers are prepared for emergencies, they have to attend a first aid course to obtain their driving license (§19 FeV) (Bundesamt für Justiz, 2010). In terms of content, the course only briefly deals with the theory of lifesaving and focuses on practical training, e.g., by using a training manikin. However, the conditions of an actual road accident differ significantly from the training environment. In an emergency, most people are themselves in shock, making it challenging to ensure that accident victims receive seamless care (Leach, 2004). Added to this are stress-increasing factors such as time pressure, gapers, or injuries.

Digital progress and the use of interactive learning systems can help to deepen the skills of first responders and reduce stress. Repeated testing and practice resulted in better retention and transfer of knowledge compared to repeated learning (Butler, 2010). The more the student learns about the importance of the content during the learning process, the higher is one's motivation. Ultimately, this leads to easier learning of theoretical and practical material (Garris et al., 2017; Vansteenkiste et al., 2006).

The digital technologies make it possible to implement principles of continuous education, build individual educational paths and organize mixed learning (Bondarenko et al., 2021). Adding

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interactivity can improve this learning process. Active involvement in the learning process facilitates learning (Evans & Gibbons, 2007). The immersion factor of VR makes interactivity even higher (Bailenson, J. et al., 2008). In contrast to passive, cinematic immersion, VR allows interaction with the virtual environment, which makes it possible to achieve a much higher intensity of immersion (Vergara et al., 2017). VR promises practical benefits in skill development and experiential learning approaches in the sense that knowledge can be practiced practically and interactively (Suh & Prophet, 2018).

In this paper, a research project is introduced, which aims for developing an interactive VR learning system, to deepen the competencies of first responders about the rescue chain in road accidents. Following the DSRM (Peffers et al., 2007), we will present our planned activities in order to introduce them to international audience at an early stage. Thus, this paper is a first step towards the development of a VR-Demonstrator for the rescue chain.

2 RELATED WORK

In the context of technological progress, the development of VR has opened up new possibilities to experience virtual environments (Gleasure & Feller, 2016). VR is a 3-dimensional computer-generated tool that gives the user the feeling of being present in a virtual environment (Desai et al., 2014). The technology is based on head-mounted displays (HMD), in which videos and images are shown three-dimensionally on a screen integrated into the VR glasses (Geng, 2013). The additional use of controllers enables the user to interact with objects in the virtual environment (Sherman & Craig, 2019). Thus, VR offers not only immersion of vision, but likewise of sound and tactile feedback (Desai et al., 2014).

VR is used in many different domains, e.g., gamification, work, and medicine (Sherman & Craig, 2019). The environments and applications range from relatively simple, such as the visualization of a didactic laboratory, to highly complex, such as a military training within virtual reality (Vergara et al., 2017). In the context of learning, especially regarding developing competencies, VR offers enormous potential (Martín-Gutiérrez et al., 2017). Virtual environments can also change social interaction through behaviour and context and improve learning (Bailenson, J. et al., 2008). VR can be used for learning processes involving the development of practical knowledge and personal competencies. Experience-led learning is not primarily based on cognitive learning processes, but also addresses subjective dimensions such as experience or intuition (Martín-Gutiérrez et al., 2017; Vakratsas & Ambler, 1999). The approach of experience-guided learning starts with learning through sensual experience, empathic experience, and breaks with the traditional educational approach. Experience -led learning highlights the reflection on theoretical knowledge of each learning process by recognizing the independent intelligence and practical action (Matthew & Sternberg, 2009). VR supports experience-led learning by enabling users to practice knowledge practically and interactively (Dick et al., 2017).

Until now, no VR applications are known for learning the holistic traffic accident and practising all steps of the rescue chain. Only the step of first aid (e.g., unconscious persons) is trained by VR applications (dualgood, 2019) or interactive videos (Techniker Krankenkasse, 2020).

3 METHODOLOGY

Since design science is essential to create successful artifacts, design science research has become increasingly important in the research field of information systems (IS). Designers of digital technology products play a critical role in ensuring that their designed artifacts are beautiful and provide value to their users (Hevner & Chatterjee, 2010). To guide researchers who work on design science research, Peffers et al. (2007) provide a methodology for presenting its outcome, which is presented in Figure 1.

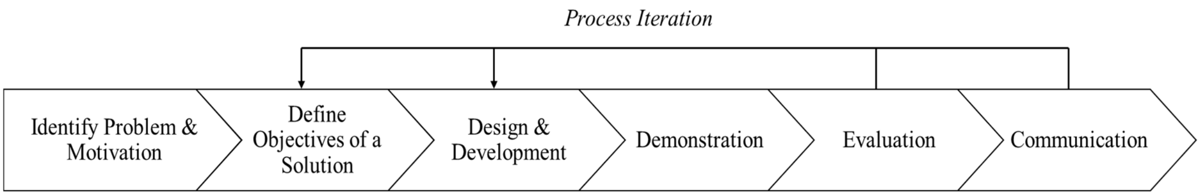

Figure 1: DSRM Process Modell adapted from Peffers et al. (2007).

The advantage of Peffers et al. (2007) DSRM is that it is consistent with previous literature, provides a nominal process model for conducting design science research, and provides a mental model for presenting and evaluating design science research. In the following, we build on the six steps of the DSRM. We describe the problem identification and motivation, definition of objectives of the solution, design and development, demonstration, evaluation, and communication of our research idea.

3.1 Problem Identification and Motivation

The German law (§ 323c StGB) regulates: Everyone is obliged to provide first aid (StGB, 2020). However, many first responders are overburdened at the scene of a road accident, and in 80% of these cases, no help is provided. One reason is that many people are afraid of making mistakes and fear the legal consequences. Furthermore, the last first-aid-course often took place a long time ago. Moreover, the conditions of an actual accident differ significantly from the theoretical training environment: Most people are in shock themselves in emergencies. In addition, there may be conditions that create unknown types of stress, such as injuries, time pressure, and gaffers.

Existing solutions prove that VR is suitable for teaching competencies in emergency or disaster situations, e.g., teaching first aid for non-professionals (4HELPVR, 2019) and rescue chains in disaster operations for specialists (FLAME Systems PTYLTD). However, there is no virtual training environment that simulates the rescue chain holistically and imparts competencies across all links. Thus, the rescue chain can only be trained to a limited extent, which might be insufficient considering the extreme stress situation of an actual road accident.

Therefore, the motivation to develop another learning platform is also based on preparing first responders for the worst-case scenario through a playful approach and a higher self-motivation.

3.2 Objective of Solution

The solution's objective is to develop a VR-based learning environment, which allows users to repeat training contents as often as they like to react more efficiently to emergencies. Users can experiment with objects and the environment itself and thereby gain valuable learning experiences (Bailenson, J. N. et al., 2008; Martín-Gutiérrez et al., 2017). The interaction with the learning environment (e.g., applying a bandage) and the feedback from the VR environment (e.g., bleeding stops) can improve the learning success. This enables users to immerse themselves in a realistic accident, to deepen their competencies without harming others (Naik & Brien, 2013) and to gain the necessary self-confidence (Pulijala et al., 2018) to apply the rescue chain in real-world settings. In this case, i.e., learning the rescue chain within VR, the immersion should be as high as possible so that users do not dismiss the application or helping within the application as a "gimmick" and they recognize the seriousness of the situation. Thereby, classical concepts like first aid courses are not replaced but instead supported. The attendees of the first aid courses are the primary target group.

3.3 Design and Development

First, we conduct a requirement analysis regarding competence development and VR design: Which steps and processes of the rescue chain's links are relevant? How can these be suitably transferred to a VR environment to convey competencies along the rescue chain?

Furthermore, it is considered how informal or realistic the representation must be. When the user learns in a virtual environment that represents the retrieval environment (environment congruence), implementation is facilitated (Jahn et al., 2018). VR can be used very well to create a realistic-looking world that can be interacted with in real-time (Burdea & Coiffet, 2003). This interaction can be with avatars or collaborative work and cooperation between several actors. Implications for designing an immersive VR system suggest strengthening the sense of embodiment and presence influences the system's immersion and provides a more artificial or a human avatar that influences the sense of social presence (Kampling, 2018). The immersion within VR is conveyed by visual aspects and reinforced by auditory and tactile feedback (Desai et al., 2014). How this feedback can be designed will also be part of the design process.

A significant disadvantage, especially when VR glasses are worn for a more extended period, is motion sickness (Munafo et al., 2017). The effect is caused by the fact that the input from several senses is perfectly coordinated in the real world, while in the virtual environment, the sense of sight is contradictory and asynchronous to the rest of the input (Lewis, 2015). Due to motion sickness, in addition to the type of VR application, the length of time the user spends in the virtual environment must be considered.

To test the conditions as mentioned earlier, interviews will be conducted with experts (e.g., paramedics, fire brigade, doctors or driving instructors) and future users (i.e., drivers or first aid course students). These interviews are conducted before the implementation of a VR environment. Here, the advantages and disadvantages of existing concepts such as learning videos or classic training will also be asked and taken up in design implementation. In addition, workshops will be held to reflect on the results and develop concrete scenarios (e.g., rollover car) with experts. These results will be compared to the classic driver training. The outcome will be a technical concept (guidelines for the competence development of rescue chain) and a technological concept (guidelines for the integration of VR).

3.4 Demonstrator

According to the technical and technological conception, the elaborated scenarios are created as a demonstrator. This development is done in an agile way to create a user-oriented and at the same time sustainable technology. Different levels of difficulty and development stages are to be created.

Example scenario: *You see a movie in VR: You are driving on a highway. In a curve, a car appears which has crashed into a tree. A tire blocks the opposite side of the road. You are stopping on the emergency lane. The accident victim sits disoriented at the side of the road and seems to be in shock. You recognize a bleeding head injury. Now you have to take action - you are the first responder! You can move freely in the virtual environment and move objects (e.g., the tire). What will you do first? Will you put on a safety vest? Do you remove the tire from the road? Do you provide first aid? Do you call the rescue service?*

For the scenario to be successful, the subjects must make independent decisions. This means that the test persons (e.g., first aid students) decide which step to take first, and the system then gives them a reaction, a feedback (decision-reaction chain). An example is when the road is not secured quickly, cars pass the test persons quickly or a rear-end collision occurs. The time component will play a role regarding the reaction chain. The total time per scenario will only play a subordinate role. This is done about the learning success, to be able to carry out the scenario to the end. For example, if the decisions are correct, but the test persons have problems with the controls in VR. Such initial problems should not reduce the learning success.

3.5 Evaluation

The VR demonstrator will be continuously evaluated. This evaluation will explore to which extend the demonstrator can be used for competence development of the rescue chain. In the context of quality assurance of the VR demonstrator a formative evaluation is aimed, which continuously checks technological (e.g., usability tests) and technical aspects (e.g., integration of different links). Formative evaluation is a study approach that is often key to success, interpretation, and replication of outcome (Stetler et al., 2006). Besides, the development is to be discussed and reflected, e.g., in workshops with experts. The objective is an iterative development based on the results of the evaluation.

3.6 Communication

Archer (1984) and Hevner et al. (2004) stress that communication is essential to diffuse the resulting knowledge. Therefore, Peffers et al. (2007) recommend communicating the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences, such as practitioners, when appropriate. We are convinced that this research idea contributes to the fact that every citizen can fulfil one's social responsibility to "provide help." Thus, it is important to contact researchers and practitioners continuously as well as at an early stage and request feedback. This is ensured not only through scientific implementation in papers and journals, but also through social internet presence such as podcast, videos, or short articles. This feedback can contribute to the implementation and quality of the realization.

4 CONCLUSION

This paper builds upon the DSRM and presents the development of a VR environment that allows practical and interactive training of the rescue chain. Therefore, this research proposal will contribute to theory and practice alike:

From the theoretical perspective, we want to build up on existing research that demonstrates that VR is suitable for developing competencies. Our contribution will not only be to investigate how the VR environment needs to be designed to ensure appropriate competencies development about the rescue chain, but rather whether VR also provides the necessary self-confidence and self-efficacy to apply the learned competencies in real emergencies. Furthermore, questions are raised about design and implementation, how close to reality does the rescue chain need to be designed. To what extent do design decision about presence, immersion and experiential learning play a role in a VR environment. Furthermore, we will also look at the acceptance of VR in terms of considering the end user's point of view from the very beginning. These will be considered in the evaluation and communication.

Our research will also make critical practical contributions. By making rescue chains experienceable, potential first responders can practice their behaviour interactively. They can gain confidence in their decisions and learn from their mistakes. The representation of the rescue chain in VR offers the advantage that behaviour in a dangerous situation can be tested without putting oneself in danger (Bourhim & Cherkaoui, 2020). In this way, more efficient learning successes should be achieved (Greenwald et al., 2017), ensuring that users feel well prepared for an emergency. Our solution is intended to be made available to institutions that are responsible for teaching competencies in the areas of driving safety (e.g., driving schools or driver safety training) and first aid (e.g., German Red Cross, Johannite, or Malteser). Here, the design will also be evaluated through expert interviews of these groups. Overall, this research project should contribute to save lives.

REFERENCES

4HELPVR. (2019). *Training program - First Aid in Virtual Reality*. https://4helpvr.com/en/home-en/

Archer, L. B. (1984). *Systematic method for designers*. N. Cross (ed.), John Wiley. *Developments in Design Methodology*, pp. 57–82.

Bailenson, J., Patel, K., Nielsen, A., Bajscy, R., Jung, S.-H., & Kurillo, G. (2008). The Effect of Interactivity on Learning Physical Actions in Virtual Reality. *Media Psychology*, *11*(3), 354–376.

Bailenson, J. N., Yee, N., Blascovich, J., Beall, A. C., Lundblad, N., & Jin, M. (2008). The Use of Immersive Virtual Reality in the Learning Sciences: Digital Transformations of Teachers, Students, and Social Context. *Journal of the Learning Sciences*, *17*(1), 102–141.

Bondarenko, T. G., Maksimova, T. P., & Zhdanova, O. A. (2021). Technology Transformation in Education: Consequences of Digitalization. In S. I. Ashmarina & V. V. Mantulenko (Eds.), *Lecture Notes in Networks and Systems. Current Achievements, Challenges and Digital Chances of Knowledge Based Economy* (Vol. 133, pp. 659–666). Springer International Publishing.

Bourhim, E. M., & Cherkaoui, A. (2020). Efficacy of Virtual Reality for Studying People's Pre-evacuation Behavior under Fire. *International Journal of Human-Computer Studies*, *142*, 102484.

Bundesamt für Justiz (2010). Verordnung über die Zulassung von Personen zum Straßenverkehr: FeV. https://www.gesetze-im-internet.de/fev_2010/BJNR198000010.html

Burdea, G. C., & Coiffet, P. (2003). *Virtual Reality Technology*. John Wiley & Sons, Inc. / Engineering.

Butler, A. C. (2010). Repeated testing produces superior transfer of learning relative to repeated studying. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *36*(5), 1118–1133.

Desai, P. R., Desai, P. N., Ajmera, K. D., & Mehta, K. (2014). A review paper on oculus rift-a virtual reality headset. *ArXiv Preprint ArXiv:1408.1173*.

Deutsches Rotes Kreuz. (2020). *Rettungskette Übersicht*. https://www.drk.de/hilfe-in-deutschland/erste-hilfe/rettungskette/rettungskette-uebersicht/

Dick, M., Haase, T., & Termath, W. (Eds.) (2017). *The Potential of Virtual Interactive Learning Environments for Individual and Organizational Learning: An Example for the Maintenance of Electrical Equipment. Advances in Ergonomic Design of Systems, Products and Processes*. Springer Berlin Heidelberg.

dualgood. (2019). *Get better results with immersive training: VR training in First Aid, Life support and more. For Healthcare and Enterprise*. https://www.dualgoodhealth.com/

Evans, C., & Gibbons, N. J. (2007). The interactivity effect in multimedia learning. *Computers & Education*, *49*(4), 1147–1160.

FLAME Systems PTYLTD. *FLAME Systems: Train Virtually, Experience Reality*. https://www.flaimsystems.com/

Garris, R., Ahlers, R., & Driskell, J. E. (2017). Games, motivation, and learning: A research and practice model. In *Simulation in Aviation Training* (pp. 475–501). Routledge.

Geng, J. (2013). Three-dimensional display technologies. *Advances in Optics and Photonics*, *5*(4), 456–535.

Gleasure, R., & Feller, J. (2016). A Rift in the Ground: Theorizing the Evolution of Anchor Values in Crowdfunding Communities through the Oculus Rift Case Study. *Journal of the Association for Information Systems*, *17*(10), 708–736.

Greenwald, S. W., Kulik, A., Kunert, A., Beck, S., Fröhlich, B., Cobb, S., Parsons, S., Newbutt, N., Gouveia, C., & Cook, C. (2017). Technology and applications for collaborative learning in virtual reality. In Philadelphia, PA: International Society of the Learning Sciences.

Henriksson, E., Öström, M., & Eriksson, A. (2001). Preventability of vehicle-related fatalities. *Accident Analysis & Prevention*, *33*(4), 467–475.

Hevner, A., & Chatterjee, S. (2010). Design Science Research in Information Systems. In A. Hevner & S. Chatterjee (Eds.), *Integrated Series in Information Systems. Design Research in Information Systems* (Vol. 22, pp. 9–22). Springer US.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, 75–105.

Jahn, K., Kampling, H., Klein, H. C., Kuru, Y., & Niehaves, B. (Eds.) (2018). *Towards an Explanatory Design Theory for Context-Dependent Learning in Immersive Virtual Reality*.

Johanniter. (2020). *Erste Hilfe: Zum Lebensretter an einem Tag*. https://www.johanniter.de/dienste-leistungen/medizinische-hilfe/erste-hilfe/

Kampling, H. (Ed.) (2018). *The role of immersive virtual reality in individual learning*.

Keersmaecker, S. de, & Meder, S. (2021, April 20). *Road safety: 4,000 fewer people lost their lives on EU roads in 2020 as death rate falls to all-time low*. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_1767

Lacerte, M., Hays Shapshak, A., & Mesfin, F. B. (2021). *StatPearls: Hypoxic Brain Injury.*

Leach, J. (2004). Why people 'freeze'in an emergency: temporal and cognitive constraints on survival responses. *Aviation, Space, and Environmental Medicine*, *75*(6), 539–542.

Lewis, T. (2015). *When Will Virtual-Reality Headsets Stop Making People Sick?* https://www.livescience.com/50129-virtual-reality-nausea-sickness.html

Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(2), 469–486.

Matthew, C. T., & Sternberg, R. J. (2009). Developing experience-based (tacit) knowledge through reflection. *Learning and Individual Differences*, *19*(4), 530–540.

Mell, H. K., Mumma, S. N., Hiestand, B., Carr, B. G., Holland, T., & Stopyra, J. (2017). Emergency Medical Services Response Times in Rural, Suburban, and Urban Areas. *JAMA Surgery*, *152*(10), 983–984.

Munafo, J., Diedrick, M., & Stoffregen, T. A. (2017). The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects. *Experimental Brain Research*, *235*(3), 889–901.

Naik, V. N., & Brien, S. E. (2013). Simulation: a means to address and improve patient safety. *Canadian Journal of Anesthesia/Journal Canadien D'anesthésie*, *60*(2), 192–200.

Organization, W. H. (2018). *Global status report on road safety 2018*. World Health Organization.

Pawłowski, W., Goniewicz, K., Goniewicz, M., Misztal Okońska, P., & Lasota, D. (2018). Law Of Health Education On First Aid. Advance online publication.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77.

Pulijala, Y., Ma, M., Pears, M., Peebles, D., & Ayoub, A. (2018). Effectiveness of Immersive Virtual Reality in Surgical Training-A Randomized Control Trial. *Journal of Oral and Maxillofacial Surgery : Official Journal of the American Association of Oral and Maxillofacial Surgeons*, *76*(5), 1065–1072.

Sánchez-Mangas, R., García-Ferrrer, A., Juan, A. de, & Arroyo, A. M. (2010). The probability of death in road traffic accidents. How important is a quick medical response? *Accident Analysis & Prevention*, *42*(4), 1048–1056.

Sherman, W. R., & Craig, A. B. (2019). *Understanding virtual reality: Interface, application, and design* (Second edition). *The Morgan Kaufmann series in computer graphics*. Morgan Kaufmann.

Stetler, C. B., Legro, M. W., Wallace, C. M., Bowman, C., Guihan, M., Hagedorn, H., Kimmel, B., Sharp, N. D., & Smith, J. L. (2006). The role of formative evaluation in implementation research and the QUERI experience. *Journal of General Internal Medicine*, *21*(2), S1.

StGB. (2020). *Strafgesetzbuch StGB: Mit Einführungsgesetz, Völkerstrafgesetzbuch, Wehrstrafgesetz, Wirtschaftsstrafgesetz, Betäubungsmittelgesetz, Versammlungsgesetz, Auszügen aus dem Jugendgerichtsgesetz, und dem Ordnungswidrigkeitengesetz sowie anderen Vorschriften des Nebenstrafrechts* (58. Auflage, Juni 2020). *dtv Beck Texte*. dtv Verlagsgesellschaft.

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, *86*, 77–90.

Techniker Krankenkasse. (2020, October 16). *360 Grad-App RescueMe VR: Für den Ernst-fall proben*. https://www.tk.de/techniker/magazin/digitale-gesundheit/tkf/leben-retten/rescue-me-app-2092150

Vakratsas, D., & Ambler, T. (1999). How Advertising Works: What Do We Really Know? *Journal of Marketing*, *63*(1), 26–43.

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational Psychologist*, *41*(1), 19–31.

Vergara, D., Rubio, M. P., & Lorenzo, M. (2017). On the design of virtual reality learning environments in engineering. *Multimodal Technologies and Interaction*, *1*(2), 11.