Recommendations for VR Developers

The first set of recommendations addresses VR developers who aim to develop experiential learning applications. To derive these recommendations, we started with a systematic literature review and market analysis of VR applications in higher education. In these studies, we identified current application scenarios and commonly used design elements to achieve different learning outcomes. Afterward, we conducted design thinking workshops and focus groups with interdisciplinary groups of lecturers and students. The participants highlighted experiential learning applications as a promising application area for VR in higher education. Based on the results, we derived the following six design principles for developers of VR-based experiential learning applications:

1. **Technical and Pedagogical Considerations:** Identify both the unique technical opportunities of VR and pedagogical requirements.
2. **Knowledge Contextualization:** Enable students to apply theoretical knowledge in realistic job scenarios.
3. **Realism and Interactivity:** Provide a realistic and interactive virtual environment to afford concrete experience and active experimentation.
4. **Integration:** Cycle between concrete experience and active experimentation activities in VR and reflective observation and abstract conceptualization activities in class.
5. **Psychological Comfort:** Provide students with the opportunity to practice skills in private spaces before allowing other students to join their learning space.
6. **Gamification:** Embrace the gaming character of VR to increase learning motivation.

Recommendations for Universities

The second set of recommendations addresses universities. We derived these recommendations based on a survey among educators across Europe. This survey revealed that the current infrastructure and support provided by universities hinders the distribution of VR. Based on these results, we derived the following five recommendations for universities:

1. **Funding Opportunities:** Provide lecturers with accessible funding opportunities to support interested teachers in buying equipment.
2. **Experimentation Opportunities:** Set up a central VR lab that allows lecturers and students to try different types of VR hardware and applications.
3. **Technological Infrastructure:** Set up a fundamental technological infrastructure (e.g., stable Wi-Fi, computers, and laptops) before investing into VR equipment and other advanced technologies.
4. **VR Training:** Offer e-learning courses informing lecturers about general benefits of VR (e.g., better knowledge retention) and specific examples of promising application areas in their field.
5. **VR Support:** Hire IT helpdesk staff who can offer technical support to lecturers and answer questions about VR-related issues.

Recommendations for Lecturers

The third set of recommendations is aimed at university teachers. We derived these based on VR experiments in real courses and a student survey. The project partners at University of Agder (Prof. Dr. Tim A. Majchrzak) introduced 360° videos in a course on Information Security Management. Students immersed themselves in hacking scenarios to improve their skills in security need and requirement analysis. The Informations Systems Institute at University of Liechtenstein (Prof. Dr. Jan vom Brocke) developed an educational VR game. Students played the VR version of "Who-am-I" to memorize theories, concepts, and methods in a fun way. The research group at University of Duisburg-Essen (Prof. Dr. Stefan Stieglitz) offered an interactive VR lecture. Students learned through online discussion and group work experiencing a sense of real social interaction. Teaching experiences and student feedback resulted in the following ten recommendations for lecturers:

1. **Teaching Concept:** Adapt the teaching concept and learning materials to make the most of VR. Do not simply present slides in VR but use collaborative or experiential learning concepts.
2. **Testing:** Try different VR apps with colleagues before using them with students to find the most appropriate app for your course.
3. **Accessibility:** Provide students with a standalone VR headset (e.g., Oculus Quest) they can use at home and silicone covers to ensure hygienic use of the device. Choose an application that supports multiple platforms in case health conditions prevent students from using VR (e.g., epilepsy, wearing a pacemaker).
4. **Preparation:** Prepare the VR environment carefully (e.g., provide whiteboard templates), so that students do not have to waste time on administrative tasks.
5. **Tutorial:** Provide students with a short guide enabling them to set up the VR headset and install the selected application before the first lesson. Prepare a short introduction session where students can get familiar with the VR application and the functionality (e.g. how to navigate in virtual meeting rooms) before starting the real lecture.
6. **Short Experiences:** Keep lectures short as VR glasses are not very comfortable to wear for a long time and to avoid motion sickness.
7. **Small Groups:** Use VR with smaller groups to avoid distractions and technical problems (maximum 10 students).
8. **Physical Space:** Make sure students have enough space free of obstacles to move freely without risk of injury (at least 2m x 1.5m).
9. **Space for Fun:** Give students enough space for fun activities to increase learning motivation and encourage regular attendance (e.g., allow students to decorate the VR environment for Christmas).
10. **Follow-Up:** Take screenshots and share these with students to document the results and enable them to learn for the exam.

See project publications for further results

Radianti, J., Majchrzak, T. A., Fromm, J., Stieglitz, S. & Vom Brocke, J. (2021). Virtual Reality Applications for Higher Education: A Market Analysis. In *Hawaii International Conference on System Sciences (HICSS)*, Maui, Hawaii.

Radianti, J., Majchrzak, T. A., Fromm, J. & Wohlgenannt, I. (2019). A Systematic Review of Immersive Virtual Reality Applications for Higher Education: Design Elements, Lessons Learned, and Research Agenda. *Computers & Education*, 147.

Wohlgenannt, I., Fromm, J., Stieglitz, S., Radianti, J. & Majchrzak, T. A. (2019). Virtual Reality in Higher Education: Preliminary Results from a Design-Science-Research Project. In *International Conference on Information Systems Development (ISD)*, Toulon, France.