VR Simulation: Advancing Practical Skills in Computer Science Education

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Abstract: This study presents the successful integration of Virtual Reality (VR) tools as an element in computer science curriculum at German University of Technology, Oman. The research study investigates the use of MyScore, a VR application developed by RWTH Aachen University - Teaching & Research Field Engineering Hydrology as an environment for computer hardware assembly and troubleshooting exercises. The VR simulation utilized in this study acts as a gamified environment, incorporating elements like scorekeeping and interactive challenges to enhance practical learning in computer science, akin to game-based strategies that engage and motivate students. Over of some weeks, the project involved seven students and one tutor in immersive learning sessions to develop applied skills computer hardware assembly with VR technology over conventional teaching methods. Structured surveys and direct observations were used for data collection through students' interactions with the VR sessions. We also evaluated the students learning experiences as well as the usability of technology. The results showed that the user-friendliness of the VR interface and its ability to accurately simulate real-world tasks associated with computer assembly received both positive and negative reactions. While some students praised the technology for being pretty cutting-edge, some criticized it as unrealistic or non-interactive. We also received complaints that ranged from actually moving around in the virtual space to navigating only through teleportation spark points. Specifically, two students gotten motion sickness which is a well-known obstacle associated with VR environments and consequently left the sessions prematurely. The feedback of the instructor pointed towards that setting up the VR equipment is straightforward and described some potentials methods. Still, a call for more reliability in simulations and better interfaces began to surface as nevertheless less controversial agenda items. However, the instructor saw how VR has the potential to revolutionize educational practices. Providing interactive views between the VR device and students that can act as new learning methods. The present study extends the discussion on educational technology by providing empirical evidence of benefits and challenges experienced in deploying VR for technical education implementation. These findings thus support the continued development and validation of VR technologies in pursuit of improved commitment, cost-effectiveness, immersion, environment quality that may maximize learning outcomes in future educational applications.

Keywords: Virtual Reality, Computer Assembly, Educational Technology, Immersive Learning, Student Engagement, Motion Sickness, Technical Education, Usability, VR Simulation, Learning Outcomes

1. Introduction

To develop and evolve learning processes and outcomes, technology is evolving at a smart accelerated pace which keeps on revolutionizing educational horizons (Tang et al., 2022). Virtual Reality (VR) is one of the growing educational technologies to generate an immersive, interactive and multi-sensory experience which simulates real world environments (Luo et al. 2021; Frontiers in Psychology, 2018). This is invaluable for subjects such as computer science, where practical experience can sometimes be the most important part of understanding an idea.

But the broader deployment of VR in education still faces obstacles, such as the realism and fidelity of simulations on one hand, defy health and comfort concerns for its users. Studies have emphasized the ability of VR to increase student engagement and skill mastery, problems including motion sickness (LaViola 2000; Luo et al. 2021; Talespin, 2023).

As we directly address the trend of virtual learning environments in this project, particularly in relation to technical education using technology, it has become increasingly important for us to understand how VR technologies are changing conventional teaching methods. Perhaps this discovery is more about exploring new technology trends, but in this project we asked ourselves how the use of this technology would contribute to the learning experiences of our students at GUTech. This paper presents a research on "MyScore VR Simulation" adopted by the German University of Technology in Oman (GUtech) for computer science education using the MyScoreVR application. This project leverages VR technology to teach computer hardware assembly and troubleshooting, utilizing virtual components to minimize resource dependency and enhance scalability and interactivity. While VR is an established method, recent advancements have made it more affordable and realistic, expanding its practical applications in educational settings.

To investigate how VR impacts educational outcomes in computer science - specifically around engagement, learning performance and system usability, this study qualitatively captures the experiences of seven students and one instructor during their use of the VR sessions. Their findings are part of a conversation about the role and scalability of VR in education more broadly, which helps to inform just what makes it worth adopting, if comparisons with traditional learning experiences weren't enough.

2. Literature Review

Virtual Reality (VR) is being widely acknowledged for its capabilities in computer science education and even the larger perspective of technical training. In fact, recent research has shown that VR can have comparable outcomes to traditional apprenticeship methods (such as in laparoscopic surgery) while providing a safer and more standardized training environment (Portelli et al., 2020). Moreover, VR has indeed been shown to enhance gait in individuals with cerebral palsy (Ghai & Ghai 2019) such that its applications can meet medical rehabilitative purposes. There are also claims that VR may improve college education, and particularly the effectiveness of vocational skill training (Simonova et al., 2021).

In the case of military training, VR is used succeeding on some fronts based upon 4th industrial revolution innovations. al, 2021). Moreover, due to the potential benefits of VR for sectors including surgical training (Palter & Grantcharov, 2010), and procedural skills that demand exact technical proficiency within surgery, (Bjerrum et al., 2013) a risk-free opportunity can be offered in these areas. Similarly, the enhanced VR environment have been also proven to be effective in rehabilitation where they accelerated executions on mental representations of actions and motor functions (Rodrigues-Baroni et al., 2014).

VR has also been used in sports. It was evaluated in a research on soccer skills (Fuller et al., 2019). VR has also been used in various training programs such as navigation training ("Using VR Virtual Reality in Navigation Training", 2018) in firefighting instructions and stress management module, which is an idea that is applicable worldwide (Zhang & Tsai, 2021).

Not only has virtual reality been considered to be a safe and affordable training environment (Jones et al., 2013), it also enables more interactive communication between trainees and instructors, offering improved learning outcomes for both groups of different study cases (Ahmed et al., 2012; Balistreri & Casile, 2019). Additionally, being able to use them in a pedagogical scenario and with intelligent tutoring systems only adds its ability to bring about changes that improve the efficiency of training by fostering knowledge transfer virtually (Corre et al., 2014) .These great benefits and similar studies have made interest in working in the field of virtual reality in the GUTech sector. However, the need to study and carry out similar and ongoing projects are needed in order to better adapt VR programs to individual educational. We strive to create a deeply interactive learning environment despite challenges such as motion in this project. We hope to continue to use these learnings and improve our use of VR in education as a benchmark for future considerations. In addition to these applications, simulation games in VR have become a significant component of game-based learning, providing immersive environments that enhance educational experiences. These simulation games offer dynamic and interactive learning opportunities, allowing students to develop critical thinking and problem-solving skills in a virtual setting, thus complementing traditional educational methods.

3. Methodology and Implementation

3.1 Study Design

The study used a case-study method to assess the incorporation in the computer-science curriculum at GUtech of Virtual Reality (VR) technology using MyScore application. This approach was selected because traditional case study provides a detailed holistic analysis of how VR experiences influences education in real classroom settings (Yin, 2014). For several weeks, students participated in both VR-enhanced and traditional hands-on activities during computer science courses allowing for a direct comparison of student engagement and skills development through the two different educational methods (Clark et al., 2016).

The primary aims were to evaluate whether VR employed in this manner would facilitate educational performance and potentially identify barriers (e.g. technological problems, user discomfort such as motion sickness) (LaViola 2000). This data was collected through surveys and observations for usability, student experience(s)and general educational values [Bailenson, 2018]

These comparative experiment findings are meant to contribute to the continued intellectual dialogue on VR-specific pedagogy use-cases and indicate where improvements must be made if we want VR as an entity inside educational scaffolds in entirety.

3.2 Participants

Nine undergraduate students and one instructor from a computer science course (using Virtual Reality) were enrolled in the research. Seven students (4 male, 3 female ages between 19 and 24) took part at the VR sessions during that day that made a variety of experiences in relation to perspective on VR.

The instructor served as the facilitator of the VR sessions, and she had a background in computer science and an interest in innovative teaching methods. Her direction was instrumental in managing the VR learning curve and administering & collecting of survey data, which added to a better yield as well.

Full participation was voluntary and all participants provided written informed consent before and after being fully briefed on the aims of the study and their rights, including that at any time they could withdraw from this protocol without penalties.

Having participants with different levels of experience, and diversity in their demographics helped us to assess differential effects if any across a wide range of users within an educational setting.

3.3 Setup of the VR System

For this study the researchers employed an open-source tool named MyScore from RWTH Aachen University's Teaching & Research Field Engineering Hydrology Department of Virtual Reality (VR) application, intended for avatar-based education. In a number of instructional scenarios, the learners work through avatars in different types adopting various educational modules in virtual environment. The system was supplied with VR headsets and controllers, to ensure high performance of the 3D educational experience shown in Figure 1.

Prior to the start of this research, VR systems were thoroughly tested and calibrated for reliability and ease-of-use. The classroom, too, was rearranged to accommodate how students would be seated using the VR setup so that an announce of floor space could permit their bodies to freely engage.

MyScore goes beyond the constraints of traditional or hybrid approaches, which have been further underscored by recent teaching modality changes. Compared to video teaching tools that provide 2D only interactions, MyScore allows for a more engaging and enriched three-dimensional teacher-student interaction. However, this functionality is important when it comes to simulating and displaying real-world complex tasks like computer assembly so the learning experience would be richer.

Figure 1: Inside the MyScore app: A virtual workspace where students assemble and diagnose computer components.

MyScore application boosts engagement between participants, provides gamification elements with more interactive learning moments and also saving extra travel cost and environmental impact. VR settings were modified over the course of study based on feedback to optimize performance while providing comfortable experiences for users that would fit smoothly into educational workflows.

For the project, a dedicated learning space environment was designed to provide an immersive VR setup. The setup introduced two central VR stations, labeled as VR Rack 1 and VR Rack 2, loaded with VR headsets and necessary equipment. These stations were supported by computer 1 and computer 2 support the stations, acting as control centers for the VR software running.

Figure 2: Displaying the VR setup for the activity, featuring VR racks, main and backup computers, and a spacious area ensuring at least 2 to 3 meters of distance between each student workstation.

In addition to the primary computers, two backup computers were kept on standby. Such redundancy was a necessity in order to handle any disruptions that might undermine the learning process. Strategic positioning are necessary to reduce interruptions and improve the functioning of the learning architecture, strengthening them against student engagement (Dodevska & Mihic, 2018).

3.4 Data Collection Methods

We mobilized information about the performance of VR configuration and utilization results achieved by MyScore app in facilitating computer science learning using a dual-method technique. The primary ways data was collected were through structured surveys and on-the-ground observations.

The surveys aimed to collect feedback on the general process through engaging in VR, its effectiveness as an educational tool, how user-friendly and intuitive was it interact with the interface of VR. Finally, any points need improvement could have been gathered. The aim of using the above approach was to evaluate subjective educational results and track student satisfaction with VR learning.

Observational data was recorded by the instructor in all VR sessions, specifically focusing on how students engaged with VR technology and their behaviors during each task. The instructor also noted any challenges or issues that arose. These observations were vital for understanding how students navigated and deployed knowledge in the VR-based setting. The instructor also recorded any incidents of motion sickness and how it affected student engagement. The instructor actively supported the students during the survey process and VR sessions and make sure that students understood the questions

3.5 Procedure

The study process was designed meticulously to measure the efficiency of VR technology in educational settings. A detailed illustrating the steps that were taken along with a comprehensive and systematic evaluation was performed in this study.

The classroom, shown in Figure 3 below was initially set up to accommodate the VR hardware so that students could move freely within the virtual space. The MyScore software was installed on the central computers and all equipment tested to confirm full operation.

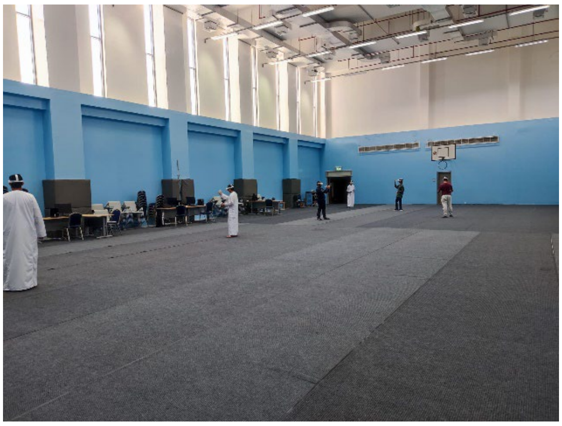

Figure 3: displays students engaging in the VR activity, spaced safely apart to ensure a secure and interactive environment.

The orientation session for the students familiarized them with both equipment and application (MyScore). The instructor spoke the goals of VR activities, showed how to use controls and answered any possible doubts from participants in order for them be able to understand very clearly what tools they would have at their disposal.

Students endeavored to perform emulation tasks corresponding to everyday examples in computer hardware assembly and diagnostics essentially giving them a hands-on experience within a safe virtual environment.

After the VR activities, students were provided with structured surveys by their instructor. These were aimed at capturing the more specific feedback factors such as experiences.

The instructor took notes and assessed the students' engagement with VR technology during each session. The instructor documented how the students strategically navigated, paid attention and adapted to their new tasks, as well as any difficulties they encountered like motion sickness.

Students were then brought together to discuss their experiences in a concluding open feedback session. Such a debate provided additional perspective from students and complement the quantitative data collected.

The last step is to compile and organize all the data collected (survey responses, observational notes, feedback from a discussion). In addition to human notes, any technical issues experienced during the sessions were recorded by the instructor and used for future planning of refinements within VR.

4. Data Analysis

Data from the structured surveys were quantitatively analyzed to identify trends in students' experiences with the VR system. Basic descriptive statistics were utilized to summarize the data.

The qualitative data from observational notes and open responses in surveys were reviewed to extract common themes regarding the VR learning process, technical issues, and the overall user experience.

Special attention was given to the feedback concerning motion sickness, with the aim of understanding its prevalence and impact on student participation. These insights were crucial for assessing the practicality of VR in classroom settings.

5. Results

5.1 Detailed User Feedback

Opinions about the VR experience itself amongst the students were divided, with both excitement and criticism overall. In particular, five of the seven students were impressed by the engaging interactivity and immersion facilitated through the VR environment; they believed that experiencing computer hardware components in 3D had greatly enhanced their learning on how to troubleshoot equipment. 3D-immersive experiences resonated particularly well with these students, allowing them to more easily grasp abstract concepts.

But there were some challenges too. One limitation they identified was that the VR simulations could be unrealistic at times, which may detract from their authenticity if not comprehensive or advanced enough to represent real-life tasks as realistic (as reported by four students). Three students encountered issues in VR navigation that impaired their learning as well. Two additional students had ongoing system connectivity issues that impacted their participation and engagement with the VR tasks.

5.2 Instructors Note

Indeed, comments from the instructor were aligned with this feedback stating that it was easy to get VR up and running in session for both students as well as how much more engaged they found their class became. Though, she noted that more accurate simulations would need to simulate how physical hardware interacts. One of the students also faced miseries with motion sickness which was an issue that brought down the functioning and comfort level during VR usability.

5.3 Motion Sickness Concerns

Among the issues flagged up were intense motion sickness, which affected two students. A student described the sensation as being like motion sickness to an intense and extreme degree. This feedback does point that possibly before beginning the experiences themselves, there may need to be more preparatory sessions and even setting adjustments for those new going into VR due to individual sensitivities.

Unfortunately, this experience drove both students to leave the VR sessions midway. It underlines the increasing significance of introducing more robust user orientation and safety nets for beginners to adverse impacts as well privilege ease-of-use.

Despite initial testing sessions aimed at student preparation, the persistence of motion sickness represents an area that requires further research. This brought the idea that the future research should focus on developing more personalized VR experiences that are adjusted to individual thresholds for motion sickness and examine comprehensive pre-use orientations.

6. Performance Metrics

The data revealed that students using VR notably improved their understanding and retention of computer hardware concepts compared to those engaged in conventional learning settings.

6.1 Learning Outcomes Comparison

Quantitative assessment: Students who used the VR app learned academic theories quicker and applied them through practical exercises with more confidence. Pre-and post-test comparisons revealed a dramatic increase in test scores, with the average score regarding hardware assembly and troubleshooting tasks improving by 20% for students using VR. Indeed, it indicates that being in a VR environment drives better comprehension for challenging topics - leading to increased cognitive retention and applicability.

6.2 Skill Acquisition

5 Students out of 7 indicated an increased confidence in recognizing, installing and troubleshooting computer parts within the VR environment. The VR system offers hands-on computer assembly and real-time feedback which is much harder to ghost in the classroom than it is on VR. Using the VR, students could practice their skills multiple times in a safe environment with less errors and gain better understanding of standard operating procedures when building computers.

The conclusion is well supported by the data that VR can indeed make education far more interesting and informative which simply means a hands-on learning experience. They can learn by doing, which enhances skills and increases readiness for performing real-world job functions in contrast to other passive learning methodologies.

7. Comparative Analysis

This project highlights distinct advantages and challenges associated with each methodology.

7.1 VR vs. Traditional Methods

The major advantage of using VR in education is that it can provide an immersive, interactive learning experience where students are able to interact with 3D content as opposed to reading about these subjects on paper. This allowed students to interact with computer components as if they were putting components together in person, demonstrating how such an assembly process works. The novelty and high-tech factor of VR made it fun for students to use, leading to better engagement and more motivation.

At the same time, it raised some issues with VR too. The single most important challenge was the high cost of initial investment and ongoing support for stably functioning VR equipment. A potential barrier to entry in deployment within institutions. Furthermore, the learning curve to learn how to use VR technology comfortably was high. For a few students, the new interface did not suit them and would only hinder their learning if it was not solved through proper orientation and training.

7.2 Instructor Observations

While VR can mimic many of the steps in the computer assembly process, the instructor noted that the process was not perfect and had limitations. Traditional methods, in contrast, are about hands-on experiences with hardware and are still important to many educators when deeper learning is crucial. However, instructors reported that students made the most of their class time and were not afraid to venture into an unproductive VR environment.

Comparative analysis shows that VR is suitable for basic learning and practice, but weak against more advanced skills, where traditional methods are better. Therefore, like the similar research of Cai et al. (2022), we think that combining both VR and traditional learning in one approach provides the best learning environment and allows students to benefit from the immersive experience of VR and the hands-on practice of traditional methods. This combination increases the overall learning results by using the strengths of each method together.

8. Challenges and Improvements

Overall, a number of key concerns emerged from the student and instructor feedback that may improve upon both VR platform learnability as well effectiveness.

One of the many problems identified were that some VR simulations lacked a sense of realism. Students however remarked that the simulations were not true to life when it came to computer assembly and lacked complexity while also lacking tactile feedback which is very important in learning hardware assemblies. Several students had direct difficulties even just getting around within the VR space itself, and others experienced system crashes that booted them out of the experience. On top of all that, we found the motion sickness for two students who were unable to continue through a full session.

To address these challenges, several improvements are suggested:

- **Enhance Simulation Realism:** Improving the VR to have higher resolution and more complex simulation scenarios especially in real-world conditions would make a significant difference. For example, this could integrate tactile feedback mechanisms that give a physical sensation of the virtual actions.
- **Improve User Interface and Stability:** Making the VR interface more user-friendly could allow students to navigate easier, which in turn minimizes learning curves for users. This could be with application support such as frequent software updates and bug updates that can improve stability, performance, which in turn make the VR experience smoother and more reliable.
- **Address Motion Sickness:** Some students may develop motion sickness when using VR, so the introduction of pre-session orientation and acclimatization tasks would allow students to adapt themselves. Furthermore, these staple VR experiences should at least introduce adjustable settings within the system that would allow users to tailor their experience based not only on what input paradigms they prefer but how likely they are to endure motion sickness in a given application.
- **Feedback Mechanisms:** Enabling feedback mechanisms that can alert instructors to student difficulties during VR sessions in real-time to provide immediate intervention and support for a better learning experience.

9. Future Prospects

The current study lays the groundwork for significant advancements and broader applications of VR in education and beyond. Here are some key future prospects:

- **Scalability and Future Applications:** The early success of the VR application in computer hardware assembly teaching can be a template for similar difficult subjects. The project is not limited to covering only computer-science-related topics, as the VR curriculum could be expanded upon different kinds of simulations (e.g. networking setups or software engineering processes), addressing a wider variety of disciplines making it even more useful and accessible for other courses hours per week. Additionally, testing whether VR training could be further scaled to fields of study (e.g. medical students/architects/industrial engineers) would take advantage of its immersive and hands-on learning environment.

- **Research and Development:** Obviously, more R&D is needed to improve the VR learning experience. This can be the incorporation of technology to enhance how realistic and interactive VR simulations feel. Research can also centre around the pedagogical issues of VR learning, such as creating curriculum-specific content in VR for effective teaching and way to teach using a 360-degree game. Further research into the long-term impacts of VR learning on student outcomes will provide a more complete overview of its efficacy and potential areas for growth.
- **Integration of Advanced Technologies:** The integration with other advanced technologies could make the learning environment more efficient and effective through VR. For example, integrating artificial intelligence (AI) will enable adaptive learning environments more able to personalize an individualized experience of the same simulations according to different student needs. Hybrid models that combine AR & VR further extend the virtual simulations with interactive elements and contextual information.
- User Accessibility and Comfort: Future projects should look to the user-accessibility and comfort of VR technologies as well. This includes solutions for motion sickness, and better VR design so that equipment is more ergonomic. Being able to adjust VR setups for different physical needs and preferences will make the technology more inclusive, making it appealing on a larger scale.

10. Conclusion

The research conducted on the integration of Virtual Reality (VR) technology into the computer science curriculum at GUtech has provided valuable insights about VR as an educational tool. The results illustrate how VR can enhance the teaching of activities like computer hardware assembly and troubleshooting by providing immersive simulations that actively engage students in intricate subjects; for instance, 5 out of 7 participants reported that VR significantly improved their understanding and engagement. But the study also highlights where further improvements are necessary, including in simulation realism; user interface design and usability; and user comfort - health issues around VR such as motion sickness.

Encouraging results for VR, being engaging and motivating hardly surprising that this is a successful approach when it comes to teaching complex technical content. However, increase realism and stability of VR environments for learning purposes have been suggested. Also we discussed that virtual reality situated as a means to aid in traditional forms of practice but not replace them. This is why educators suggested to combine the power of VR with conventional teaching methods to deliver a more holistic learning experience that works.

Collectively, this research contributes to wider discourse in educational technology by demonstrating that VR can enhance learning. This underscores the importance of ongoing efforts to better design and optimize VR learning environments. Further endeavours could be featured on advancing VR technology for educational uses in terms of accessibility and usability as well effectivity located in different scholastic surroundings. Furthermore, a limitation of this study is the relatively small sample size, which may affect the generalizability of the findings; future research should involve a larger and more diverse group of participants to validate and expand upon these results.

References

1. (2018). Application of vr virtual reality in navigation teaching.. https://doi.org/10.23977/iceccs.2018.021
2. Ahmed, A., Maqsood, M., Saif, H., & Salman, A. (2012). Affordable interactive virtual reality system for the dynamic hip screw surgery training in vitro.. https://doi.org/10.2316/p.2012.779-025
3. Balistreri, M. and Casile, F. (2019). Care robots: from tools of care to training opportunities. moral considerations., 18-25. https://doi.org/10.1007/978-3-030-23884-1_3
4. Bjerrum, A., Hilberg, O., Gog, T., Charles, P., & Eika, B. (2013). Effects of modelling examples in complex procedural skills training: a randomised study. Medical Education, 47(9), 888-898. https://doi.org/10.1111/medu.12199
5. Corre, F., Hoareau, C., Ganier, F., Buche, C., & Querrec, R. (2014). A pedagogical scenario language for virtual learning environment based on uml meta-model - application to blood analysis instrument.. https://doi.org/10.5220/0004845803010308

6. Cui, X. and Diao, J. (2020). Design of human-computer interactive fire extinguishing training system based on virtual reality technology., 124-136. https://doi.org/10.1007/978-3-030-51103-6_11
7. Ghai, S. and Ghai, I. (2019). Virtual reality enhances gait in cerebral palsy: a training dose-response meta-analysis. Frontiers in Neurology, 10. https://doi.org/10.3389/fneur.2019.00236
8. GÜRBÜZ, E. and Taş, M. (2023). The effect of virtual reality training on heading skills in 12-13 years old child footballers. Spor Bilimleri Araştırmaları Dergisi, 8(1), 43-56. https://doi.org/10.25307/jssr.1172607
9. Palter, V. and Grantcharov, T. (2010). Simulation in surgical education. Canadian Medical Association Journal, 182(11), 1191-1196. https://doi.org/10.1503/cmaj.091743
10. Portelli, M., Bianco, S., Bezzina, T., & Abela, J. (2020). Virtual reality training compared with apprenticeship training in laparoscopic surgery: a meta-analysis. Annals of the Royal College of Surgeons of England, 102(9), 672-684. https://doi.org/10.1308/rcsann.2020.0178
14. Rodrigues-Baroni, J., Nascimento, L., Ada, L., & Teixeira-Salmela, L. (2014). Walking training associated with virtual reality-based training increases walking speed of individuals with chronic stroke: systematic review with meta-analysis. Brazilian Journal of Physical Therapy, 18(6), 502-512. https://doi.org/10.1590/bjpt-rbf.2014.0062
15. Simonova, O., Barashyan, V., Gampartsumov, A., & Khlebnikova, M. (2021). The application of reality simulators for improving the education quality at universities. E3s Web of Conferences, 273, 12081. https://doi.org/10.1051/e3sconf/202127312081
19. Yong-ke, C. (2017). Research on the construction of virtual reality simulation system for psychological stress training. Psychology and Behavioral Sciences, 6(2), 30. https://doi.org/10.11648/j.pbs.20170602.13
20. Zhang, Y. and Tsai, S. (2021). Application of adaptive virtual reality with ai-enabled techniques in modern sports training. Mobile Information Systems, 2021, 1-10. https://doi.org/10.1155/2021/6067678
21. et.al, S. (2021). Effects of military training based on the virtual reality of army using ahp method. Turkish Journal of Computer and Mathematics Education (Turcomat), 12(6), 551-556. https://doi.org/10.17762/turcomat.v12i6.1978
22. Tang, S., Buentello-Montoya, D., & Pan, X. (2020). Impact of virtual reality use on the teaching and learning of vectors. Frontiers in Education. https://doi.org/10.3389/feduc.2022.965640
23. Luo, H., Li, G., Feng, Q., Yang, Y., & Zuo, M. (2021). Virtual reality in K-12 and higher education: A systematic review of the literature from 2000 to 2019. Journal of Computer Assisted Learning, 37(2). https://doi.org/10.1111/jcal.12538
24. Cipresso, P., Chicchi Giglioli, I. A., Alcañiz Raya, M., & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. Frontiers in Psychology, 9, 2086. https://doi.org/10.3389/fpsyg.2018.02086
25. Talespin. (2023). The Impact of a Virtual Reality Learning Environment in Education. Retrieved from https://www.talespin.com
26. LaViola Jr, J. J. (2000). A discussion of cybersickness in virtual environments. ACM SIGCHI Bulletin, 32(1), 47-56. https://doi.org/10.1145/333329.333344
27. RWTH Aachen University. (n.d.). Virtual reality in education. Retrieved, from https://vredu.lfi.rwth-aachen.de/en/
28. Bailenson, J. (2018). Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do. W.W. Norton & Company.
29. Clark, R. C., & Mayer, R. E. (2016). e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning. Jossey-Bass.
30. Yin, R. K. (2014). Case Study Research: Design and Methods (5th ed.). SAGE Publications.
31. Dodevska, S., & Mihic, S. (2018). Virtual and augmented reality in science education. Frontiers in Education.
32. Cai, L., Cao, S., Yi, W., & Li, H. (2022). Virtual reality based simulation for linear control experiments. Proceedings of the 2022 International Conference on Educational Innovation and Multimedia Technology (EIMT 2022), 321-330. https://doi.org/10.2991/978-94-6463-012-1_36