Maastricht University

EDLAB

DEX LAB

VR-ENHANCED PBL

EDUCATIONAL REPORT

ROBERTA DI PALMA (SBE)
WALTER JANSEN (EDLAB)

CONTENT

PREFACE

Picture this scenario

A group of students gathers in a PBL classroom tasked with tackling an environmental issue affecting the Amazon rainforest. Despite their best efforts, they need help to fully grasp the complexity of the problem and feel disconnected from the situation. In this context, VR technology can enhance the learning experience by providing a simulated environment for deeper exploration of the subject matter.

By integrating VR into the PBL classroom, students can immerse themselves in simulated environments resembling real-life situations or explore abstract concepts more tangibly. In the case of our environmental scenario, students can virtually visit the affected area, analyze the situation from multiple perspectives and disciplines, and even test their proposed solutions in a risk-free environment.

This immersive experience can foster a deeper understanding of the problem and inspire creative, out-of-the-box thinking. Beyond deeper understanding, VR offers opportunities for skill development that may complement or extend beyond traditional teaching methods. By providing students with a safe space to practice and develop various professional and academic skills, such as public speaking, empathy, and teamwork, VR can enhance their overall learning experience and help them become well-rounded individuals.

Virtual Reality (VR) is rapidly impacting various professional and educational domains. Research shows that VR is a powerful learning tool that augments the motivation and performance of higher education students (Loureiro et al., 2020; Majchrzak et al., 2022; Halvorson et al., 2011; Cowan & Ketron, 2019). Integrating VR into Maastricht University's student-centered Problem-Based Learning (PBL) setting can create more ingenuity and diversity in educational content and formats.

The project explores how VR's immersive experiences align with the principles of situated cognition theory (Brown et al., 1989). It enables learners to undertake experiences otherwise not feasible in reality, such as virtual explorations and training (Chien et al., 2020). This approach facilitates a high level of interactivity and involvement, which is instrumental in PBL for fostering motivation and collaborative problem-solving (Chen et al., 2021; Abdullah et al., 2019).

The inherent flexibility of PBL pedagogy lends itself to creating and incorporating diverse learning formats, effectively addressing students' varying needs and preferences. This adaptability fosters motivation and participation and encourages active learning and critical thinking, which are central to the PBL approach.

By embracing the versatility of PBL and its core learning principles, 'constructive, contextual, collaborative, and self-directed' (CCCS), educators can provide students with various learning experiences. This, in turn, contributes to a more engaging and inclusive learning environment where students are empowered to take charge of their education and develop essential problem-solving skills. Still, diversifying the PBL classroom can be challenging for educators. The introduction of VR technology at UM aims to enrich the learning experience, offering students alternative scenarios for engaging with course material.

"VR is a powerful learning tool that augments the motivation and performance of higher education students."

Purpose of Report

This report is a Maastricht University Centre for Teaching & Learning (EDLAB) production. We aim to offer recommendations based on successfully implemented pilot projects across various UM faculties. This report explores the benefits of incorporating VR technology into PBL classrooms, presenting a developed framework and discussing two specific activities: apps for presentation skills training and 360-degree videos. The learnings and best practices from the VR-Enhanced PBL project will be shared, covering both didactic and technical aspects. By the end, readers will have a deeper understanding of how VR can break the routine in PBL classrooms and offer a fresh, engaging approach to learning that can significantly enrich the educational experience for students. Furthermore, this report contains a guide with instructions for teaching staff to apply VR within their education.

This project could not have been realized without the pro-activity, expertise, and enthusiasm of DEXLab (SBE), particularly Roberta Di Palma, who co-coordinated the project with EDLAB Sr. coordinator Walter Jansen. EDLAB is furthermore grateful for all the input it has received and wants to thank the UM colleagues involved in the process: Natalja Sarneel (FPN), Dalena van Heugten-van der Kloet (FPN), Nynke de Jong (FHML), Stefan Jongen (FSE), Anna-Lena Hoh (UB), Gonneke van Luttikhuizen (UB), Aodhán Kelly (FASOS), Thomas Frissen (FASOS), Emilie Sitzia (FASOS), Josje Weusten (FASOS), Dominik Mahr (SBE), Jonas Heller (SBE) and Tim Hilken (SBE). Lastly, a big thank you to Mariska Geerts, DEXLab student intern, for designing the layout of this report.

VR-ENHANCED PBL: PROJECT SUMMARY

VR as a Pedagogical Tool: Integrating VR into PBL classrooms at Maastricht University represents a strategic alignment between cutting-edge technology and established educational principles. By embedding VR within the framework of Constructive, Contextual, Collaborative, and Self-Directed (CCCS) learning, we underscore our commitment to not merely adopting new technologies but enhancing the depth and quality of learning experiences in a meaningful way.

Project Deliverables

Rooted in constructivist learning philosophy, this project explores the integration of digital education technologies at UM by exploring how VR can be woven into PBL. It sought to actualize two prominent VR practices in education across UM faculties:

1. Training presentation skills in VR
2. Using 360-degree videos to enhance the PBL learning experience

To this end, the project has articulated several key deliverables.

Note: This project was guided by an interdisciplinary PhD in digital education with a focus on fostering service innovation.

1. VR Integration Guidelines

Produce guidelines and practical examples for effectively integrating VR in PBL for presentation and academic skills training.

2. Network of Practice

Foster a UM-wide network connecting VR users, expertise, resources and digital labs to exchange VR-enhanced PBL practices, organised in a self-regulatory way.

3. UM Wide Event

Conduct a university-wide event to educate on VR use and promote digital labs, spurring VR adoption in PBL.

4. Research Expansion

Advance VR in PBL research by establishing "VR Experts" across faculties to contribute to the scientific foundation.

VR and CCCS Principles: A Synergistic Relationship

Relationship: The adoption of VR in PBL should be designed to complement and enhance the CCCS principles, ensuring its use is purposeful and pedagogically sound.

Constructive Learning: VR enables students to actively construct knowledge by immersing them in experiences that integrate with and expand upon their existing understanding, fostering a deeper connection with the material.

Contextual Learning: Through realistic simulations, VR provides rich, relevant contexts for learning, allowing students to explore complex concepts in environments that mirror real-world situations, enhancing comprehension and application of knowledge.

Collaborative Learning: VR's shared virtual environments promote collaboration, enabling students to work together on projects or simulations, thus supporting PBL's emphasis on learning as a social process.

Self-Directed Learning: By offering a range of interactive experiences, VR supports self-directed exploration, allowing students to navigate their learning journeys within immersive environments, fostering autonomy and engagement.

Benefits of VR in PBL

Integrating VR into PBL offers multifaceted benefits, aligning closely with Maastricht University's educational philosophy:

1. Enhanced Realism & Engagement

VR brings subjects to life, providing tangible experiences that deepen understanding and foster engagement.

2. Empathy & Perspective

By experiencing situations from multiple viewpoints, students develop empathy and a nuanced understanding of diverse perspectives.

3. Accessiblity & Inclusivity

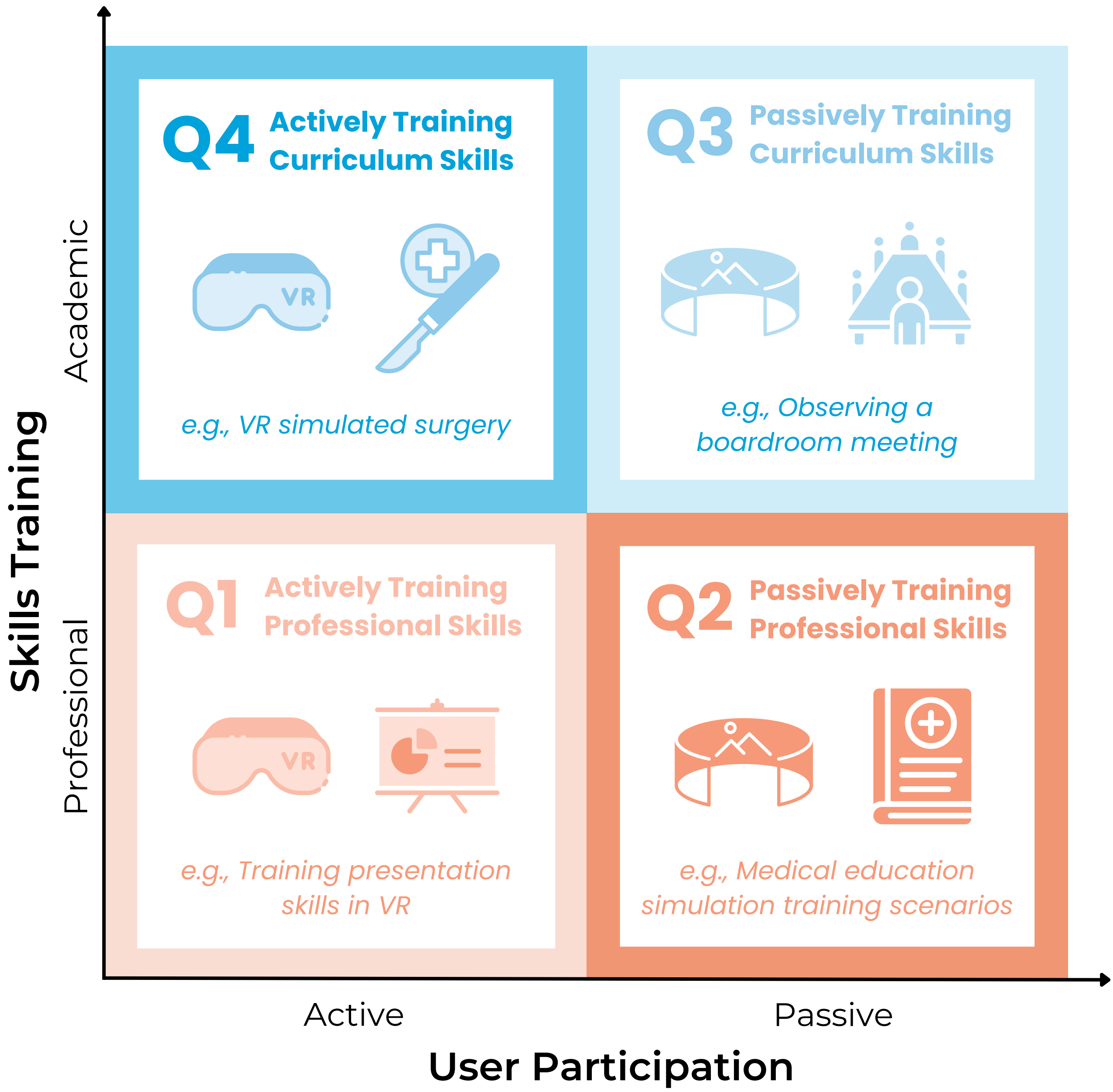
VR makes experiential learning accessible to all students, breaking down physical, financial, and geographical barriers to education.

4. Bridging Theory & Practice

VR enables the practical application of theoretical know-ledge, enhancing skill development and preparing students for real-world challenges.

Type of VR Activities

This 2x2 matrix classifies VR activities along two axes: user participation (active vs. passive) and skill training focus (professional employability vs. academic curriculum skills). It guides the selection of VR experiences in education, matching the type of interaction with the intended learning outcome.



Project Findings

Based on seven pilots across UM faculties, the project findings can be summarized as follows:

Enhanced Learning Experience: Preliminary findings suggest that VR significantly enriches the PBL environment. By offering immersive and interactive experiences, VR facilitates a deeper understanding of complex subjects and has been shown to increase student motivation and engagement, especially in areas where conventional teaching methods are less effective.

VR is complementary to the learning experience: The use of VR in PBL enriches the student learning experience yet cannot replace conventional educational design. With its current functionalities and taking the adaptivity of the organization into account, VR has to be regarded as an 'add-on.'

Diverse Applications: VR has been utilized effectively for presentation skills training and 360-degree video sessions. These applications demonstrate VR's adaptability across various disciplines and learning objectives, catering to different educational needs.

Technical and Pedagogical Support: The importance of robust technical support and pedagogical guidance for educators integrating VR into their curriculum is a key finding. This support is crucial for VR's effective and smooth implementation in PBL.

Reservations About VR Integration: Despite the positive outcomes, there are reservations from both students and teachers regarding VR integration. Concerns primarily revolve around the technical challenges and the learning curve associated with using new technology, as well as ensuring that VR adequately adds value rather than distracts from the learning activity.

Stratetgic Considerations for VR Integration

The rationale for incorporating VR into PBL transcends the pursuit of innovation for its own sake. It is grounded in a strategic effort to enrich and diversify educational approaches. This proposed integration of VR into PBL marries innovation with core educational principles, embodying a forward-thinking approach. While VR can align with the CCCS principles to enhance educational quality, it is essential to approach its integration with caution. The implementation is time-intensive and demands thorough pre-planning. Despite these challenges, our pilots have affirmed VR's potential to yield positive outcomes, making the effort to incorporate this technology a worthwhile endeavor for the complexities of modern education.

Outcomes

Based on these findings, the project team has developed guidelines for implementing VR-enhanced PBL formats at UM. Additionally, it has provided a theoretical and empirical basis for using VR in education and nurtured university-wide engagement in adopting VR-enhanced PBL methodologies. In our search for existing VR initiatives, the project team has established an interconnected web of digital labs and assisted in realizing VR-based presentation skills training and 360-degree videos across faculties. The resulting synergies and shared learning experiences have benefited the entire academic community—students and educators alike.

Report Outline

In synthesizing the project experiences and outcomes, this report delivers an overview of insights and established best practices, laying the groundwork for expanding VR expertise and establishing technologically advanced laboratories within the UM faculties. This project’s output aligns with UM's strategic vision of technology-enhanced education in classrooms and establishing "specially equipped spaces for digital collaboration" (Maastricht University, 2021, p. 17-18). To make the project outcomes appeal to numerous educational stakeholders at UM, the report is structured along a conceptual part and a practical guidelines part that can also be used independently from each other.

1. VR AND PBL

1.1. Background

As an immersive technology, VR simulates a three-dimensional, interactive environment (Hew & Cheung, 2010). It allows users to experience a simulated world through specialized hardware like head-mounted displays (HMDs) and controllers (Shu et al., 2019). This technology finds practical application in enhancing educational methodologies by offering an experiential learning platform (Asad et al., 2021).

In the context of PBL, VR can be used as a cognitive and skill development tool. It supports PBL's focus on student-centered inquiry and problem-solving by simulating real-world scenarios (Chen et al., 2021). For example, VR's integration has facilitated experiential learning at the School of Business and Economics (SBE) within Maastricht University. Here, VR simulations are used to enable students to assume various professional roles, developing empathy and understanding of different perspectives. These simulations offer more than visual experiences; they encompass interaction, decision-making, and analytical thinking. Integration of VR within PBL classrooms presents multiple benefits.

Key Educational Benefits of VR in PBL

Enhanced Realism: VR's ability to simulate realistic environments is crucial in fields where real-world experience is difficult to replicate in a traditional classroom setting.

Interactive Learning: VR's interactive nature engages students more deeply than traditional learning methods. This active engagement can lead to better problem-solving skills and a deeper understanding of the subject matter, as students are not just passive recipients of information but active participants in the learning process.

Empathy and Perspective: VR enables students to experience situations from multiple perspectives, which can be particularly beneficial in fields like social sciences, psychology, and cultural studies. This can foster empathy and a better understanding of diverse viewpoints, which are critical skills in an increasingly interconnected world.

Theoretical and Practical Synergy: VR bridges the gap between theoretical knowledge and practical application. This is especially important in PBL, where the focus is on solving real-world problems. VR allows students to apply theoretical knowledge in simulated scenarios, thus enhancing learning effectiveness.

Accessibility and Inclusivity: VR can make certain types of experiences more accessible to students who might not have the opportunity to experience them in real life due to geographical, financial, or physical constraints.

From a pedagogical standpoint, the use of VR aligns with several learning theories. Constructivism and the theory of situated cognition are particularly relevant, as VR enables learners to build knowledge through contextualized, interactive experiences (Marougkas et al., 2023). Maastricht University's integration of VR into PBL reflects a commitment to digital innovation and addresses the growing need for digital proficiency in higher education.

Implementing VR in PBL requires a structured approach encompassing curriculum design, technology integration, and pedagogical strategy (Pellas et al., 2021). It involves aligning VR content with learning objectives and redefining the educator's role to focus more on facilitating learning experiences (Schmidt et al., 2023). The VR-enhanced PBL initiative represents an innovative educational step, aiming to enhance cognitive engagement and equip students with skills essential for the modern workplace.

1.2 VR and the CCCS Principles

PBL at Maastricht University is guided by four key learning principles—constructive, contextual, and self-directed learning (CCCS) (Bastiaens, & Bastiaens, 2021). This section shows how VR technologies potentially impact these principles and, ultimately, how VR can enrich the PBL learning experience.

1. Constructive Learning

Principle Description: Constructive learning suggests that learners build new knowledge by integrating their experiences with what they already know. It emphasizes active learning through experience and reflection rather than passive reception of information.

Connection to VR: Educational experiences in VR transform the student's role. Instead of being passive recipients of information, students become active participants in their learning n fact, in VR, students can manipulate virtual objects, make decisions, and see the immediate consequences of their actions, which promotes deeper understanding and retention of knowledge.

2. Contextual Learning

Principle Description: Contextual learning involves situating the educational content within the context of real-world examples and scenarios. It is about making the learning material relevant to students' practical applications outside the classroom.

Connection to VR: VR immerses students in highly realistic simulations of real-world environments, allowing them to apply theoretical knowledge in a virtual yet practical context. . For instance, medical students can perform virtual surgeries, giving them a feel for the operating room without the risks associated with real-life procedures.

3. Collaborative Learning

Principle Description: Collaborative learning is based on learning as a social activity. Working together, students can achieve more by sharing knowledge, debating concepts, and supporting each other's learning processes.

Connection to VR: VR can facilitate collaboration through shared virtual spaces where students can work on projects or solve problems despite physical distances. This promotes teamwork and prepares them for the increasingly digital and remote workspaces of the future.

4. Self-directed Learning

Principle Description: Self-directed learning encourages students to take initiative, make decisions about their learning processes, set goals, and evaluate their progress. It is about fostering independence and the ability to learn autonomously.

Connection to VR: VR facilitates self-directed learning through interactive scenarios that allow students to practice independently. Within the VR environment, students can select their learning paths and make decisions that shape their experiences, all without the need for a tutor or educator.

1.3. Types of VR Activities in Education

With the conceptual potential of VR in PBL education in mind, introducing VR into the PBL classroom offers a multifaceted landscape for educational activities. To classify the type of use of VR in education, we introduce four quadrants, each representing a distinct type of **interaction** (user participation) and **learning focus** (skills training) (Figure 1).

As we navigate through the quadrants, we will explore how VR supports and amplifies the four central CCCS principles of PBL. Each quadrant, whether it involves active or passive participation and focuses on professional or curriculum skills, leverages VR to create immersive and impactful learning experiences that align with these principles.

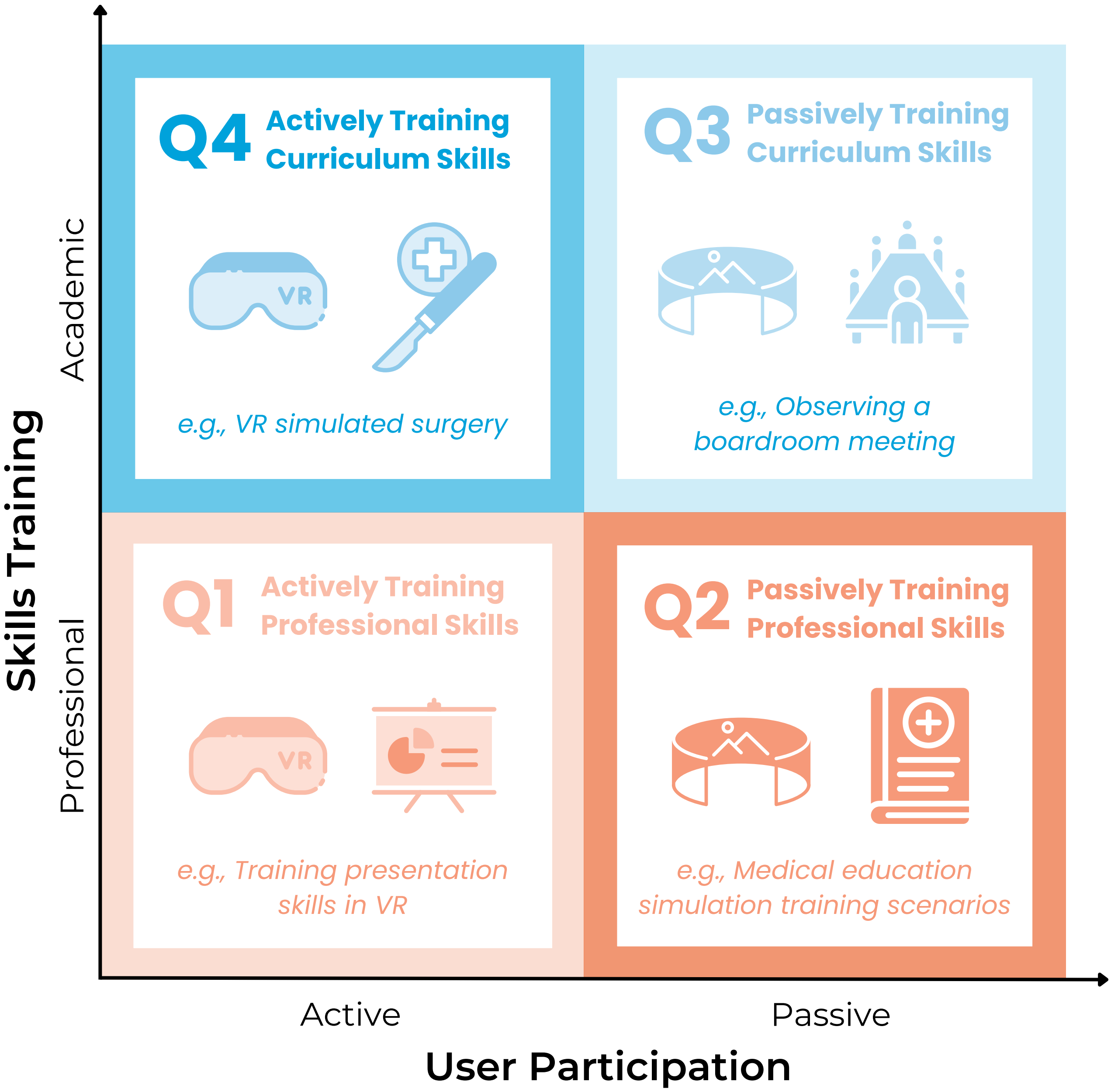


Figure 1: VR Educational Activities Framework

Quadrant 1: Actively Training Professional Skills

This quadrant is characterized by **active student engagement** with VR to develop employability-related **professional skills**. It emphasizes students participating in real-life professional scenarios actively applying their skills and knowledge in a controlled, virtual environment that mirrors the professional world.

Quadrant 2: Passively Training Professional Skills

In this quadrant, students are less active and more observant. They learn by watching and reflecting on VR scenarios that simulate professional environments. This **passive engagement** provides a safe space to understand **professional conduct** and processes without direct interaction.

Quadrant 3: Passively Training Curriculum Skills

Here, the focus shifts to **academic skills** within the curriculum, with students passively **immersed in VR experiences** that relate directly to their fields of study. The experiences are designed to supplement and enrich the curriculum by providing a contextual backdrop from which students can observe and learn.

Quadrant 4: Actively Training Curriculum Skills

The final quadrant represents an **active approach** to applying **curriculum knowledge** within VR. Students actively engage with VR simulations that are tied directly to their area of study, such as performing a virtual lab experiment or a simulated medical procedure, thus enabling them to apply theoretical knowledge tangibly.

With the quadrant definitions clarified, we now present a structured overview that illustrates the interplay between each quadrant's activities and the CCCS principles.

Table 1 on the next page is a practical guide for educators to visualize and plan how to integrate VR into their PBL curriculum, ensuring that each activity is purposefully tailored to enhance specific learning outcomes.

Table 1: Overview of VR Activities per PBL Principle

Quadrant 1		
Example CCCS Principle	**Example VR-practises**	**Assessment/ Reflection Tool**
Constructive Learning	• Interactive VR lab for science subjects • Virtual archaeological dig for anthropology students • VR communication skills training	AI-generated feedback from the system

Quadrant 2		
Example CCCS Principle	**Example VR-practises**	**Assessment/ Reflection Tool**
Contextual Learning	• Virtual field trips to geographical locations • Simulated business scenarios for management students	Group discussion and analysis

Quadrant 3		
Example CCCS Principle	**Example VR-practises**	**Assessment/ Reflection Tool**
Collaborative Learning	• VR observation of a negotiation process • Virtual role-playing for conflict resolution training • Virtual museum tour for history students	Group Interactive quiz or discussion

Quadrant 4		
Example CCCS Principle	**Example VR-practises**	**Assessment/ Reflection Tool**
Self-directed Learning	• Simulated chemistry experiment in VR • Virtual language learning environments • Independent virtual reality research projects of e.g., interactive environments for Bachelor or Master Thesis.	Self-assessment checklist, e-portfolio or grading rubrics

1.4. VR in different PBL Formats

At UM, we incorporate a range of PBL formats to engage students in active learning (Bastiaens, 2017). These include, but are not limited to, the PBL 7-step process, flipped classrooms, challenge-based learning, and student-led facilitation (Moust et al., 2005; de Jong et al., 2022). Integrating VR technology in these formats can provide an additional tool for enhancing learning experiences. For example, Table 2 below provides an overview of the potential application of VR within common PBL formats at UM.

Table 2: Examples of VR in Different PBL Formats

PBL Format	**Description**	**Integration of VR**
1. PBL 7-Step Format	Students work through a sequence of stages to explore and solve problems.	VR can provide an immersive context for problem-solving. For example: • Step 1 (Clarifying terms and concepts): VR for visual representations of concepts. • Step 3 & 5 (Brainstorm and Formulating learning objectives): VR to explore perspectives and identify inquiry areas.
2. Flipped Classroom	Involves students engaging with pre-recorded lectures or materials at home, followed by in-class discussions and activities.	VR can offer interactive learning materials for home study, fostering deeper understanding. • In-class VR simulations can facilitate collaboration and critical thinking.

Table 2: Examples of VR in Different PBL Formats (Continued)

PBL Format	Description	Integration of VR
3. Challenge-Based Learning	Students work in groups to address real-world challenges, collaborating with businesses or societal stakeholders and engaging with community or societal issues.	VR can be used to simulate both business/civic environments and real-world contexts affected by specific challenges. For instance: • Students might collaborate with companies to develop industry/societal solutions. • Use VR to understand and address community issues, such as environmental concerns or urban planning.
4. Student-Led Facilitations	Students lead and facilitate PBL sessions within tutorial groups.	VR enhances these facilitations by creating realistic learning experiences. • It can visually present complex concepts • Provide immersive simulations, • Foster collaboration in virtual spaces • Offer opportunities for peer feedback and self-reflection.

1.5. VR potential across disciplines

VR is a versatile educational tool in the context of diverse PBL formats used at UM. Its ability to adapt to different academic needs showcases its relevance across various disciplines (Radianti et al., 2020). While VR's role in enhancing specific PBL strategies is outlined in Table 2, its applications extend to broader educational objectives within different faculties. This adaptable nature of VR allows for tailored educational experiences, meeting the unique requirements of each discipline.

The following table, Table 3, shows the practical ways VR can be integrated into different areas of study at UM. It highlights VR's role in providing varied learning experiences, from facilitating immersive understanding in cultural studies to aiding in technical skill development in scientific fields.

Table 3: Application of VR for Multiple Disciplines

Educational Goal/ Theme	Benefits of VR Across Faculties
Immersive Understanding & Contextual Learning	**FASOS:** Historical and cultural immersion. **Law:** Legal scenarios and courtroom simulations. **FHML:** Medical and health care simulations. **FPN:** Simulated psychological environments. **FSE:** Scientific visualization and engineering models. **SBE:** Business and economic simulations.
Skills Training & Practical Application	**FASOS:** Interactive social research methods or negotiation skills. **Law:** Legal argumentation and procedural practice. **FHML:** Hands-on medical procedures. **FPN:** Behavioral study techniques. **FSE:** Technical skills in lab and fieldwork. **SBE:** Management and marketing strategies.
Critical Analysis & Problem-Solving	**FASOS:** Social and historical issue analysis. **Law:** Ethical dilemma and case analysis. **FHML:** Diagnosis and treatment planning. **FPN:** Mental health and neurological disorder studies. **FSE:** Engineering and scientific problem-solving. **SBE:** Economic and business challenge resolution.
Collaborative Learning & Teamwork	**FASOS:** Group projects in cultural studies. **Law:** Collaborative legal strategies. **FHML:** Team-based medical diagnostics. **FPN:** Joint psychological research. **FSE:** Collaborative scientific research and design. **SBE:** Teamwork in business simulations.
Innovative Research & Exploration	**FASOS:** Exploring new, interdisciplinary perspectives in the humanities. **Law:** Investigating new legal concepts. **FHML:** Innovative health sciences research. **FPN:** Neuroscience and psychological exploration. **FSE:** Advanced research in science and technology. **SBE:** Exploring novel business theories and models.

1.6. Examples of VR-enhanced practices at UM

This project piloted two relevant types of VR functionalities across UM:

1. Presentation skills training through an immersive and interactive simulation and
2. Real-life, situated experiences through immersive 360-degree video.

These activities were selected to:

1. Accommodate large groups of students with diverse learning needs.
2. Be replicated across various educational contexts without significant customization.
3. Provide significant value with relatively low investment after initial setup.
4. Offer measurable improvements in skillsets that are universally beneficial.
5. Offer scalability and adaptability across disciplines.

A detailed description of piloted VR activities is provided in Table 4 on the next page.

Table 4: Description of VR-enhanced-PBL Activities

VR Activity Type:	Presentation Skills Training through immersive, interactive simulation
Objective	**Implementation Features**
To enhance students' public speaking and presentation skills in a controlled and safe yet dynamic virtual environment.	• Custom environments help simulate various presentation contexts. • A dynamic virtual audience provides real-time, lifelike reactions to improve user engagement. • AI-driven analytics offer instant feedback on delivery and body language. • The ability to record, playback, and critically review one's performance is a key feature. • Live Q&A sessions enabled by AI following the presentation are a recent value-adding development

VR Activity Type:	Real-life, situated experiences through 360-degree video
Objective	**Implementation Features**
To provide an immersive learning experience that takes students beyond the classroom walls to virtually anywhere in the world.	• Immersive storytelling engages students in a more personal and emotional way. • Interactive elements in videos facilitate a more active learning experience. • Virtual field trips allow exploration of places otherwise inaccessible. • Training simulations create realistic scenarios crucial for vocational training. • Virtual tours support subjects like real estate and tourism with lifelike walkthroughs.

1.7. Other Examples of VR Skills Development

With regard to professional and academic skills education at UM, VR emerges as a dynamic tool (Phoon et al., 2021; Wu et al., 2023). Through its immersive and interactive functionality, VR facilitates experiential learning that is crucial for developing these essential skills.

Table 5 below outlines practical examples of how VR can train various 21st-century skills, highlighting its versatility and effectiveness in modern education.

Table 5: Examples of VR Training for 21st-Century Skills

Skill	VR Application for Skill Development
Communication & Collaboration	VR team-building exercises to enhance cooperation and communication in virtual settings.
Critical Thinking & Problem-Solving	Engaging in VR puzzles and simulations that require critical analysis and inventive problem-solving.
Creativity and Innovation	Using VR art tools and ideation sessions for creative expression and collective innovation in 3D spaces.
Digital Literacy	Interactive VR tutorials on software usage and cybersecurity training for hands-on digital proficiency.
Emotional Intelligence and Empathy	Virtual role-plays and narrative experiences to improve perspective-taking and emotional understanding.
Adaptability and Resilience	Learning adaptability and stress management through VR-induced challenges and scenarios.
Global Awareness and Cultural Competence	Immersive travel and language experiences in VR for global cultural understanding and language practice.

Table 5: Examples of VR Training for 21st-Century Skills (Continued)

Skill	VR Application for Skill Development
Negotiation Skills	Refining negotiation tactics through interactive VR simulations of real-world bargaining situations.
Leadership	VR programs focused on strategic decision-making and team management in simulated environments.
Networking	Virtual networking events and career fairs in VR for professional relationship building and job opportunity exploration.

These examples illustrate the breadth of VR's application in skill development, underscoring its potential as a multifaceted educational tool. By engaging users in varied and realistic scenarios, VR enhances technical abilities and fosters critical interpersonal and cognitive skills, preparing learners for the complexities of the modern world (Wu et al., 2023).

1.8. Other Examples of 360-degree Video Situated Experiences

360-degree videos in VR offer a unique medium to visualize and interact with abstract concepts, facilitating a deeper understanding of complex ideas and theories (Pirker & Dengel, 2021). This immersive approach is particularly beneficial in educational contexts where abstractness can hinder learning (Dooley, 2017). For instance, in various STEM (Science, Technology, Engineering, and Mathematics) disciplines, students often encounter abstract theories and principles that can be challenging to grasp solely through traditional teaching methods.

Take, for example, the concept of complex mathematical algorithms in computer science. These abstract algorithms can be difficult to understand through textbooks alone. However, by using algorithms in a virtual environment. This interactive learning approach provides students with a tangible and practical understanding of complex mathematical concepts, making abstract theories more accessible and facilitating deeper comprehension (Zhao et al., 2020). Table 6 provides other examples of how 360-degree VR videos can be employed across various disciplines to bring intricate concepts to life.

Table 6: Examples of VR Training for 21st-Century Skills

Concept or Field	VR 360-degree Video Application
Virtual Art Galleries	360-degree tours of museums and galleries, e.g., a virtual walk through the Louvre.
Historical Reenactments	Recreating historical events or periods, like the Renaissance or ancient Egypt, in VR.
Creativity and Innovation	Using VR art tools and ideation sessions for creative expression and collective innovation in 3D spaces.
Historic Debates	Simulated discussions between historical figures or philosophical debates in VR.
Ethical Dilemmas	Interactive simulations of scenarios like the Trolley Problem to explore moral decision-making.
Mathematical Concepts	Visualizing abstract mathematical ideas like fractals or the Fibonacci sequence in VR.
Quantum Physics	360-degree experiences of quantum models, atoms, and particles for tangible theory understanding.
Astronomy	Virtual tours of the universe, exploring celestial bodies and cosmic events in VR.
Biological Systems	Journeys through biological systems, like a virtual tour through the bloodstream or a coral reef.

Using 360-degree VR videos as an educational tool demonstrates how technology can bridge the gap between abstract theory and tangible understanding. By providing students with immersive and interactive experiences, these VR applications enhance comprehension and engagement in various disciplines, making complex subjects more accessible and intriguing.

2. PROJECT FINDINGS

As part of our commitment to enhancing PBL through VR at UM, we conducted seven distinct pilot projects at five UM faculties:

- Faculty of Science & Engineering (FSE),
- Faculty of Psychology and Neuroscience (FPN),
- Faculty of Arts and Social Sciences (FASoS),
- Faculty of Health, Medicine and Life Sciences (FHML),
- School of Business and Economics (SBE)

2.1. Aggregated Pilot Findings

These pilots' primary goal was to explore VR's effectiveness in training presentation skills and enhancing the PBL experience through the use of 360-degree videos. We present the aggregated findings from these diverse initiatives, offering a comprehensive overview of the outcomes and insights gained. For those interested in a more detailed exploration of each pilot, you can find more information in Appendix A.

FSE

Pilot Focus: Presentation Skills in VR.

Main Findings: Reduction in public speaking anxiety.

Limitations: Small sample size, short testing period, technical glitches in VR app, lack of control group.

Future Suggestions:

- Select user-friendly VR software with clear instructions;

- Start by using VR in a few select lessons or activities and slowly expand its use as students and instructors become more comfortable with the technology;

- Provide basic training sessions for both students and instructors

SBE

Pilot Focus: Presentation Skills in VR.

Main Findings: Positive impact on motivation, output transfer behavior, and performance within VR feedback.

Limitations: Need for environment realism in VR training.

Future Suggestions:

- Incorporate VR sessions into courses where presentation skills are assessed. Ensure that the VR training directly supports the assessment criteria, helping students prac-tice and refine the spe-cific presentation skills that will be evaluated;

- Offer introductory VR sessions for students and educators.

FASOS

Pilot Focus: 360-degrree Videos in Class.

Main Findings: Positive feedback despite low engagement.

Limitations: Low participation rate, ethical concerns, preference for real-life practice.

Future Suggestions:

- Incorporate VR training as a compulsory element of the course to ensure all students experience its benefits. Given that some students might not realize the value of VR until they engage with it, making it mandatory can ensure wider participation and exposure;

- Provide simple, step-by-step VR tutorials.

FHML

Pilot Focus: 360-degree Videos in Class.

Main Findings: Effective substitute for fieldwork, increased engagement in healthcare settings.

Limitations: The development of tailored, 360-degree VR videos can be costly.

Future Suggestions:

- Develop more VR scenarios for active student roles, focus on different stakeholder perspectives, and collaborate with other departments or institutions for content creation;

- Explore pre-made VR content options.

SBE

Pilot Focus: Two VR Immersion Case Studies.

Main Findings: Deeper understanding of service innovation and customer experiences.

Limitations: Complexities in tech integration, increased workload for teachers and students.

Future Suggestions:

- Provide straightforward instructions for using VR technologies;

- Create a dedicated team or assign roles within the existing staff to assist with VR technology management. This team can provide technical support, help with the setup and troubleshooting of VR equipment, and ensure smooth integration of VR activities in the classroom;

- Start with simpler VR activities and progressively introduce more complex ones as students become more comfortable with the technology;

- VR is complementary to the learning experience. The use of VR in PBL enriches the student learning experience yet can't replace conventional educational design. With its current functionalities and taking the adaptivity of the organisation into account VR has to be regarded as an ‘add on’.

2.2. Teacher Needs – Focus Group & Research

In parallel with capturing student experiences as part of the pilots listed above, a core objective of our project was to explore the perspectives of tutors, educators, and course coordinators on integrating VR into UM’s educational landscape. To achieve a comprehensive understanding from an instructional standpoint, we conducted a focus group with UM educators, including both early adopters and non-adopters of VR technology. This diverse mix of participants ensured that we covered a broad spectrum of needs and thoughts related to VR integration.

Additionally, insights were also drawn from the master thesis 'Perceptions of Teachers Towards Acceptance: Immersive Virtual Reality in Higher Business Education' by Yannick Lortz, supervised by Roberta Di Palma. The insights gained from this collaborative exploration provide important information on the adoption and application of VR in education from a teacher’s perspective, as detailed in Table 7 on the next page.

Table 7: Teacher’s Perceptions of VR-enhanced-PBL

Factor	Explanation
VR-Enhanced Learning Experience	Teachers recognize the potential of VR to significantly enhance the learning experience, particularly in areas where traditional methods have limitations. These areas include, for example, complex concept visualization, simulated experiences, skill-based training.
VR Technology Adoption Barriers	Teachers highlight difficulties in integrating VR tech into educational systems, pointing out the need for more accessible and user-friendly VR solutions.
Educator VR Training & Skill Development	Teachers highlight the need for specialized training sessions and resources to help educators effectively integrate VR into their teaching practices. Examples include hands-on VR workshops, instructional guides, and best practices, peer-sharing sessions, and continuous professional development courses.
Student Interaction with VR	Teachers note that student engagement in VR can vary due to factors like unfamiliarity with VR technology, content relevance, and passive VR experiences. To enhance engagement, they recommend interactive, curriculum-aligned VR content that encourages active participation. The goal is to integrate VR as a complementary, not replacing, element in the learning process, ensuring it adds value without overwhelming students.
VR Content Creation and Curation	Teachers discuss the need for effective strategies in developing relevant and engaging VR content, as well as sourcing existing educational VR materials. Examples include clear roadmaps for content selection, collaborating with networks of VR users, and building partnerships with VR content creators.

Table 9: Teacher's Perceptions of VR-enhanced-PBL (Continued)

Factor	Explanation
Investment in VR Resources	Teachers address the challenges related to the financial and resource investments required for VR implementation, calling for institutional support and strategic resource management.
VR in Learning Assessment	Teachers explore the potential of VR tools in student assessments, noting the opportunities for innovative and immersive evaluation methods.
VR Ethics and Data Privacy	Teachers express concerns regarding ethical practices and data privacy in VR usage, emphasizing the need for clear guidelines and adherence to privacy laws.

2.3. Support and Structural Needs - The Role of Tech Labs

As highlighted from the teacher perspective above, as we move towards a future where VR and other new technologies become more diffused within the educational experience at UM, a key objective is to establish dedicated tech labs across faculties. Two prominent examples of existing tech labs at UM are DEXLab at SBE and The Plant at FASOS. These labs are envisioned as nerve centers for VR integration, where innovation and education converge.

To pursue this goal, we collaborated with bachelor's student and DEXLab intern Philipp van Dalden, who meticulously researched the operational frameworks of 11 established tech labs within prominent universities across the Netherlands and Germany. His investigative efforts aimed to uncover the core principles and structures underpinning the most effective and innovative tech labs, thereby informing the development of our state-of-the-art facilities. Drawing from this extensive research, the next page captures the strategic recommendations that emerged, providing a roadmap for creating successful tech labs within our university.

Key Success Factors of University Tech Labs

1. Purposeful Association:
It is essential to link each tech lab directly to specific study programs or defined use cases, ensuring that lab activities are closely aligned with educational objectives and innovation goals.

2. Organizational Structure:
Teachers highlight difficulties in integrating VR tech into educational systems, pointing out the need for more accessible and user-friendly VR solutions.

3. Focus and Specialization:
Emphasizes the importance of maintaining a clear focus or specializing in certain areas, allowing labs to channel resources effectively and drive advancements in targeted fields.

4. Collaborative Networks:
Stress the need for active collaboration and networking, encouraging both internal and external partnerships to create a culture of shared knowledge and idea cross-pollination.

5. Visionary Leadership:
Highlight the need for a clear, strategic vision to ensure the lab's long-term sustainability, keeping it adaptable and relevant in the evolving educational landscape.

Appendix B provides useful information and advice on establishing UM Tech Labs.

2.4. Summary of Main Project Findings

Based on the conceptual assumptions and the pilots that have been conducted, a couple of overall conclusions can be drawn.

Enhanced Learning Exerience

Preliminary support suggests that VR significantly enriches the PBL environment. By offering immersive and interactive experiences, VR facilitates a deeper understanding of complex subjects and has been shown to increase student motivation and engagement, especially in areas where conventional teaching methods are less effective.

VR is complementary to the learning experience

Using VR in PBL enriches the student learning experience yet can't replace conventional educational design. With its current functionalities and taking the adaptivity of the organization into account VR has to be regarded as an 'add-on'.

Diverse Aplications

VR has been utilized effectively for presentation skills training and 360-degree video sessions. These applications demonstrate VR's adaptability across various disciplines and learning objectives, catering to different educational needs.

Technical & Pedagogical Support

The importance of robust technical support and pedagogical guidance for educators integrating VR into their curriculum is a key finding. This support is crucial for VR's effective and smooth implementation in PBL.

Reservations About VR Integration

Despite the positive outcomes, there are reservations from both students and teachers regarding VR integration. Concerns primarily revolve around the technical challenges, the learning curve associated with using new technology, and ensuring that VR adequately adds value rather than distracts, from the learning activity.

3. GUIDELINES

These guidelines are derived from the VR-enhanced PBL project findings. The guidelines provide input for didactic and technical applications of VR-enhanced PBL classrooms. Furthermore, they provide a suggested roadmap for VR implementation.

3.1. Didactic Guidelines

Guideline 1

Align VR Activities with Intended Learning Outcomes

Guideline 1: What it means

Aligning VR activities with intended learning outcomes is crucial for ensuring that the VR implementation complements the course's learning goals and teaching methods. This is essential for the VR activity to provide educational value. The integration of VR should be in line with the assessment methods in the course e.g., to integrate the VR presentation skills training, the course must have a final presentation assessment. This strategic alignment helps bridge theoretical knowledge and practical application, making learning more engaging and effective.

Guideline 1: What it takes

Determine Learning Objectives:

- Identify whether your learning goals are focused on knowledge acquisition or skill development. This distinction will guide your search for appropriate VR content. Refer to sections 1.7 and 1.8 for inspiration.
- Regardless of the type of activity, use platforms such as the Meta Game Store, Sidequest.com, and YouTube 360 to explore available VR applications. These resources cater to broad educational needs, from immersive experiences that elucidate complex concepts to interactive simulations for hands-on skill training.

Research and Selection of VR Content:

- Conduct a thorough search for VR apps that align with your course's specific learning objectives. For knowledge development, prioritize content that offers detailed explorations of concepts. For skill training, look for interactive simulations that provide practical experience.

- Compile a list of potential VR activities that seem promising for meeting your educational goals.

Engage with VR Experts and Technical Support:

- With your list of potential VR activities in hand, consult with your institution's VR experts, tech labs, or educational technology support staff. They can offer valuable insights into the practicality of integrating these VR activities into your curriculum and suggest additional resources or alternatives you may not have considered.
- Utilize the faculty sheets provided at the end to find the appropriate point of contact within your institution for a consultation.

Evaluate and Test Selected VR Activities:

- Personally test the VR applications to assess their alignment with learning objectives, educational value, technical reliability, and user-friendliness.

Integrate VR into the Curriculum:

- Plan the integration of the selected VR sessions into your curriculum, choosing moments that naturally complement and enhance the course material without overwhelming students.
- Address logistical needs such as scheduling, room bookings, and technical setups in advance, especially for activities requiring special arrangements like individual VR training rooms or a dedicated VR content session space.

Prepare for Debriefing and Assessment:

- Develop a clear instructional plan for how VR sessions will be followed up, including debriefing discussions, reflective assignments, or application of VR experiences in subsequent class activities.
- Outline how VR participation will be assessed and integrated into the overall grading scheme of the course, if needed.

Collect Feedback and Adjust Implementation:

- After conducting VR sessions, gather student feedback to evaluate the effectiveness and impact of VR activities on learning outcomes.
- Use this feedback to refine future VR integrations, optimizing content selection, timing, and technical arrangements to better align with course objectives.

Guideline 2

Integrate VR as a Complementary Tool

Guideline 2: What it means

VR technology should be leveraged to enhance the educational experience by providing unique, immersive opportunities that complement traditional teaching methods. This approach enriches the curriculum without replacing fundamental educational practices. VR should offer supplementary experiences that deepen understanding, introduce new perspectives, or allow students to practice skills in a risk-free environment.

Guideline 2: What it takes

Early and Strategic Planning:

- Begin planning the integration of VR into your curriculum at least three to six months in advance. This foresight is crucial for thorough app testing, scheduling considerations, and logistical preparations.

- For coordinators looking to implement VR on a shorter timeline, identify "quick win" VR experiences that require minimal setup, learning and align closely with course objectives.

Logistical arrangements:

- Ensure there are sufficient individual rooms for VR training sessions that require voice interaction, like presentation skills training. This is important because VR applications utilizing voice recognition need a quiet environment to function correctly.
- For content-driven VR sessions, secure a dedicated VR room where headsets can be set up once for the entire day. This setup includes charging stations and a defined play area or boundary for each headset, facilitating a smooth rotation of students through the VR experience.

Managing VR session duration:

- Limit VR activities to a maximum of 30 minutes to maintain student engagement and prevent fatigue. If a VR experience is designed to last longer, incorporate scheduled breaks to allow students to rest, especially their eyes.
- Be mindful of the potential for adverse effects from prolonged VR exposure, such as decreased concentration or physical discomfort. Planning breaks not only mitigates these risks but also ensures a more effective learning experience.

Scheduling considerations:

- Coordinate with academic scheduling teams to ensure VR sessions do not conflict with other critical learning activities. VR should act as an enriching addition to the curriculum, enhancing rather than disrupting the overall educational flow.
- For individualized VR training sessions, schedule times with enough flexibility to accommodate all students without rushing the experience. This might involve booking additional time slots or extending the VR activity over several class periods.

Guideline 3

Choosing the right type of VR activities: Active vs Passive Engagement

Guideline 3: What it means

The effectiveness of VR in promoting active learning hinges on selecting the right type of activity—active or passive—based on the educational objectives. Active engagement in VR, where students interact, make decisions, and solve problems, is crucial for developing critical thinking and practical skills. However, passive experiences, where students observe and absorb information as a 'fly on the wall,' can also be incredibly effective, particularly for conceptual understanding and exposure to new environments. The choice between active and passive VR experiences should be informed by the learning goals of the course, with a clear understanding of how each type of VR activity contributes to these goals.

Guideline 3: What it takes

Determine the goal of the activity:

- Determine whether the goal is to develop skills (indicating a preference for active participation) or to enhance understanding of concepts (where passive observation may suffice).

Refer to the activity quadrants:

- Consult the quadrant framework that classifies VR activities into active and passive engagement for skill training and knowledge acquisition. This framework can guide the selection of VR experiences that align best with your educational goals.

Selecting VR apps:

- For active engagement, look for VR applications that allow students to manipulate the environment, engage in simulations, or complete tasks that require critical thinking.
- For passive engagement, select 360-degree videos or observational VR experiences that immerse students in scenarios relevant to the course content without requiring direct interaction.

Guideline 4

Enable Self-Directed Learning with Accessible VR Resources

Guideline 4: What it means

This emphasizes the importance of accommodating diverse learning styles by making VR technology accessible for self-directed learning. By providing a spectrum of VR experiences—ranging from interactive simulations to narrative-driven explorations—educators can support students in engaging with content in a manner that best suits their learning preferences. The key is to offer VR as a flexible resource that students can utilize independently, allowing them to delve deeper into course concepts at their own pace or practice skills such as public speaking in a low-pressure environment.

Guideline 4: What it takes

Establish a VR learning hub:

- Set up a dedicated space within the library, tech lab, or faculty where VR equipment is available for student use. This VR hub should be equipped with a variety of VR headsets and preloaded with educational content relevant to different courses and subjects.

Curate a VR app library:

- Assemble a comprehensive library of VR content that spans various disciplines and learning objectives. This library should include a mix of interactive, explorative, and narrative-based VR experiences catering to different learning styles and educational needs.

Implement a booking system:

- Create an easy-to-use booking system for students to reserve VR equipment and sessions. This system should allow students to select specific VR experiences they wish to explore and book times that fit their schedules, enabling flexible, self-directed learning opportunities.

Promote VR as a study tool:

- Actively promote the availability of VR resources to students as a supplementary study tool. This can be done through course syllabi, class announcements, or informational sessions highlighting how VR can enhance their understanding of course material and provide additional practice opportunities.

3.2. Technical Guidelines

Guideline 1

Maintain Ethical and Privacy Standards

Guideline 1: What it means

Prioritizes ethical considerations and privacy protection in VR usage, ensuring content appropriateness and secure handling of personal data in compliance with regulations like GDPR.

Guideline 1: What it takes

Conduct Content Reviews:

- Regularly evaluate VR content for ethical integrity, appropriateness, and adherence to privacy standards, particularly for content that involves sensitive topics or simulations.
- Keep the educational community informed about privacy practices and any changes to VR platforms that may affect data handling.

Implement Privacy Protections:

- Use non-identifiable user accounts for VR applications to protect personal information or data encryption to safeguard personal information accessed or generated through VR activities.

Educate on Ethical Use:

- Provide training for educators and students on ethical VR usage, highlighting specific concerns related to VR, such as the potential for virtual harassment or the ethical implications of simulating sensitive historical events.
- Educate users about the types of data collected by VR applications, including motion tracking and biometric data, and discuss the implications for privacy and consent.

Develop VR Ethics Guidelines:

- Create guidelines that outline the ethical use of VR in education, covering content selection, user interaction norms, and privacy measures.

Review & Comply with Regulations:

- Ensure all VR content and activities comply with existing educational and data protection regulations, updating practices as laws evolve.

Guideline 2

Select User-Friendly VR Platforms

Guideline 2: What it means

Emphasizes the selection of VR hardware and software that are accessible and easy to use, minimizing technical barriers for educators and students and enhancing the learning experience.

Guideline 2: What it takes

Prioritize Intuitive Interfaces:

- Choose VR platforms with straightforward, intuitive user interfaces that facilitate easy navigation and interaction, especially for first-time users (e.g., intuitive navigation, responsive controls, adaptive interface etc.)
- Opt for VR systems that require minimal setup and technical knowledge (e.g., no additional hardware beyond the VR headset), streamlining the process for educators to integrate VR into their teaching.

- Before finalizing selection, conduct trials with representative user groups (students and educators) to assess the usability and overall user experience of the VR platforms.

Tailor Support Needs to Content Complexity:

- Ensure that the chosen VR platforms provide adequate support materials, like tutorials, FAQs, and user forums, tailored to the complexity of the VR content and the platform's functionalities. This comprehensive support is essential for platforms hosting interactive simulations or environments that require user navigation and manipulation.
- For simpler VR experiences such as 360-degree videos, which generally involve basic playback functionality, the need for extensive support resources is significantly reduced. For these types of content, focus on ensuring accessibility and straightforward playback controls, acknowledging that the simplicity of "pressing a play button" inherently lowers the barrier to entry and reduces the demand for detailed support materials.

Guideline 3

Select High-Quality VR Content

Guideline 3: What it means

Prioritize choosing VR content that adheres to both educational and technical excellence. High-quality VR experiences should be engaging, pedagogically sound, and technically robust, providing meaningful and immersive learning opportunities.

Guideline 3: What it takes

Assess Immersion and Interactivity Levels:

- High-quality VR content should offer a deep level of immersion, making learners feel genuinely part of the virtual environment. This is especially important when selecting 360 videos.
- When Interactivity is included, it should be meaningful and facilitate active learning, allowing students to manipulate objects, make decisions, and experience the consequences of those decisions in a controlled, virtual setting.

Ensure Technical Reliability and Accessibility:

- The content should run smoothly on the available VR hardware, with minimal technical issues by ensuring compatibility with the hardware available (i.e., Oculus Quest)

Seek Customization Opportunities:

- Consider exploring partnerships with VR content developers to create custom materials specifically designed for your educational needs. Such tailored content can fill gaps in existing resources and offer highly engaging learning experiences. However, due to the significant costs involved, it is advisable to first familiarize yourself with commercially available VR apps before pursuing customized solutions.

Train Educators and Students:

- Offer training sessions that include practical tips on quickly addressing minor technical issues. Emphasize that no advanced developmental skills are required to solve most problems encountered during VR sessions.
- Develop and distribute easy-to-follow troubleshooting guides that educators and students can use to resolve basic technical problems. These guides should cover common issues and their solutions in a step-by-step manner.

Prepare for Inevitable Technical Issues:

- Acknowledge that technical glitches may occur despite careful selection. Establish straightforward protocols for addressing common issues, ensuring that these can be resolved quickly and without the need for advanced technical knowledge.

Guideline 4

Ensure Robust Technical Support

Guideline 4: What it means

Underlines the necessity of having a solid support framework for VR integration, covering everything from technical troubleshooting to regular maintenance.

Guideline 4: What it takes

Develop Specialized VR Support Channels:

- Establishing dedicated support channels for VR ensures that users have direct access to help when facing VR-specific issues. This step is crucial because the unique challenges of VR technology—ranging from hardware setup to software navigation—require specialized knowledge for effective troubleshooting.

Offer VR-Specific Training for Technical Staff:

- Given the specialized nature of VR technology, providing targeted training for technical support staff is essential. This ensures that they are equipped with the knowledge and skills to address VR-specific problems, which can significantly reduce downtime and enhance the overall user experience.

Implement a VR Equipment Check and Maintenance Routine:

- Regular maintenance and check-ups of VR equipment are vital for preventing technical issues before they impact classroom activities. Proactive maintenance helps in identifying and addressing potential hardware or software problems, ensuring that VR resources are always ready for educational use.

Establish an Accessible VR Equipment Booking System:

- Create an intuitive and user-friendly booking system that allows educators and students to reserve VR equipment easily. This system should be accessible online and provide clear information on availability and booking procedures

Guideline 5

Facilitate Access to VR Equipment and Promote a Network of Practice

Guideline 5: What it means

Aim to democratize access to VR technology and foster a community of practice among educators, facilitating the exchange of ideas and experiences.

Guideline 5: What it takes

Build a Supportive Community of VR Educators:

- Foster a network of practice by creating online forums, social media groups, or regular meetups where educators can ask questions, share resources, and collaborate on VR projects. This community should be welcoming to both experienced VR users and newcomers.

Organize Interactive VR Workshops and Sharing Sessions:

- Schedule regular events that bring together educators from various disciplines to share their experiences, challenges, and successes with VR in education. These sessions can be a platform for exchanging best practices and innovative teaching strategies.

Highlight Success Stories and Best Practices:

- Collect and disseminate stories of successful VR implementations across different educational contexts. This could include case studies, interviews, or presentations that showcase how VR has been effectively integrated into teaching and learning, providing practical inspiration and ideas to others.

Create Incentives for Innovation:

Develop recognition or reward programs that acknowledge and incentivize faculty members who incorporate VR in innovative ways into their curriculum. This could range from grant opportunities for VR project development to awards for outstanding VR-based teaching initiatives.

3.3. Step-by-step Implementation - VR-Enhanced-PBL Roadmap

Integrating VR into PBL environments offers a dynamic and engaging educational experience but requires careful planning, preparation, and flexibility. It is not a process that can be hastily assembled; instead, it demands a thoughtful and methodical approach, often spanning several weeks or even months. Educators need to allocate adequate time for exploring and testing various VR applications, preparing the necessary equipment, and aligning the VR activities with the course's curriculum. Additionally, it is crucial to anticipate and prepare for potential technical issues that may arise during implementation. Despite these challenges, the effort to integrate VR into PBL can be immensely rewarding, providing students with a unique and immersive learning experience.

The following steps are designed to guide educators through this process, highlighting key considerations and best practices. While challenges may arise, we encourage educators to embrace this innovative teaching method and explore the vast potential of VR in education.

Roadmap

1. Curriculum Alignment

Review the course syllabus to identify where VR can enhance learning objectives, teaching methods, and/or assessment strategies.

Determine the type of VR activity (i.e., interactive skills training, immersive 360 videos, interactive exploration and simulations, VR education games) best suited to achieve these objectives.

2. Tech Lab Consultation

Meet with your institution's technical lab or VR support team 3-6 months before integration to explore VR options and seek outsider opinions. Depending on your VR knowledge, the time required may be more or less than the suggested timeframe.

Discuss technical requirements, available equipment, software licenses, and the potential need for custom VR content development.

3. Course Integration Timing & Scheduling

Decide on the optimal timing for VR integration within the course schedule, considering the impact on learning outcomes and course flow.

Plan for additional time or space requirements, such as booking individual rooms for skills training or a dedicated space for immersive video sessions. Contact scheduling if needed.

Ensure sessions are designed with time limits to prevent VR fatigue. Recommended session length should not exceed 20-30 minutes without breaks to accommodate the physical and cognitive comfort of users.

4. Technical Preparation & Equipment Setup

A few days before the planned activity, ensure VR hardware is operational, software is up-to-date, and all necessary technical support structures are in place.

On the day of the integration, set up the VR experience room. We suggest having students rotate to the room rather than moving the VR headsets across rooms.

5. Student Preparation & Engagement

Inform students about the upcoming VR activities, highlighting their educational objectives and how these fit into the broader course context.

In large courses, create sign-up mechanisms for skills training sessions or simply use tutorial group time for 360 video viewing, ensuring all students have the opportunity to participate.

6. Conducting VR Activities

Facilitate the VR experience, whether guiding students through skills training or coordinating in-class post-discussion questions following a VR experience.

Provide immediate support for any technical issues, relying on prepared troubleshooting guides and technical staff assistance.

troubleshooting guides and technical staff assistance.

We suggest screen sharing (also known as casting) the headset to your laptop/smart screen to guide students through their experiences easily.

7. Feedback, Reflection, & Debriefing

Organize debriefing sessions after VR activities to allow students to reflect on their experiences, discuss insights, and connect VR learnings to course content.

Encourage feedback on the VR experience to gauge its effectiveness and identify areas for improvement.

8. Assessment & Continuous Improvement

Assess the impact of VR activities on learning outcomes using student feedback, performance data, and personal observations.

Adjust future VR integrations based on these assessments, seeking to enhance the educational value of VR experiences continuously.

3.4. Faculty VR-Resources Information

Whether you are exploring VR for the first time or looking to expand your current use of VR in teaching, these Faculty Sheets are a valuable resource for educators looking to incorporate VR into their teaching. They provide tailored information for each faculty, ensuring educators have access to the most relevant point of contact for VR experts for their specific disciplinary needs.

Faculty: FASOS

General	
Contact information	Jaime Simons / Arnoud Wils Creative Lab Technologist / Research Software Engineer plant-fasos@maastrichtuniversity.nl Faculty of Arts and Social Sciences, Grote Gracht 76, Room 0.10
Outreach	Website: https://theplant.maastrichtuniversity.nl/ Instagram: https://www.instagram.com/theplantfasos/ LinkedIn: https://www.linkedin.com/company/theplant-fasos/ X/Twitter: https://twitter.com/PlantFasos
Availability	
General	Monday-Thursday, 9am-5pm
Preferred Method of Contact	Email
Hardware and Software Resources	
Types of VR Headsets/ Equipment	VR for Presentation Skills (with DEXLab), VR for Museum Spaces, VR Play Sessions, VR for Dementia patients, and various VR video/tour production
Expertise & Research Interests	
Past VR Projects	VR for Presentation Skills (with DEXLab), VR for Museum Spaces, VR Play Sessions, VR for Dementia patients, and various VR video/tour production
Research & Education Innovation Interests	VR for research and teaching within the humanities and social sciences (general)

Faculty: FHML

General	
Contact information	Nynke de Jong Associate professor n.dejong@maastrichtuniversity.nl 043-3881827 Located at central point in Randwyck: Office of Nynke de Jong Duboisdomein 30| Room 0.031
Outreach	https://www.maastrichtuniversity.nl/e-reality (in progress)
Availability	
General	Always
Preferred Method of Contact	Via email or physical appointment
Hardware and Software Resources	
Types of VR Headsets/ Equipment	20 Meta Quest 2
Software	None
Other	None
Expertise and Research Interests	
Past VR Projects	360-degree projects (On a home visit, Technology in healthcare, Advance care planning, Problem-based Learning, Intercultural awareness)
Research & Education Innovation Interests	Instructional design

Faculty: FSE

General	
Contact information	Stefan Jongen Assistant Professor stefan.jongen@maastrichtuniversity.nl 06-14330806
Outreach	None
Availability	
Preferred Method of Contact	E-mail
Hardware and Software Resources	
Types of VR Headsets/ Equipment	15 VR Glasses
Software	None
Other	None
Expertise and Research Interests	
Past VR Projects	Virtual Reality as a tool to enhance Problem-Based Learning experiences at Maastricht Science Programme (Bachelor Thesis Research) Virtual Reality as a tool for presentation skills: a UM case study on students (MSP Project)
Research & Education Innovation Interests	VR in STEM Education VR in PBL ...

Faculty: FPN

General	
Contact information	Natalja Sarneel - Assistant professor natalja.sarneel@maastrichtuniversity.nl Phone via Teams UNS 40 2.771 Dalena van Heugten - Assistant professor dalena.vanheugten@maastrichtuniversity.nl Phone via Teams UNS 40 2.771
Outreach	https://www.maastrichtuniversity.nl/e-reality (in progress)
Availability	
General	Natalja= mon-tue-thu-fri Dalena= mon-tue-wed-thu
Preferred Method of Contact	Email
Hardware and Software Resources	
Types of VR Headsets/ Equipment	Located at central point in Randwyck: Office of Nynke de Jong Duboisdomein 30| Room 0.031
Expertise and Research Interests	
Past VR Projects	• VR practical in bachelor GGZ on clinical skills in mental health care aimed at senior citizens • Out-of-body experiences using VR leads to dissociation (research study at University of Oxford in collaboration with Dr. Stephen Hicks)
Research & Education Innovation Interests	Teaching: VR in Clinical Practice/ VR in Clinical Skills Teaching Research: out-of-body experiences and dissociation

Faculty: SBE

General	
Contact information	Dominik Mahr – Professor Jonas Heller – Assistant Professor Tim Hilken - Assistant Professor Roberta Di Palma – PhD Student sbe-dexlab@maastrichtuniversity.nl Tapijnkazerne 11, I1 017, 6211 ME Maastricht, Room I1.017
Outreach	Website: https://www.sbe-dexlab.com/ Linkedin: https://www.linkedin.com/company/sbedexlab/ Instagram: https://www.instagram.com/sbe.dexlab
Availability	
General	Any day upon request
Preferred Method of Contact	Email
Hardware and Software Resources	
Types of VR Headsets/ Equipment	https://www.sbe-dexlab.com/equipment
Software	VirtualSpeech – Presentation Skills Training But access to many others
Expertise and Research Interests	
Past VR Projects	https://www.sbe-dexlab.com/publications
Research & Education Innovation Interests	**Education:** Education Innovation & Business Education **Research:** Digital Experiences in Businesses i.e., Service and Retail Marketing, Supply Chain Management , End user experiences & Broader Business and Economic and Innovation Scope

Faculty: LAW

General	
Contact information	Dr. Catherine De Rijdt Coördinator Staff Development catherine.derijdt@maastrichtuniversity.nl 0433884852 Law
Outreach	https://www.maastrichtuniversity.nl/e-reality (in progress)
Hardware and Software Resources	
Types of VR Headsets/ Equipment	15 oculus quest 2 headsets
Expertise and Research Interests	
Past VR Projects	EDLAB Project. Tutor Training in 360-degrees: group dynamics

3.5. Conclusion & Call-to-Action

Drawing on the insights garnered from this comprehensive project, we have explored the dynamic realm of integrating VR into PBL environments. This report has highlighted various innovative practices in VR-enhanced education, emphasizing the substantial benefits it brings to student engagement and learning outcomes. Despite the promise VR shows to enrich educational experiences, we also acknowledge the reservations expressed by both students and educators regarding its integration. This underscores the need for a balanced approach, where digital innovations complement rather than replace traditional non-digital practices.

Key advancements in VR-enhanced education include the effective use of VR for developing presentation skills and providing immersive 360-degree video experiences. These applications have shown the potential of VR in bridging theoretical concepts with practical, real-world scenarios. The integration of VR also necessitates robust technical support and thoughtful pedagogical planning, ensuring that educators are well-equipped to leverage this technology effectively. While VR offers new frontiers in collaborative and experiential learning, our findings also stress the importance of maintaining the core principles of PBL – Constructive, Contextual, Collaborative, and Self-directed learning. In light of our findings, it is evident that while VR can significantly enhance the learning experience, the foundational elements of education remain integral.

Moving forward, our goal is to establish and nurture a network of educators keen on exploring and implementing VR within our classroom. This network will play a pivotal role in disseminating our findings, making them widely accessible to the broader educational community. By fostering this network of interested educators, we aim to create a collaborative ecosystem that encourages experimentation, innovation, and continuous learning. This community will be instrumental in refining and enhancing the guidelines, drawing from a wide range of experiences and perspectives.

In conclusion, this project begins an exciting journey in VR-enhanced education at Maastricht University. We invite educators to join us in this venture, to explore the vast potential of VR in PBL, and to contribute to the ongoing development of this innovative educational paradigm. Together, we can shape the future of VR in education, creating enriching, immersive, and transformative learning experiences for our students.

REFERENCES

Abdullah, J., Mohd-Isa, W. N., & Samsudin, M. A. (2019). Virtual reality to improve group work skill and self-directed learning in problem-based learning narratives. *Virtual Reality, 23,* 461-471.

Asad, M. M., Naz, A., Churi, P., & Tahanzadeh, M. M. (2021). Virtual reality as pedagogical tool to enhance experiential learning: a systematic literature review. *Education Research International, 2021*, 1-17.

Bastiaens, E. (2017). *Research-based learning: Case studies from Maastricht University. Professional Learning and Development in Schools and Higher Education*. springer.

Bastiaens, E. T. W., & Bastiaens, T. J. (2021). *The Innovation of Pedagogy: Towards a Systematic Approach for Teaching in Higher Education*. In Design Thinking and Innovation in Learning (pp. 95-112). Emerald Publishing Limited.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Psychology of Education: Major Themes: Pupils and Learning 18*(1), 32-42.

Chen, C. H., Hung, H. T., & Yeh, H. C. (2021). Virtual reality in problem-based learning contexts: Effects on the problem-solving performance, vocabulary acquisition and motivation of English language learners. *Journal of Computer Assisted Learning, 37*(3), 851-860.

Chien, S. Y., Hwang, G. J., & Jong, M. S. Y. (2020). Effects of peer assessment within the context of spherical video-based virtual reality on EFL students' English-Speaking performance and learning perceptions. *Computers & Education, 146*, 103-751

Cowan, K., & Ketron, S. (2019). A dual model of product involvement for effective virtual reality: The roles of imagination, co-creation, telepresence, and interactivity. J*ournal of Business Research*, 100, 483-492.

de Jong, N., van Rosmalen, P., Brancaccio, M. T., Bleijlevens, M. H., Verbeek, H., & Peeters, I.G. (2022). Flipped Classroom Formats in a Problem-Based Learning Course: Experiences of First-Year Bachelor European Public Health Students. *Public health reviews, 43*, 1604795.

Dooley, K. (2017). Storytelling with virtual reality in 360-degrees: a new screen grammar. *Studies in Australasian Cinema, 11*(3), 161-171.

Halvorsen, F. H., Fosse, E., & Mjåland, O. (2011). Unsupervised virtual reality training may not increase laparoscopic suturing skills. *Surgical Laparoscopy Endoscopy &Percutaneous Techniques, 21*(6), 458-461.

Hew, K. F., & Cheung, W. S. (2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. *British journal of educational technology, 41*(1), 33-55

Loureiro, S. M. C., Bilro, R. G., & de Aires Angelino, F. J. (2020). Virtual reality and gamification in marketing higher education: a review and research agenda. *Spanish Journal of Marketing-ESIC, 25*(2), 179-216.

Maastricht University. (2021). Strategic Programme 2022-2026. Retrieved from: https://www.maastrichtuniversity.nl/strategic-programme-2022-2026

Majchrzak, T. A., Radianti, J., Fromm, J., & Gau, M. (2022). Towards routinely using Virtual Reality in higher education.

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: a review of learning theories, approaches and methodologies for the last decade. *Electronics, 12*(13), 2832.

Moust, J. H., Berkel, H. V., & Schmidt, H. G. (2005). Signs of erosion: Reflections on three decades of problem-based learning at Maastricht University. *Higher education, 50*, 665-683.

Pellas, N., Dengel, A., & Christopoulos, A. (2020). A scoping review of immersive virtual reality in STEM education. *IEEE Transactions on Learning Technologies, 13*(4), 748-761.

Pirker, J., & Dengel, A. (2021). The potential of 360 virtual reality videos and real VR for education—a literature review. *IEEE computer graphics and applications, 41*(4), 76-89.

Phoon, G. C., Idris, M. Z., & Nugrahani, R. (2021). Virtual reality (VR) in 21st. century education: The opportunities and challenges of digital learning in classroom. *Asian Pendidikan, 1*(2), 105-110.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778.

Schmidt, M., Newbutt, N., Lee, M., Lu, J., Francois, M. S., Antonenko, P. D., & Glaser, N. (2023). Toward a strengths-based model for designing virtual reality learning experiences for autistic users. *Autism,* 136-231.

Shu, Y., Huang, Y. Z., Chang, S. H., & Chen, M. Y. (2019). Do virtual reality head-mounted displays make a difference? A comparison of presence and self-efficacy between head-mounted displays and desktop computer-facilitated virtual environments. *Virtual Reality, 23*, 437-446.

Wu, W. C. V., Manabe, K., Marek, M. W., & Shu, Y. (2023). Enhancing 21st-century competencies via virtual reality digital content creation. Journal of Research on *Technology in Education, 55*(3), 388-410.

Zhao, J., LaFemina, P., Carr, J., Sajjadi, P., Wallgrün, J. O., & Klippel, A. (2020,). Learning in the field: Comparison of desktop, immersive virtual reality, and actual field trips for place-based STEM education. *IEEE conference on virtual reality and 3D user interfaces*, 893-902.

Appendix A: Pilots & Outcomes per Faculty

Based on the above-presented functionalities, we have conducted seven pilots across several UM faculties, aiming to enrich existing PBL courses with VR. The results and experiences are described below.

FASOS VR Pilot: 360 Videos in Arts & Heritage (pilot coordinator Emilie Sitzia)

1. Executive summary

The Faculty of Arts and Social Sciences (FASOS) at Maastricht University conducted a VR pilot to explore the use of VR in analyzing exhibition spaces. Utilizing 360 videos in the 'Arts and Audiences' master's elective, coordinated by Dr. Emilie Sitzia, the session aimed to test the adaptability of traditional analysis tools in virtual environments and investigate audience engagement with art in VR.

2. Introduction

The pilot was integrated into the curriculum to enhance the students' understan-ding of spatial analysis and audience engagement in both physical and virtual museum settings, contributing to their theoretical and practical knowledge of Arts and Heritage.

3. Pilot Design

Context: The elective involved 10 students and 2 tutors. The VR session was a follow-up to a previous real-world exhibition space analysis.

Objectives: To determine if existing spatial analysis methodologies apply to VR environments and to understand audience engagement with art in VR.

Implementation:

1. Mobilization of prior knowledge on space analysis.
2. Group familiarization with VR technology.
3. Execution of two main tasks using VR: application of Roppola's analytical tools in VR environments and engagement with art in VR.

Initially unfamiliar with VR, students engaged in hands-on activities in VR environments, first exploring freely and then applying focused analysis using Roppola's framework.

4. Outcomes & Analysis

Observations: Students required initial training but demonstrated enthusiasm and a sense of novelty in engaging with the VR technology.

Findings: Students successfully applied the analytical framework in VR, leading to insightful discussions on inclusion, content flexibility, and the potential for serious games within VR museums. The analysis of VR museum spaces showed parallels and differences with physical spaces, highlighting VR's unique considerations for spatial and audience engagement analysis.

5. Student & Faculty Feedback

Students expressed a newfound understanding of the possibilities for exhibitions in VR, while faculty noted the necessity of technological support and the value of structured analytical tasks in student engagement.

6. Recommendations & Future Directions

The pilot revealed positive student engagement with VR and valuable insights into the applicability of traditional analysis tools in virtual settings. The importance of hands-on experience in VR was highlighted, influencing student interest in VR applications within the arts.

- Implement screen sharing for technology introductions.
- Consider smaller group sizes or multiple sessions to manage noise and ensure quality interaction with VR.
- Further integration of VR into the curriculum should focus on specific, structured tasks to enhance learning outcomes.

FASOS VR Pilot: VR Presentation Skills Training (pilot coordinator Josje Weusten)

1. Executive summary

The VR pilot at FASoS, led by Dr. Josje Weusten, aimed to explore using VR to improve students' presentation skills. Despite a comprehensive setup and support from staff, the pilot faced low engagement, with only three out of twelve students participating. The feedback from these students was positive, suggesting improvements in their presentation skills, but the pilot also raised important ethical and practical questions about using such technology in educational settings.

2. Introduction

The Discourse Analysis course introduced the VR pilot to provide an alternative platform for students to practice and refine their presentation skills. The course, traditionally reliant on in-person presentations, offered VR as an optional tool, aiming to leverage technology to enhance learning experiences. This initiative also presented an opportunity to evaluate the receptivity and effectiveness of emerging technologies in a pedagogical context.

3. Pilot Design

The pilot was designed to offer students a voluntary, supplementary method to practice presentation skills using VR. Efforts were made to demonstrate the technology and ease reservations by introducing VR headsets in the classroom. The initiative was not mandatory, providing flexibility and respecting the students' choice regarding their learning tools.

4. Outcomes & Analysis

Despite the innovative approach, the pilot faced several challenges, including low participation rates, with only three out of twelve students opting to use the VR system. Factors affecting student participation included apprehensions about the technology, ethical concerns about using VR and its producer, a preference for real-life practice over VR, and time constraints.

5. Student Feedback

The students who engaged with the VR system found it beneficial, noting improved presentation skills. A request for privacy during practice was honored, and the feedback received post-VR sessions was well-appreciated. The pilot did show potential benefits for those willing to engage with the technology.

6. Recommendations & Future Directions

For future iterations, it is recommended to:

- Offer a more comprehensive introduction to VR technology, addressing ethical and practical concerns.
- Consider making the VR training a mandatory course component to ensure higher participation.
- Encourage facilitators to experience VR presentations themselves in order to understand better and support student engagement.
- Further investigate the relationship between form and content in presentations and how VR may affect this dynamic.

The ethical considerations raised by both faculty and students warrant a broader discussion on the role of emerging technologies in educational settings. Balancing innovation with ethical responsibility is essential, ensuring that technology enhances rather than distracts from educational goals.

FSE VR Pilot: Virtual Reality as a Tool For Presentation Skills: A UM Case Study on Students (pilot coordinator Stefan Jongen)

1. Executive summary

This FSE (Faculty of Science & Engineering) pilot was orchestrated by a group of dedicated bachelor students—Mariam El-Jashamee, Nikoleta Florou, Aleksander Friis, Lila Gianni, Jonathan Ginting, Braden Lyons, Geraldine Morales, Srishti Rajani, and Kaan Stassen—under the expert supervision of Dr. Stefan Jongen—the initiative aimed to assess the potential of VR as a tool for enhancing public speaking competence. Students were immersed in simulated presentation environments using the Virtual Speech app that provided a platform for practicing and refining their public speaking abilities. This innovative approach allowed the research team to explore and quantify the effects of VR on anxiety reduction and the subsequent improvement of public speaking skills. With the participants engaging in repeated exposure to VR, the pilot sought to provide empirical evidence on the viability of VR technology in honing communication skills in educational settings, particularly for those who may experience heightened anxiety levels during public performances.

2. Introduction

The pilot introduced VR as a tool for training in public speaking, proposing an innovative approach to overcoming one of the most common fears. The research explored whether a virtual environment could provide a realistic yet controlled setting for individuals to practice and improve their presentation skills.

3. Pilot Design

The pilot involved 15 participants who engaged with the Virtual Speech app. The methodology focused on measuring participants' heart rates as a proxy for anxiety levels during VR-assisted presentations.

Objectives:

1. To explore the extent to which VR can reduce public speaking anxiety.
2. To examine the potential improvement in public speaking skills when practicing with VR.

4. Outcomes & Analysis

The preliminary findings suggested that VR exposure can decrease anxiety levels and improve presentation skills. However, the results require further investigation for confirmation due to constraints such as the small sample size, the lack of a control group, and technical glitches in the app.

5. Limitations & Considerations

The pilot faced several limitations worth acknowledging:

- A small sample size and a short testing period might not represent the general population.
- Absence of a control group to measure against the results.
- Technical issues within the Virtual Speech app may have influenced the outcome.
- Manual recording of some data due to heart rate monitor malfunctions introduces the possibility of human error.

6. Recommendations & Future Directions

Despite the few shortcomings, this pilot reveals a great number of interesting recommendations for educators considering integrating VR presentation skills training within their curricula. Specifically:

Look for Software that:

- Personalizes Training: software that offers adaptive learning and immediate feedback tailored to individual performance, covering aspects such as speech clarity, pacing, and audience engagement.
- Supports Extended Immersion with Comfort: software that allows for prolonged periods in a user-friendly interface, minimizing distractions and discomfort for effective skill development.
- Motivates and Engages: software that includes elements like gamification to maintain user interest and a positive learning experience.

Enhance Training Protocols:

- Build Incremental and Consistent Practice: Develop a structured curriculum that starts with simple tasks and gradually increases in complexity, ensuring regular practice in VR.

- Develop Comprehensive Curricula: Integrate VR training within a broader traditional presentation skills development program.

Facilitator Involvement:

- Train Facilitators for Comprehensive Guidance: Prepare facilitators to lead the VR experience effectively and provide supportive feedback to reinforce learning.

Enhance User Experience:

- Create a Supportive and Interactive Environment: Establish a non-judgmental space that encourages peer interaction and community building.
- Track Long-Term Progress: Use mechanisms to monitor and display users' improvements over time.

SBE VR Pilot: Presentation Skills Training (pilot coordinator Roberta Di Palma)

1. Executive summary

This pilot study, conducted under the supervision of Ph.D. candidate Roberta Di Palma at the School of Business and Economics (SBE), merges VR with presentation training to enhance student competencies. The findings provide valuable insights into the efficacy of VR in boosting presentation skills and yield actionable recommendations for refining the software's design and its strategic incorporation into educational programs.

2. Introduction

This pilot study innovatively probes how VR elements within the presentation skills software used, namely feedback and presence elements, should be seamlessly integrated within the educational curriculum to boost student motivation and performance. The study's core objective revolves around assessing the effectiveness of VR training to enhance real-world academic outcomes, particularly focusing on the integration of VR within education to prepare students for actual presentations in class.

3. Pilot Design

The pilot engaged 261 students who utilized VR to train for an upcoming class presentation, practicing their delivery in a virtual environment twice. This approach provided a opportunity to bridge the gap between virtual training and actual performance. A pre-and post-test design measured shifts in student motivation and performance outcomes were analyzed to assess the tangible outcomes of VR training.

- Students who received precise and actionable feedback in VR demonstrated marked improvements in their transfer output behavior and overall presentation skills motivation.
- Increased motivation and interest in presentation skills correlated with the utility of VR training, as reflected in students' self-reports and academic grades.

4. Outcomes & Analysis

The study unscored that:

- ·Integrating VR training within the educational curriculum significantly enhances the practicality and relevance of presentation skills training.

5. Student Feedback

Students who took part in this pilot found strengths and improvement opportunities in this training. Specifically:

Strengths:

- Immediate Feedback: Direct feedback after presentations is highly valued.
- Realistic Environment: The VR setting is immersive, enhancing the learning experience.
- Skill Improvement: Users report better eye contact, volume control, and body language.

- Confidence Building: Repeated practice in VR boosts presenter confidence.
- Engagement with Technology: The novelty of VR is engaging and enjoyable for users.

Areas for Improvement:

- Access to Notes: Participants want the ability to refer to notes during VR presentations.
- Distraction Management: Introducing distractions could more closely mimic real-world conditions.
- Personalized Feedback: Users seek detailed feedback on content and speech patterns.
- Interactivity: There's a desire for more dynamic interactions, like impromptu speaking tasks.
- Gesture Tracking: Improved monitoring of hand movements would be advantageous.
- Audience Realism: Enhancing avatar behaviors to be more lifelike would add authenticity to the practice.

6. Recommendations & Future Directions

Based on this pilot's findings and student feedback, we offer the following recommendations for educators hoping to implement VR presentation skills training within their course:

- Focus on adequate VR integration within the course assignment timeline and ensure environment realism: Seamlessly integrate VR sessions into the curriculum at key points before major assessments, ensuring the VR environment includes realistic distractions and audience interactivity to mirror actual presentation conditions.
- Combine detailed VR-generated feedback on presentation delivery with educator and peer reviews on content relevance, encouraging a holistic approach to skill development that also adapts to various learning styles.
- Introduce VR familiarization sessions to address equipment concerns (like fitting over glasses) and allow students to access and use personal notes within the VR system, ensuring accessibility for all users.
- Opt for VR simulations that encourage dynamic speaking skills, such as improvisation and adaptability, while offering exercises tailored to improving specific areas like pace, volume, and eye contact.

- Host reflective workshops where students analyze their VR feedback, set personal improvement goals, and develop strategies for skill enhancement under educator guidance.
- Adjust the VR training setup to replicate the actual presentation environment more closely,ensuring students gain experience in a space that matches their real-world presentation context.

SBE VR Pilot: Two VR Immersion Case Studies (pilot coordinator Tim Hilken)

1. Executive summary

In the quest to provide an immersive learning experience, the Service Marketing course at SBE, supervised by Dr. Tim Hilken, embarked on a pilot project integrating VR and Virtual Cave technologies into its curriculum. These technologies were leveraged in tutorials to enhance students' understanding of service innovation and the customer service experience, offering them a firsthand experience of the digital transformation in marketing practices.

2. Introduction

In collaboration with DEXLab, the educational landscape of SBE is advancing to embrace innovative technologies that enhance learning through experience. With this in mind, the Services Marketing course has implemented two distinct VR-based activities. This initiative has

has allowed approximately 100 students across all tutorial groups to engage with and reflect on service innovations and customer experiences via immersive technological applications. In addition to VR, students had the opportunity to experiment hands-on with various other technologies, such as Augmented Reality and Service Robots, that were incorporated into their respective tutorial sessions.

3. Pilot Design

Specifically focusing on VR technology, two tutorials were enhanced by ensuring every student had the opportunity for a practical trial of the technology. The leaders of each session were equipped with essential background information on the technology, details on the integrated activity, and a set of potential discussion questions to facilitate post-trial dialogue. Although guidance was provided, the responsibility to determine the timing and manner of the technology trial within the tutorial rested with the students.

Try out examples:

Tutorial 1: VR and Service Innovation

- Technology: Virtual Reality (TRIPP app - VR meditation App)
- Objective: To delve into the role of gamification within mental wellness applications and prompt discussions on how service innovation can improve mental well-being.

Tutorial 2: The Customer Service Experience

- Technology: Virtual Cave (at Zuyd Hotel Management Maastricht)
- Objective: To provide insight into customer perspectives and service experiences within the hospitality and tourism sectors by simulating environments akin to those found in destinations like Disney World.

The structure for both tutorials was designed to include predetermined discussion points while granting facilitation teams the latitude to tailor the technological integration to suit their thematic dialogue.

4. Outcomes & Analysis

Integrating VR and Virtual Cave technologies within the Service Marketing course represented an innovative approach to education in service innovation and the customer service experience.

The outcomes of this pilot project were multifaceted:

- Students gained a deeper, more empathetic understanding of service innovation and customer experiences by immersing themselves in environments that would otherwise be challenging to recreate in a traditional classroom setting.

5. Student Feedback

The feedback from students was generally positive, with many expressing excitement about the innovative use of technology in their learning:

- Students appreciated the hands-on experience, stating that it allowed them to understand theoretical concepts better and apply them to real-world scenarios.
- There was a sense of motivation and increased engagement thanks to the novel teaching methods which diverged from traditional lecture-based learning.
- However, some students pointed out the increased workload associated with using VR, noting the additional effort required to effectively integrate these technologies into their presentations.
- A minority of students felt that while the technology was engaging, it sometimes drew focus away from fundamental course content, suggesting a need for balance.

6. Recommendations & Future Directions

Based on the outcomes and student feedback, the following recommendations are proposed for future iterations of the course:

- Provide more support for students in integrating technology into their coursework, potentially through workshops or guided tutorials on using VR technologies effectively.
- Ensure that the use of technology serves as a complement to, rather than a replacement for, the core content. The theoretical foundation of service marketing should remain the central focus, with technology acting as an illustrative tool.
- Consider establishing a dedicated team or role to handle VR headsets' technical setup, maintenance, and scheduling to minimize disruption and ensure a smooth experience for all students.

FPN VR Pilot: VR Presentation Skills Training (pilot coordinator Natalja Sarneel)

1. Executive Summary

At the Faculty of Psychology and Neuroscience (FPN), Dr. Natalja Sarneel spearheaded a VR pilot to advance presentation skills. While the project faced unexpected technical challenges, these events provided valuable learning opportunities, pinpointing the importance of robust technical infrastructure and legal clarity for using VR technologies.

2. Introduction

The introduction of VR technology for presentation skills training at FPN was an ambitious move to modernize traditional skills training activities. However, the challenges encountered—primarily technical glitches and a lack of immediate technical support—highlighted the complexities of integrating advanced technological tools in educational settings.

3. Recommendations & Future Direction

The insights gained from these challenges provide a compelling case for establishing a dedicated technical support framework, laboratory, and clear guidelines for using such technologies. The following recommendations emerge:

- Develop a dedicated technical support team specialized in VR equipment and software. This unit should be capable of rapid response to technical issues to minimize downtime and ensure the smooth operation of VR-based educational activities.
- Rigorous testing protocols must be established before deploying VR technologies in the classroom to identify and address potential technical issues proactively.
- Invest in reliable storage solutions and maintenance for VR equipment to prolong its lifespan and ensure it is ready for use when needed.
- Provide training for educators and technical staff on the operational aspects of VR technology to enhance their proficiency in troubleshooting and integrating these tools into the curriculum effectively.
- Clarify legal and safety issues related to the use of VR software and hardware, including the use of email addresses and data protection, to ensure compliance with institutional policies and regulations.
- Implement a structured feedback loop involving students, educators, and technical staff to monitor the VR experience and make continuous improvements.
- Develop a backup plan for educational activities should VR technologies fail, ensuring that learning objectives can still be met without disruption.

FHML VR Pilot: 360 videos for Health Sciences Education (pilot coordinator Nynke de Jong)

1. Executive summary

In health-care education, passive immersion within a VR-operated 360-degree setting has increased student engagement. 360-degree VR video is a better replacement for field work in long-term care than a normal video, and is perceived by students as more active participation in the care setting. Attractive education should lead to deeper understanding and longer retention of course content.

2. Introduction

Within the Bachelor of Health Sciences at FHML, associate professor Nynke de Jong has run several pilots to improve practical, real-life experiences for students about different healthcare settings. Students within the course 'Care in Context' experienced health-care issues of patients within their own homes or institutions.

3. Pilot Design

The 360-degree video is integrated into the module 'Care in Context' in which the PBL 'seven-step approach' is applied. It is part of case 5, 'doing for… towards doing with…'. Students complete the first five steps of the seven-step approach, ending with formulating learning goals. Directly after the tutorial group, students watch the 360-degree video (9 minutes) using Virtual Reality (VR) glasses. Afterward, students discuss two questions about the video in small groups. In a 2D video (10 minutes), the story continues. After this session, students study additional resources (e.g., book chapters, journal papers). The learning goals are answered and discussed in the post-discussion based on the videos and the additional resources. During the post-discussion, students can watch fragments of the two videos again (2D format) to strengthen the discussion and explain uncertainties.

4. Outcomes & Analysis

The 360-degree VR experience breaks the PBL routine and affects long-term retention of the experience compared to a 'normal' PBL experience. Some students remarked on the intimate and personal setting of a patient they could witness. Overall, students were positive about using VR glasses in education and saw a surplus value in using this new technology.

5. Recommendations & Future Directions

The piloted VR experience affects student engagement and is seen as an added value about practical experience. In the future, more VR scenarios can be developed to give the student a more active role in choosing different perspectives from different stakeholders.

Appendix B: Tech Lab Establishment Advice Per Faculty

Faculty: FHML, FPN, FSE

Section	**Details/Comments**
Getting Started	
Initial Steps	FHML, FPN, and FSE are exploring the option to establish a VR/tech-lab.
Anticipated Challenges	Start July 2023: Update the VR glasses, I (Nynke) asked FSE and FPN to update their glasses. FPN gave them their glasses, which we also can use, so we do not need to buy new VR glasses. FSE updates their glasses themselves. **Challenge: Diverse Technical Requirements and Expertise** Potential Solution: Each faculty might have different technical requirements for their specific field. To address this, conduct thorough requirement analysis sessions with each faculty to understand their unique needs. Invest in modular and adaptable technology that can cater to a variety of uses. Additionally, provide cross-disciplinary training sessions to help faculty members understand and utilize the full range of technologies available in the lab. **Challenge: Scheduling and Resource Allocation** Potential Solution: A shared lab space can lead to conflicts in scheduling and resource allocation. Implement an efficient booking system that allows faculties to reserve equipment and space in advance. This system should be transparent and equitable to ensure fair access for all. Periodic review meetings can help assess usage patterns and adjust policies as needed to meet evolving demands. **Challenge: Budget and Funding Constraints** Potential Solution: Setting up a VR/tech lab can be expensive due to the cost of cutting-edge technology and ongoing maintenance. Explore various funding sources such as grants, partnerships with industry, and university funds. Consider a phased approach to building the lab, starting with essential equipment and gradually adding more as funds become available. Engaging in collaborative research projects can also attract external funding.
Additional Tips/Best Practices	

Faculty: FHML, FPN, FSE (Continued)

Section	Details/Comments
Infrastructure Requirements	
Space Specifications	E-reality education (= LAB in Duboisdomein 30, room 0.031). In the future, we could explore the need for expanding the VR/tech lab.
Equipment & Technical Needs	I have a technician for questions (not paid – that should be structured). I need money for paying this technician. Now I have to wait too long for an answer sometimes.
Maintenance & Updates	I update the devices myself.
Team Composition	
Required Roles & Expertise	I need a technician. I need money for starting the LAB, so I can give up some other roles. So I can explore collaboration with FPN and FSE. 1. VR Lab Manager/Coordinator (required) Role: Oversee the overall operation of the lab, manage resources, and coordinate between different stakeholders. Skills: Leadership, project management, excellent communication, and familiarity with VR/tech trends. 2. VR Technician (required) Role: Responsible for the setup, maintenance, and troubleshooting of VR equipment and software. Skills: Technical proficiency in VR hardware and software, problem-solving, and an understanding of safety protocols. 3. Educational Specialists (required) Role: Design and develop educational content and programs utilizing VR technology. They may cater to different educational fields (e.g., one specializing in sciences, another in arts). Skills: Background in education or instructional design, understanding of curriculum development, and ability to integrate VR into learning experiences. 4. IT Support Specialist (optional) Role: Ensure the smooth operation of the lab's IT infrastructure, including network management and data security. Skills: Strong IT background, knowledge of networking and cybersecurity, and ability to troubleshoot and resolve technical issues.

Faculty: FHML, FPN, FSE (Continued)

Section	Details/Comments
Team Composition (Continued)	
Required Roles & Expertise (Continued)	5. Content Developer/Designer (optional) Role: Develop immersive content and experiences for VR applications. Skills: Creative skills in digital content creation, proficiency in VR content development tools, and a strong understanding of user experience design. 6. Research and Development Specialist (optional) Role: Conduct research on new VR technologies and methodologies, and develop innovative applications for educational purposes. Skills: Research skills, ability to conduct experiments and analyze data, and staying updated with the latest VR advancements. 7. Administrative/Logistical Support (optional) Role: Handle administrative tasks, scheduling, and logistical aspects of running the lab. Skills: Organizational skills, attention to detail, and proficiency in administrative software. 8. Marketing and Outreach Coordinator (optional) Role: Promote the lab's services, establish partnerships, and manage community outreach programs. Skills: Marketing skills, public relations, and ability to network and build relationships. This team composition aims to cover all essential aspects of running a VR/tech lab, from technical maintenance and educational content development to research, administration, and outreach. The synergy between these roles is crucial for the successful operation and utilization of the lab.
Recruitment/ Training Strategies	
Key Stakeholders	1. Dean or Department Head Role: Provide high-level oversight, secure funding, and ensure alignment with the institution's strategic goals. Involvement: Approving plans, facilitating inter-departmental collaboration, and advocating for resources.

Faculty: FHML, FPN, FSE (Continued)

Section	Details/Comments
Team Composition (Continued)	
Key Stakeholders (Continued)	2. Faculty from Relevant Academic Disciplines Science and Engineering: For technical expertise and integration of VR into STEM education. Arts and Humanities: To explore creative applications of VR and its impact on human experience. Education and Instructional Technology: For insights into curriculum integration and pedagogical strategies. Computer Science and IT: Key for technical development and maintaining the technological infrastructure. Role: Contribute subject matter expertise, guide curriculum integration, and foster research and innovation. Involvement: Developing specific applications of VR in their fields, conducting research, and using the lab for teaching. 3. IT Department Representatives Role: Support the technological infrastructure, network setup, and cybersecurity aspects. Involvement: Ensuring robust and reliable tech support for the lab's operations. 4. Librarians or Information Specialists Role: Assist in managing digital resources and facilitating access to relevant research materials. Involvement: Curating resources, aiding in research, and integrating VR into information literacy programs. 5. Student Representatives Role: Provide a student perspective on usability and educational value. Involvement: Giving feedback on VR experiences, suggesting improvements, and acting as liaisons with the student body.
Securing Funding	
Funding Strategies	**University or Institutional Funding** Approach: Present a detailed proposal to your institution's funding bodies, highlighting the lab's potential benefits for research, teaching, and student engagement. Key Points: Demonstrate how the lab aligns with the institution's strategic goals, potential for cross-disciplinary projects, and long-term value. **Government Grants and Scholarships** Approach: Apply for government-funded grants and scholarships that support technological innovation and education.

Faculty: FHML, FPN, FSE (Continued)

Section	Details/Comments
Securing Funding	
Funding Strategies (Continued)	**Government Grants and Scholarships (Continued)** Key Points: Tailor applications to meet grant criteria, focusing on educational innovation, technology advancement, or specific research areas supported by the grant. **Industry Partnerships** Approach: Collaborate with tech companies or industry partners who might benefit from research or skilled graduates. Key Points: Offer collaborative research opportunities, student internships, and branding opportunities for the companies in the lab. **Research Collaborations** Approach: Partner with other universities or research institutions on joint projects that can attract larger funding. Key Points: Leverage combined expertise and resources to pursue ambitious projects with greater funding potential. **Hosting Events and Workshops** Approach: Host paid workshops, seminars, or conferences related to VR and emerging technologies. Key Points: Attract participants from both academia and industry, providing networking opportunities and showcasing lab capabilities.

Faculty: SBE

Section	Details/Comments
Getting Started	
Initial Steps	• Find seed money and use cases together with your faculty's education institute. • Identifying education funding for tech-enabled education • Having a group of like-minded, entrepreneurial people with research backgrounds as well. • Perform initial marketing activities and have a promotional mindset. • Start looking for a room, processes, and infrastructure.
Anticipated Challenges	• It should not only be relevant for education but also for research: keep dual use always in mind. • Not a must activity for faculty: do cool "instagram-compatible"stuff, always remain seeking support and funding, use network, scale –up on UM level • Many tech initiatives fail: focus on reaching education goals, not tech per se
Additional Tips/Best Practices	Just do it!
Infrastructure Requirements	
Space Specifications	• One room for developing and testing VR environments, and another room for the laboratory space to conduct studies with VR equipment. • Thanks to VR flexibility, educational activities with VR can take place in regular classrooms. However, it is important to have a central location to store all devices, as it enables all course coordinators to gain access to these.
Equipment & Technical Needs	• Workstations with adequate hardware (GPUs, CPUs, RAM etc.) to develop VR environments • License VR software that is relevant for your faculty
Maintenance & Updates	• Staff to maintain software and hardware required • IT support needed to maintain, inventoried, and manage equipment

Faculty: SBE (Continued)

Section	Details/Comments
Team Composition	
Required Roles & Expertise	Lab Manager • to run lab operations, admin, booking, invoicing, communication with relevant stakeholders, develop and host workshops for staff and/or students (and potential outreach activities), marketing of the lab, networking with stakeholders VR Designer (degree in Graphic Design / Interactive Design): • Develop innovative VR designs and concepts that meet project objectives and user needs • Create wireframes, prototypes, and visual designs to illustrate VR concepts and user interactions • Work with cross-functional teams, including developers, UX designers, and project managers to ensure the successful implementation of VR experiences and applications VR Developer (degree in Computer Science or Software Development) • Design and develop VR applications with Unity or Unreal, using programming languages such as C++, JavaScript, Python, etc. • Collaborate with designers, researchers, educators, and stakeholders to create immersive and engaging VR experiences • Test and debug VR applications to ensure they function properly on different platforms and devices
Recruitment/ Training Strategies	Recruit internally at UM
Key Stakeholders	Roles outside the core team: EDIN director, Faculty board, Managing director, IT and facilities, MSCM HoD, ERD, all interested researchers and educators
Securing Funding	
Funding Strategies	Constantly look for funding: Small fundings can add up
Recommended Funding Sources	Education related sources at UM, impact sources from outside UM
Budgeting Tips	Funding sources are seeking for good use, be flexible to adapt to funding source goal if necessary; learn and change own boundaries within the limits of the vision

Faculty: FASOS

Section	Details/Comments
Getting Started	
Initial Steps	Initial idea - Discussions - Whitepaper – Taskforce assigned – Requirements Research & Analysis - Proposal – Discussions with FB – Business Plan – Implementation – Facility renovations – Recruitment of fixed staff – Equipment acquisition - Operational
Anticipated Challenges	Limited availability of space for both storing and using equipment; limited funding for people-power to ensure that the equipment and infrastructure is properly supported
Additional Tips/Best Practices	Involve as many stakeholders as possible throughout the process of ideation and development
Infrastructure Requirements	
Space Specifications	At least one flexible working room, but ideally more permanent space for larger items/more permanent installations
Equipment & Technical Needs	Display screen/speakers/projector, Audio-Video Equipment for filming, podcast microphones & sets, lighting set, microphones and recorders, 3d printers (PLA and resin), 3D scanner and photo boxes, Arduinos and Raspberry Pis, general tinkering and prototyping tools, laptops for use and rental
Maintenance & Updates	Ideal: monthly laptop and desktop maintenance, VR headset updates, testing of 3D printers, cameras, etc.; regular upkeep and tidying of areas; replacement of certain equipment after regular use lifetimes (ie: laptops 3-5 years, etc.)
Team Composition	
Required Roles & Expertise	The team is structured as an Executive Cooperative Group of 6 members (4 academic staff as coordinators and 2 permanent fixed lab staff). Lead Coordinator Education Coordinator Research Coordinator Networking & Outreach Coordinator

Faculty: FASOS

Section	Details/Comments
Team Composition (Continued)	
Required Roles & Expertise (Continued)	Creative Lab Technologist Research Software Engineer There is additionally an ex-officio member from the faculty ICT office and an Academic Advisory Board composed of 5 academic staff members
Recruitment/ Training Strategies	
Key Stakeholders	Faculty Board, Finance Dept., ICTS (FASoS and Central)
Secure Funding	
Funding Strategies	Initial funding was secured from the Faculty Board after presenting a full Business Plan that was approved by the board after some rounds of discussion and modification. In our case we had some fortunate timing with infrastructural funding then becoming available through the Sector Plan – the Faculty Board then asked us to scale up our plans as the key component for digital infrastructural investment at our faculty. Therefore, the Plant is also currently not intensively seeking funding but is exploring strategies for long term financial (self-)sustainability that may involve charging costs connected to use of equipment and expertise in certain circumstances.
Recommended Funding Sources	
Budgeting Tips	• Ensure that the funds for people are enough for running the lab and teaching others about equipment, not just for doing the administration/ordering of the equipment • Focus on what is both currently in use at the faculty and what you think might develop/should be developed for the future • Structuring all or most expenditures in connection with some fixed Deliverables connected to the mission and Business Plan of the facility