Programme: Erasmus+
Action Type: Cooperation partnerships in higher education

Co-funded by the European Union

Project: *Innovative Integration of Virtual Reality in Chemical Engineering Education*

Acronym: *VRChem;* **Project no.:** *2024-1-PL01-KA220-HED-000245347;* **Duration:** *2024-2027*

Report 01

A set of best practices and knowledge to be processed in the curriculum of the Virtual Reality course

Document developed as part of the tasks in the VRChem project:

Work package n°2 - Development of VR course framework, methodology and the train trainer's material

Activity 2.1: Gathering best practices and knowledge to be processed in the curriculum, collection of requirements and regulations relevant to the course

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Date of completion: 20.12.2024

Free publication

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1. Introduction

Chemical engineering is a multifaceted, experiment-driven scientific discipline essential for meeting the demands of rapidly advancing industries, energy-efficient technologies, and in particular environmental protection. Its progress is intrinsically tied to experimental research, which is often constrained by factors such as reaction speed (e.g., excessively long reaction times), high costs, safety concerns, and the unique properties of materials and processes. Additionally, traditional chemical engineering education faces challenges, particularly the lack of opportunities for students to engage with full-scale industrial equipment. This limitation arises from the vast scale of industrial apparatuses, as well as technical and safety constraints, which prevent hands-on experience with real-world systems.

Students in chemical engineering classes predominantly focus on theoretical knowledge, which often poses challenges when it comes to applying these concepts effectively in real-world scenarios. This gap between theory and practice can hinder their ability to develop the practical skills necessary to become competent engineers. Bridging this divide has become increasingly important, especially in the context of rapid technological advancements and the transformative impact of the COVID-19 pandemic on education. The pandemic accelerated the adoption of innovative information and communication technologies in teaching, providing new tools for enhancing learning experiences. Among these, ***virtual reality (VR) technologies*** have emerged as a particularly promising solution. VR offers a highly immersive and interactive environment that engages multiple senses, making it an effective medium for conveying complex information. Its ability to present three-dimensional objects and concepts in a dynamic and visually intuitive manner allows students to ***better understand and visualize intricate chemical engineering processes*** that are often difficult to grasp through traditional methods. By integrating VR into the curriculum, teachers can create engaging, hands-on learning experiences that could simulate real-world scenarios, fostering deeper comprehension and practical competence among students.

Referring to the project ***VRChem: Innovative Integration of Virtual Reality in Chemical Engineering Education*** main objectives, students' VR experiences can make chemical engineering more interesting and allow them to ***develop their skills***, thus stimulating innovative learning and teaching practices. What's more, VR enables students to explore 3D elements engagingly and interactively, offering experiences that are typically limited to traditional teaching methods, such as lectures, textbooks, and videos. These methods often rely on passive absorption of information, which can lead to superficial understanding and limited recall over time. VR, on the other hand, engages students actively by immersing them in interactive, three-dimensional environments that bring abstract concepts to life. In a VR environment, it is possible to create highly realistic and immersive simulations that provide a sense of spatial awareness far surpassing the capabilities of traditional video. One of the ***biggest advantages*** of educational virtual reality is that it reinforces material taught through other channels, which increases the long-term retention of course material.

VR technology also aligns with the goals of advancing digital innovation and promoting sustainability within the higher education sector. By reducing the reliance on physical resources and enabling immersive, interactive learning experiences, VR contributes to a ***greener, more efficient educational ecosystem***. However, the integration of VR into university courses presents significant challenges, particularly for educators unfamiliar with this technology. These challenges include the difficulty of sourcing high-quality VR content that meets pedagogical standards and the need to adapt or develop teaching methodologies to effectively leverage the immersive nature of VR.

To address these issues, the VRChem project aims, among other things, to increase the digital potential at the project partner universities by exchanging experiences in the implementation of VR. This collaborative effort focuses on developing comprehensive resources, high-quality educational materials, and subject-specific VR content. These resources will not only help educators build confidence and expertise in using VR but also ensure that the technology can be seamlessly integrated into the curriculum. By fostering cross-border collaboration and sharing best practices between project partners, educators and students will be empowered to fully realize the benefits of VR technology.

2. Project assignments to be carried out in WP n°2

Implementation the new VR technology into the curriculum at universities ***requires professional support*** from lecturers and researchers who have not previously had experience working in the VR environment. Therefore, within the framework of the "VRChem" project, a framework program for a virtual reality course will be developed, including methodology and training materials for academic teachers. This task is included in project's *Work package n°2 - Development of VR course framework, methodology and the train trainers* in *Activity 2.2 Benchmarking (or catalogue) of best practices, production of the VR course methodology framework and the train-the-trainers material*. The leader of this task will be the METID group from the Polytechnic University of Milan (POLIMI), specializing in the area of teaching methodology using VR. The framework will be structured in form of ***booklet*** with the objective of offering the theoretical basis of the model and guidelines for integration into study courses. Also will be complemented by the train-the-trainers material to support teaching staff and students in getting involved in the framework experimentation.

The participating universities in VRChem project, which possess extensive and valuable experience in VR technology, will collaboratively ***propose*** for further work the content of this document based on their academic expertise. This approach ensures that the proposed content is rooted in proven practices and insights. This activity is part of the project task designated in ***WP n°2 as Activity 2.1:*** Gathering best practices and knowledge to be processed in the curriculum, collection of requirements and regulations relevant to the course.

3. The main assumptions of the document

In collaboration with the project partners, this document outlines internal agreements on the key content deemed essential for inclusion in the educational materials, which was called "***VR Booklet***" for the purposes of the project. This document will serve as a comprehensive resource tailored to the specific needs of the target groups identified through consortium analysis. It will integrate insights from the most effective practices and cutting-edge developments in VR technology, ensuring that the solutions proposed align with current trends and innovations. Special emphasis will be placed on addressing the unique educational requirements within the field of chemical engineering and related disciplines, where complex concepts, processes, and equipment often necessitate advanced teaching tools to enhance understanding and engagement.

By combining theoretical knowledge with practical applications, the document will ***outline*** how VR can be leveraged to bridge gaps in traditional learning methods, such as the inability to access industrial-scale equipment or conduct high-risk experiments. ***It will provide clear guidelines and recommendations*** on designing and implementing VR-based educational modules, including considerations for content quality, technical specifications, and pedagogical methodologies.

Furthermore, the document will highlight ***case studies and examples*** of successful VR applications in chemical engineering education, including but not limited to, offering valuable insights into their impact on student learning outcomes. It will also address potential challenges, such as the cost of VR technology, accessibility issues, and the need for educator training, proposing actionable solutions to overcome these barriers. Ultimately, this resource aims to empower educators, institutions, and stakeholders to harness the transformative potential of VR, fostering a more interactive, immersive, and effective learning environment in chemical engineering and beyond.

4. Target groups

In collaboration with the project partners, using the MS Teams platform and during joint project progress meetings, general target groups and information about the content in the project materials were established. As far as target groups are concerned, it was accepted that in addition to the obvious persons to whom these materials should be directed, i.e. ***students, teachers, trainers and researchers*** in academic institutions, it was also proposed that these materials could be distributed to:

A. Technical staff of universities

They play a key role in preparing classrooms for virtual reality (VR) learning environments, ensuring that both the hardware and software required for immersive experiences are properly set up and maintained. Their responsibilities in this context go beyond simple technical support—they are integral to the successful integration of VR technology into the academic curriculum. These professionals can be involved in:

- setting up and calibrating VR systems, including the installation of headsets, sensors, and interactive equipment necessary for an effective VR experience,
- ensuring that all devices are functioning correctly,
- troubleshoot technical issues,
- providing ongoing maintenance and updates to the systems (configuring software platforms, uploading educational VR modules, ensuring compatibility with the university's IT infrastructure).

This is crucial because VR technology can be complex and requires specialized knowledge to operate and maintain. They also ensure that the VR content aligns with the specific needs of the course, especially in disciplines like engineering, medicine, or architecture, where practical, hands-on simulations are key to student learning.

Moreover, they provide support for educators and students, offering training sessions or guidance on how to use VR equipment effectively. In some cases, they may also assist in the development of VR content or collaborate with academic staff to ensure that the VR experiences are pedagogically sound and enhance the learning objectives.

B. Companies employees specializing in chemical engineering issues

Employees in the chemical industry need to educate themselves in the field of VR for several important reasons, especially as the technology becomes increasingly integrated into industrial and educational applications. First and foremost, VR offers the potential to revolutionize training and simulation processes in chemical engineering and manufacturing environments. Chemical industry professionals can enhance their ability to design and interact with immersive simulations of chemical processes, equipment, and safety procedures, all without the risks associated with real-world operations.

One of the most critical applications of VR in the chemical industry is safety training. Hazardous chemicals, high-risk procedures, and complex equipment often require meticulous safety protocols. VR allows employees to practice handling dangerous materials and managing emergency situations in a controlled, virtual environment. This is a cost-effective and risk-free way to train workers in handling potential hazards.

Moreover, VR enables employees to visualize complex chemical processes in three dimensions, offering a deeper understanding of the dynamics and interactions that occur in reactors, pipelines, and other industrial settings. This enhanced understanding can help optimize process efficiency, reduce errors, and improve troubleshooting capabilities, which is essential in ensuring the smooth operation of chemical plants.

Additionally, as the industry embraces digital transformation, VR is becoming an important tool for product development, design testing, and process optimization. By gaining proficiency in VR, employees can simulate and test new chemical processes or equipment designs before they are physically built, reducing time and costs in the R&D phase. This capability can lead to faster innovation cycles and more effective process engineering. Employees specializing in chemical engineering issues must stay ahead of technological trends to remain relevant and improve productivity. Educating themselves in VR technology allows them to leverage personal career development. Understanding VR is not only a way to enhance skills but also an investment in the future of the chemical industry, where digital tools are set to play an even greater role in improving safety, efficiency, and sustainability.

5. Content proposal to be processed in the curriculum of VR courses

In collaboration with the project partners, using the MS Teams platform and during joint project progress meetings, information on the proposed ***content curriculum of VR courses*** has been established. This jointly developed information is provided below:

1. Best practices of VR applications in higher education.
2. Case studies of VR applications/technology.
3. Methods and pedagogical approaches to VR that can be applied in chemistry classes/curricula.
4. Strengths and weaknesses of VR technology.
5. Guidelines for adapting VR technology in higher education.
6. Base documents for launching VR activities.
7. Guidelines for integration VR into academic courses.
8. Training materials allowing to carry out simple exercises using VR technology.
9. Theoretical basis of VR, Extended (XR), Augmented (AR) and Mixed (MR) reality.
10. Train-the-trainers material to support teaching staff and students in getting involved in VR technology.
11. Sample lesson plans with VR.
12. IT equipment recommended for conducting VR technology courses including hardware requirements.
13. Ethical considerations and accessibility in VR.
14. Evaluation metrics for VR in education.
15. Collaboration in virtual spaces.
16. Gamification and motivation in VR learning.
17. Legal and institutional frameworks for VR.

At the same time, the consortium proposed ***learning outcomes*** of VR Booklet and listed them below:

1. Develop a comprehensive understanding of chemistry and chemical engineering processes and equipment through immersive VR simulations.
2. Apply theoretical knowledge in a practical, virtual environment, enhancing problem-solving and design skills.
3. Acquire practical experience in equipment and process control, safety, and risk management without the constraints of a physical lab.
4. Promote teamwork and collaboration through group VR projects that simulate real-world chemical engineering challenges.
5. Enhance critical thinking and decision-making skills in VR environments.
6. Understand and evaluate the role of VR in modern education and industry.
7. Promote awareness of sustainability and green chemistry through VR scenarios.
8. Improve communication skills through virtual presentations and discussions.

In collaboration with the project partners, ***pedagogical/practical activities*** were proposed:

1. Assignments and/or Quizzes.
2. VR lab performance and reports of the activities.
3. Interactive case studies in VR.
4. Role-playing scenarios in VR.
5. Peer review of VR projects.
6. Team-based problem-solving challenges.
7. Immersive safety training modules.
8. Gamified learning activities.
9. Student-led VR workshops.
10. Prototype testing and iteration.

6. Proposed content of the VR Booklet

In cooperation with consortium project partners, the proposed content curriculum for the VR BOOKLET was developed through discussions on the MS Teams platform and during joint project progress meetings. This document will be the basis for developing more detailed and in-depth information in accordance with project VRChem ***Activity 2.2:*** *Benchmarking (or catalogue) of best practices, production of the VR course methodology framework and the train-the-trainers material* be the METID group from the Polytechnic University of Milan.

VR BOOKLET - TABLE OF CONTENTS - PROPOSAL

This booklet is for university teachers and decision-makers, but also for non-academic staff within operational units in higher education institutions and anybody interested in education processes. It is especially focused, but not limited to, the integration of VR in chemistry and other Science Technology Engineering and Mathematics (STEM) areas.

Executive summary

[Objectives, main target, how the booklet is structured]

1. Virtual Reality: overview and technology

[This chapter offers and introduction to the technology, presenting the existing devices and software orienting. It proposes orienting criteria in the choice of a specific VR technology. Finally, it explores the role of VR in education, presenting inspiring case studies focused on chemistry and STEM field, but not limited to]

This chapter will comprehensively introduce VR, detailing its technological foundations, available devices, and software. Key devices include head-mounted displays such as the Oculus Rift, HTC Vive, and Meta Quest, as well as more affordable options like Google Cardboard and smartphone-based VR. The chapter will cover peripheral technologies, such as motion controllers, haptic gloves, and omnidirectional treadmills, which enhance the immersive experience. The software landscape is equally rich, ranging from game engines like Unity and Unreal Engine to specialized VR development tools that enable the creation of interactive and visually compelling virtual environments. Criteria for selecting specific VR technologies will also be discussed, including cost, compatibility, ease of use, and the intended application—whether for gaming, education, training, or professional simulations.

The chapter will explore VR potential to revolutionize learning, particularly in fields like chemistry and STEM. By allowing students to interact with molecular structures, simulate laboratory experiments, or explore complex systems in 3D, VR creates engaging, hands-on learning experiences that are otherwise challenging or impossible to achieve in traditional settings. Case studies will illustrate how VR teaches abstract concepts, such as chemical bonding, through immersive simulations that enhance understanding and retention.

Beyond STEM, VR is presented as a versatile educational tool that can be adapted for various disciplines, fostering creativity, collaboration, and problem-solving skills. The chapter concludes by reflecting on the future of VR in education, highlighting the need for accessible, scalable solutions to integrate this technology into mainstream learning environments.

1.1 Definition of Virtual Reality

The term *Virtual Reality* is relatively recent, having been introduced into cyberculture for the first time in the early 1980s, in the cinema (The Lawnmower Man), as the concept that describes a reality completely synthesized by digital means. However, several authors, including Oliver Grau, have noted that immersive strategies in visual and artistic media date back to classical antiquity.

Nowadays, Virtual Reality is defined as a three-dimensional, interactive and real-time simulation, synthesized by digital technology that is experienced by the user as if it were the real world, through dedicated hardware such as Head-Mounted Displays (HMD) and electronic sensors.

Virtual Reality, in the context of virtual worlds, cannot be defined without framing it within the family of Extended Reality technologies that includes a range of visualization systems in the virtual continuum from Augmented Reality to Augmented Virtuality.

1.2 Perceptive Immersion in VR

To understand the immersive properties and the uniqueness of Virtual Reality technology compared to other virtual environment visualization systems, it is necessary to analyse how the human perceptual system works in depth vision (3D).

On one hand, ***depth cues*** used by the human perceptual system to judge the depth of visual stimuli can be divided into several criteria. The most important of which are the distinction between monocular and binocular, dynamic and static, and oculomotor and pictorial cues. In this context, it is essential to understand the role that the stereopsis depth cue plays in particularly in the functioning of VR Head-Mounted Displays.

On the other hand, the study of the relationships between the perceptual system and the proprioceptive system allows us to understand some fundamental psychophysiological phenomena and behaviours, of which motion sickness is an example, and which can compromise a good VR user experience.

1.3 Categorizing VR technology

[list of different displays technologies that can be used]

Virtual reality is a sufficiently broad concept to include a good variety of technologies, from visualization systems to different types of content. Based on this last criterion, we can categorize VR content or software into two groups, namely Computer-Generated VR and Video VR.

VR based on computer-generated content consists of complete 3D environments, which may have previously been modelled in specific software, such as Blender, 3D Studio Max or Maya, and generated real time renderings from 3D game Engines, such as Unreal, Unity or Godot.

In turn, video-based VR consists of the 360 viewing of footage produced by special cameras that capture live images. The latter can also be divided into monoscopic Video 360 or Sterescopic Video 360 (also commonly known as 3D Video).

Another criterion for categorizing VR technology is to group systems that offer 3 or 6 degrees of freedom. Some HMDs allow, in addition to the free orientation of the head (3 degrees of freedom), to also capture the user's translational movement in real time (6 degrees of freedom), when the user walks, for example.

Sometimes, in software, the implementation of only 3 degrees of freedom is a deliberate choice of the application design and not any limitation of the hardware system. In certain circumstances, from the point of view of the user's experience, it is more comfortable for the user to remain in a fixed location and be able to simply explore the virtual world by orienting their head. For example, in the case of VR astronomy applications for exploring the night sky, in which the objects of interest are too far away to be explored by walking.

As for Hardware, the most popular category consists of see-through video Head-Mounted Displays, which typically include, in addition to the binocular viewing system, input controllers for interactive exploration of environments. An alternative category to HMDs for exploring immersive virtual environments is the typology known as CAVE. This setup consists of a cube several meters long, and the virtual environment results from six projectors that cast each of the orthogonal views of the virtual world onto its faces. The user is placed inside the cube and in some systems he can wear polarized glasses to view the scene in stereoscopy.

1.4 Software and devices

[Categories of software/devices/ IT equipment recommended for conducting VR technology courses including hardware requirements]

VR technology comprises two key components: hardware and software. To better understand the potential of VR, it's essential to categorise the hardware and software used. This categorisation helps identify the most suitable tools and technologies for different types of applications, from game and simulation development to training and education experiences.

When trying to define each of these components we may define Hardware as the physical devices essential for creating VR experiences, such as headsets, controllers, sensors, and input devices. These elements are crucial for providing immersive VR environments, enabling accurate tracking of user movements and interactions within these environments. The hardware’s characteristics are critical for ensuring realistic and comfortable VR experiences, directly influencing factors such as visual quality and movement precision.

As for the **software** side of VR experiences and their production it encompasses the digital content and programs that underpin the experiences, including VR applications, games, simulations, interactive content, 360° videos, and more. It plays a decisive role in the user experience, providing engaging content, realistic simulations, and interactive scenarios that exploit the capabilities of VR devices. Software development tools and platforms enable creators to design and optimise VR content for various platforms and devices, driving innovation and expanding the possibilities of its application across diverse sectors. Some of the most widely used software for creating immersive VR experiences include Unity, Unreal Engine, 3D Vista, and Krpano.

1.5 VR in education

[VR and learning spaces, engagement, strengths and weaknesses of the technology use in didactics, such as fostering inclusion, favour experimentation without risks and with reduced cost; ethical considerations and accessibility in VR; legal and institutional frameworks, etc.]

In recent years, there has been a tendency in STEM education to design and develop resources that promote experiential and active learning, in contrast to the traditional teacher-centred (passive) approach. Numerous studies have demonstrated that immersion in VR has the potential to enhance learning experiences and improve creativity and engagement. Specifically, the use of this technology has numerous benefits from both teacher and student perspectives.

One of the most significant advantages of VR in engineering education is its capacity to provide immersive and interactive learning environments. Thus, it allows students to move into a virtual environment that would be difficult to show by using traditional teaching resources. The use of these virtual resources would facilitate the design of spectacular activities by incorporating, or linking, these materials with other materials already used in theoretical teaching, that would serve as support. In addition, the novelty and excitement that it creates may lead to greater student engagement and concentration. It allows for personalized learning tailored to individual needs (including disabilities) and, moreover, VR can foster inclusivity by providing equitable and accessible experiences. Besides, one of the most critical applications of VR in the chemical industry is safety training, because hazardous chemicals, high-risk procedures and complex equipment often require meticulous safety protocols. Thus, VR allows viewers to practice handling dangerous materials and managing emergencies in a controlled virtual environment.

However, building a useful virtual environment is a complex process that involves implementing different components, from interactive interface and visualisation to pedagogy, which requires additional time, effort and cost. Various studies have shown that VR can be used to develop immersive learning environments for chemical engineering education, but most of them do not discuss the educational impact on the student. Besides, the need for specialized hardware and software, the digital gap, and ethical considerations related to data privacy and security must be considered. Finally, the RV could include simulation sickness (induced by the shaky movements produced when viewing and navigating) or a sense of isolation, aspects that should be considered in the development of these resources.

1.6 Applications in Higher Education

[Best practices of VR applications in higher education; Meta Platform for higher education applications]

In higher education, VR applications have the potential to revolutionize the learning experience. Best practices include aligning VR experiences with specific learning outcomes, ensuring high-quality immersive content, and fostering active student engagement. By personalizing learning paths and providing realistic simulations, VR can enhance student motivation and retention. Moreover, the integration of VR with collaborative learning tools can promote teamwork and critical thinking. Meta© platforms, such as Horizon Worlds® and Spatial©, offer robust tools for creating virtual classrooms and collaborative spaces, enabling students to interact with each other and virtual content in real-time. On the other hand, Unity© and Unreal Engine© Meta platforms, are more advanced tools for creating highly customised and complex virtual reality experiences. Thus, these platforms, in general provide a flexible framework for educators to design immersive learning experiences that cater to diverse learning styles and promote deep understanding of complex concepts.

Meta© platforms have emerged as powerful tools for educators seeking to leverage the potential of VR in higher education. By providing intuitive interfaces and a wide range of features, these platforms, which differ from each other in their level of complexity and customization, empower educators to create engaging and interactive learning experiences. Key features of Meta© platforms include the ability to design custom avatars, build virtual environments, and incorporate interactive elements such as 3D models and simulations. Furthermore, these platforms often offer robust analytics tools that allow educators to track student engagement and progress, enabling data-driven instructional decisions. Thus, the selection of the platform will depend on specific needs considered.

1.7 Supporting research

Here are some key studies and findings about VR education:

- Pedagogy of Emerging Technologies in Chemical Education during the Era of Digitalization and Artificial Intelligence: A Systematic Review (https://doi.org/10.3390/educsci11110709). In this study, a review of emerging technologies adopted in chemical education is presented, identifying the major types of technologies adopted in chemical education and analyse the empirical findings from relevant studies.

- Virtual laboratories for education in science, technology, and engineering: A review (https://doi.org/10.1016/j.compedu.2016.02.002). This paper summarizes the state of the art in virtual laboratories and virtual worlds in the fields of science, technology, and engineering.

- Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach (http://dx.doi.org/10.1016/j.compedu.2010.05.014). This paper introduces the educational use of Web-based 3D technologies and highlights in particular VR features. In addition, the authors provide two case studies to investigate Virtual Reality Learning Environments for learning purposes.

- Towards design guidelines for virtual reality training for the chemical industry (https://doi.org/10.1016/j.ece.2021.01.014). This work includes the design principles for a virtual reality training environment and can assist in exploring the potential of this virtual environment in the chemical industry from a multidisciplinary perspective.

- Virtual reality in chemical and bio-chemical engineering education and training. (https://doi.org/10.1016/j.ece.2021.05.002). In this study, the authors discusses the opportunities and challenges for the incorporation of virtual reality into chemical and biochemical engineering education with an emphasis on the fundamental areas of technology, pedagogy and socio-economics.

- Use of virtual learning to increase key laboratory skills and essential non-cognitive characteristics (https://doi.org/10.1016/j.ece.2020.07.006). In this work, a virtual bioprocess engineering laboratory was designed to evaluate the possibility of using the virtual laboratory as a learning tool to mitigate practical dilemmas in the chemical engineering curriculum.

2. How to integrate VR into curricula

[This chapter is focused on teachers offering guidelines for VR integration into their courses curricula. It explores the methods and pedagogical approaches to VR]

Integrating Virtual Reality (VR) into the curriculum requires a thoughtful approach that aligns technological potential with pedagogical goals. Teachers must first identify clear educational objectives that VR can uniquely address, such as improving the visualization of complex processes, enabling hands-on practice in a safe environment, or fostering deeper engagement with abstract concepts. For example, in chemical engineering courses, VR can simulate laboratory environments or industrial-scale equipment, allowing students to interact with scenarios that are otherwise inaccessible due to cost, safety, or logistical limitations. This ensures that VR becomes a tool for active learning rather than a supplementary or novelty feature.

Effective integration begins with careful planning. Teachers should familiarize themselves with the available VR tools and platforms, considering both the technological capabilities and content relevance to their subject matter. Collaborating with VR experts, instructional designers, or interdisciplinary teams can help tailor VR applications to specific learning goals. The next step involves designing activities that complement existing teaching methods, such as using VR to reinforce theoretical knowledge or to offer virtual field trips that deepen understanding of real-world applications. It is also essential to provide students with clear guidance on how to use VR tools effectively and to assess their learning outcomes through targeted evaluation methods.

Ultimately, successful VR integration hinges on a balance between innovation and practicality, ensuring that the technology enhances the learning experience without overwhelming either educators or students. A phased approach, starting with pilot implementations and gradually expanding VR's role in the curriculum, allows for iterative improvement based on feedback and observed outcomes.

2.1 Where do I start?

Starting with VR in education can seem daunting for teachers unfamiliar with the technology, making clear guidance essential for successful implementation. Unlike traditional teaching tools, VR introduces unique requirements, such as understanding the hardware, software, and the immersive nature of this medium. Educators need foundational knowledge about how VR works, its capabilities, and its limitations to make informed decisions about its integration into courses. Without this information, there's a risk of misusing VR—either by overestimating its potential or failing to leverage its unique strengths effectively.

A crucial part of this process is planning the physical setup of classrooms to ensure safe and effective VR experiences. Spatial configuration plays a vital role in enabling seamless and collision-free interactions among students. For seated VR experiences, arranging desks with adequate spacing between participants prevents disruptions caused by overlapping virtual environments. If the session involves standing or movement-based VR interactions, the room must have ample free space to allow users to move safely within their designated areas. Clearly marked boundaries or physical indicators, such as mats or taped zones, can help ensure students remain within their VR play areas, reducing the risk of collisions.

Safety considerations should also address the proper use of VR equipment, including headset adjustments to prevent discomfort and guidelines for managing cables to avoid tripping hazards. Educators must also anticipate the form of immersion required for the activity—whether seated, standing, or involving physical movement. For instance, simulations that require walking or gestures may necessitate open spaces and additional monitoring to maintain safety. Establishing a protocol for pausing or exiting VR experiences in case of disorientation or motion sickness is equally important. By addressing these spatial and safety considerations upfront, educators can create an environment that fosters immersive and engaging learning while prioritizing student well-being.

2.2 Intended Learning Outcomes

[Introduction to the concept and its value for learning design. How to formulate ILOs on knowledge acquisition but also on the development of digital, spatial and psychomotor competences through VR; lesson plan]

Integrating VR into curricula requires a strategic approach that aligns the immersive potential of VR with the specific educational goals of a course. Teachers should begin by identifying aspects of their subject matter that benefit most from visualization, interactivity, and experiential learning. For example, in chemical engineering, VR can simulate dangerous or resource-intensive processes, allowing students to explore scenarios that would otherwise be inaccessible. By targeting specific learning outcomes, such as improving spatial understanding of chemical reactors or visualizing molecular dynamics, teachers can use VR as a complementary tool that enhances traditional teaching methods rather than replacing them.

Pedagogical approaches should emphasize active learning, where students engage directly with VR environments to solve problems, conduct virtual experiments, or explore 3D models. Teachers can create hybrid lesson plans that incorporate VR alongside lectures, discussions, and hands-on activities to provide a well-rounded educational experience. It’s also critical to consider accessibility and inclusivity, ensuring that VR activities are suitable for students with varying levels of technical proficiency and physical abilities. For example, offering seated VR options or alternative visualizations can make the experience more accommodating. Regular feedback from students can further help in refining VR-based activities, ensuring they meet educational goals effectively while maintaining engagement.

Finally, professional development for educators plays a crucial role in successful integration. Teachers should be provided with resources and training to understand VR tools and their potential applications in teaching. Collaboration with interdisciplinary teams, such as instructional designers and VR specialists, can help develop tailored content and overcome technical challenges. By combining thoughtful planning, pedagogical creativity, and technical support, VR can become a transformative component of modern curricula, offering students immersive, engaging, and practical learning experiences.

2.3 Assessment tasks

[The value of assessment and how the tasks may change when VR is integrated in curricula with examples enriched with practical advice, rubrics]

Integrating VR into curricula transforms not only how content is delivered but also how student learning is assessed. Traditional assessment methods, such as written tests or reports, may not fully capture the depth of understanding or skills developed through immersive experiences. VR provides unique opportunities to design assessment tasks that are interactive, practical, and aligned with real-world applications. For example, in a chemical engineering VR module, students could be tasked with operating a virtual distillation column, troubleshooting errors, or optimizing processes in a simulated plant. These tasks assess not only theoretical knowledge but also problem-solving skills, spatial awareness, and the ability to apply concepts in a realistic context.

To ensure effective evaluation, rubrics should be adapted to reflect the specific competencies VR-based tasks aim to develop. For instance, a rubric for a VR laboratory experience might include criteria such as the accuracy of task completion, adherence to safety protocols, efficiency in solving problems, and the ability to interpret and analyse simulation data. Practical advice for educators includes clearly communicating these criteria to students beforehand, providing step-by-step instructions for VR activities, and incorporating formative assessments that allow for feedback and improvement during the learning process.

Moreover, educators should consider using a mix of assessment methods to capture different dimensions of learning. For example, VR tasks can be complemented by reflective journals where students document their experiences, challenges, and learning outcomes, or by group discussions to encourage collaboration and deeper understanding. By embracing the unique affordances of VR, assessments can become more dynamic, engaging, and representative of the skills needed in professional practice.

2.4 Teaching and Learning Activities (TLAs)

[Pedagogical frameworks that can be used to (re)design TLAs for VR, such as problem-based learning, inquiry-based learning, learning, Kolb cycle. Examples of teaching and learning activities that can be proposed in virtual labs. VR and modalities (hybrid and blended learning)]

Redesigning teaching and learning activities (TLAs) for VR requires leveraging pedagogical frameworks that emphasize active and experiential learning. Frameworks such as problem based learning (PBL), inquiry based learning (IBL), and Kolb's experiential learning cycle are particularly well-suited for VR integration. For example, PBL in VR can immerse students in a virtual lab where they are tasked with diagnosing and resolving process inefficiencies in a chemical plant. This approach encourages critical thinking, teamwork, and application of theoretical knowledge in a simulated real-world context. Similarly, IBL can guide students through exploratory activities, such as investigating the behaviour of molecular interactions in a virtual simulation, fostering curiosity and self-directed learning.

Kolb's experiential learning cycle—comprising concrete experience, reflective observation, abstract conceptualization, and active experimentation—aligns naturally with VR. For instance, students might engage in a VR-based lab experiment (concrete experience), discuss their observations with peers or instructors (reflective observation), relate findings to theoretical concepts (abstract conceptualization), and apply this knowledge in a subsequent simulation to test hypotheses (active experimentation). These cycles deepen understanding and retention while building practical skills.

VR also enhances the versatility of TLAs by supporting hybrid and blended learning modalities. In hybrid setups, students can prepare for VR activities through online modules, such as watching instructional videos or completing pre-lab quizzes, before engaging in immersive simulations during in-person sessions. Blended learning can combine VR with traditional tools, such as using virtual labs for initial experiments and physical labs for validation. This multimodal approach ensures flexibility, accessibility, and comprehensive learning experiences. By incorporating well-established pedagogical frameworks and utilizing VR's unique capabilities, educators can create TLAs that are engaging, effective, and aligned with modern educational goals.

2.5 VR Onboarding Challenges

[Guidance to ensure that instructors and learners are equipped with the knowledge and skills to engage with VR (training, communication, support)]

During the VR onboarding process, it is important to ensure that both instructors and learners are well-equipped with the knowledge and skills to engage with VR to engage with virtual reality (VR). In the case of instructors, training sessions must be organized to familiarize them with VR technology, providing opportunities for instructors to use VR tools themselves to gain confidence and proficiency, also giving training on how to integrate VR into lesson plans effectively, aligning with learning objectives. Instructors may have access to the necessary VR hardware and software, and to a support system or IT staff that may help them with VR-related queries. It is advisable to involve instructors in the planning process to incorporate VR activities into the curriculum, encouraging flexibility in adapting VR activities to meet the diverse learning needs.

Regarding the learners, it is highly recommended to conduct initial orientation sessions to introduce students to VR technology, including basic operations and safety guidelines. It is also advisable to provide access to tutorials, guides, or instructional videos to help students navigate VR environments. After the orientation session, it is important to schedule at least one practice session where students can familiarize themselves with VR tools before engaging in course-related activities. In order to detect the main difficulties and possible improvements, stablish any feedback mechanisms for students to provide feedback on their VR experiences.

2.6 First steps for educators

[Rules of thumb - sort of 10 golden rules (derived from hands-on practice) for teachers to have in mind when concretely organize the activity once designed]

The use of VR in higher education courses can be highly beneficial, but it requires careful planning and execution. The main golden rules for teachers to consider, among others, could be:

1. Onboarding on VR may need a lot of time and effort from teachers if they have not previous experience with the VR equipment and software, and especially if it is intended to create the VR material and activities by their own.
2. Only integrate VR in a course if the benefits in the learning process justifies its use and compensate the requirements mentioned in the first rule. VR should enhance understanding, not just be a novelty.

3. Ensure that instructors are equipped with the knowledge and skills to engage with VR
4. Make sure that VR activities are aligned with the course's learning objectives and outcomes.
5. Try to use the potential of VR to bridge the gap between theoretical knowledge and practical application (hands-on experience).
6. All students must have access to the necessary VR equipment and software, either setting up VR labs or providing loaner devices.
7. Give students clear, step-by-step instructions on how to use the VR tools. This can include tutorials, guides, and practice sessions before diving into VR.
8. Collect feedback from students about their VR experiences. Use this feedback to make improvements and ensure the VR activities are meeting educational goals.
9. Balance VR and Traditional Methods. While VR can be a powerful tool, it should complement, not replace, traditional teaching methods, so use blended approaches to maximize learning outcomes.
10. Avoid using VR in excess during a session or course, addressing any potential health concerns related to prolonged VR use.

2.7 Supporting research

There is a growing research supporting the use of VR in higher education, including Chemical Engineering courses. Here are some key studies and findings:

- The Impact of Virtual Reality in Education: This study explores the potential benefits, challenges, and implications of using VR in education. (https://link.springer.com/chapter/10.1007/978-3-031-50204-0_11). It highlights VR's ability to engage students on a deeper level, facilitate immersive learning experiences, and improve knowledge retention.

- Immersive Virtual Reality as a Pedagogical Tool in Education: A systematic literature review examining experimental studies on VR's learning outcomes (https://link.springer.com/article/10.1007/s40692-020-00169-2). Most studies found significant advantages of using VR, although some of them highlight the need for assessment measures.

- 20 Years of Research on the Use of Virtual Reality in Education: This analysis reviews 20 years of research on VR in all stages of teaching, including higher education. (https://newsroom.wiley.com/press-releases/press-release-details/2021/20-Years-of-Research-on-the-Use-of-Virtual-Reality-in-Education/) . It highlights the increasing adoption of VR in educational institutions and its potential to improve teaching methods.

These studies collectively suggest that VR can enhance student engagement, facilitate hands-on learning, and improve learning outcomes when integrated effectively into the curriculum. Furthermore, there are several studies focusing on the application of VR in Chemical Engineering education. Some examples not belonging to the professors of this Project are:

- "Virtual Reality in Chemical and Biochemical Engineering Education and Training": (https://research.tue.nl/en/publications/virtual-reality-in-chemical-and-biochemical-engineering-education). This paper explores the opportunities and challenges of incorporating VR into Chemical Engineering education. The study highlights the importance of novel educational impact assessment methodologies for evaluating VR-based learning.

- "Mass Effect: A Chemical Engineering Education Application of Virtual Reality Simulator Technology". (https://www.academia.edu/87775424/Virtual_reality_in_chemical_and_biochemical_engineering_education_and_training). This work explores the use of advanced three-dimensional virtual environment technology to create realistic online virtual environments for educational purposes. It includes a case study on the implementation of a VR learning environment which simulates the configuration and operation of a polymerization plant.

3. Run VR learning experimentation, the Polytechnic University of Milan experience

[This chapter is mainly for university decision-makes considering piloting a VR project and provides step-by-step guidance deriving from Polytechnic University of Milan (POLIMI) experience and research to facilitate the adoption of VR by considering the specific context of

an HEI, modalities, strengths and weaknesses, evaluation methodologies and activities, monitoring approaches and tools]

3.1 Building up VR Labs

[Info and first steps for decision makers to start organizing a VR Lab inside the university; arguments here are related to the two past years' experience of POLIMI into its laboratories equipped with VR headsets, in relation to the processes for which POLIMI VR Labs are born, infrastructures and devices used, other entities inside the university involved into the VR Labs mechanism, materials and tools shared in between colleagues coordinating the Labs]

3.2 VR-enhanced classes at POLIMI

[Departments, courses, specific lessons here are reported to inform the reader on the use of the Labs from students and teachers into university, and to understand insights from the displacement of these lessons; specific focus will be given to chemistry classes in the Labs]

3.3 Monitoring and evaluating tools

[Evaluation process of the experience and material that can be re-used to better coordinate the working process of the VR Labs: tools such as tables, forms, questionnaires, impact assessment reports are given. Includes iterative improvements through monitoring and evaluation metrics. Info become useful to be replicated in different contexts.]

3.4 Supporting research

4. Training materials for VR classes

[Documents and materials for training teachers and students in using VR environments and devices in Labs]

Training materials for VR classes are essential to ensure both teachers and students are well-equipped to utilize VR environments and devices effectively. Virtual Reality introduces a unique set of tools and interactions that differ significantly from traditional teaching and learning methods. Without proper guidance, users may face challenges in understanding how to operate VR hardware, navigate virtual environments, or leverage the full potential of immersive learning. Comprehensive materials, such as user manuals, tutorial videos, and interactive guides, help bridge this gap by providing step-by-step instructions and best practices for integrating VR into classroom activities.

For teachers, these materials enable them to design engaging and meaningful lessons that align with the course objectives while effectively using VR technology. They offer insights into pedagogical approaches tailored for VR, such as how to facilitate student engagement in virtual labs or assess learning outcomes in immersive scenarios. For students, training materials reduce the learning curve associated with VR technology, allowing them to focus on mastering the subject matter rather than struggling with technical barriers. By empowering both educators and learners, these resources foster confidence, improve the adoption of VR technologies, and ensure a smoother integration of immersive experiences into the curriculum.

4.1 Students Vademecum

[POLIMI open and ready to use VR tutorial for students that can be edited by the user to be adapted to his/her context + video]

4.2 Teachers Vademecum

[Train the trainers guidelines developed by POLIMI for teachers and educators working inside the VR labs, to elaborate content lessons into VR displacement]

7. VR Case Studies of Project Partners

This chapter will present materials prepared by the VRChem project partners regarding VR-related activities that have been implemented or are currently being implemented at the consortium universities.

01 Case study - University of Aveiro		
GENERAL	**Name of the initiative**	ChemXP: engaging organic chemistry students with two serious games that integrate mixed reality technologies
	Year(s) of activation	2023-2024
	Country/city/university	Portugal, Aveiro, University of Aveiro
	Discipline	Chemistry Classes
	Devices and software used	Oculus Quest 2, Smartphones
	Platform hosting the activity	No data
	Number of students in-volved	20
VR	**Brief description of the initi-ative**	ChemXP is a project developed by a multidisciplinary team, in-volving researchers from Multimedia Communication, Com-puter Science and Chemistry, from the University of Aveiro and University of Oviedo, which resulted in an educational experi-ence carried out in the classroom and a master's thesis. This project centres on the creation and evaluation of two seri-ous games utilizing mixed reality technologies (MR) — aug-mented reality (AR) and virtual reality (VR) — to enhance stu-dent engagement in Organic Chemistry exercises. Both games focus specifically on the task of determining the R/S absolute configuration of enantiomers. The AR game features diverse missions, a narrative, a tutorial, badges, and a physics-based molecular creation tool, while the VR game incorporates unique mechanics, including special powers.
	Brief description on how on boarding activity is orga-nized	Two Serious Games were developed, one in Augmented Reality and the other in Virtual Reality with the aim of helping students understand the process of identifying molecules in terms of their enantiomer's configuration. The usability of the games was tested with 1st year Chemistry students at the University of Aveiro using smartphones for the AR Game and the HMD Quests II for the VR gaming experience.
	Software and Hardware	Unity 3D, Blender, Vuforia, XR Interaction Toolkit, Android Smartphone, Quest II
EDUCA-TION	**Intended Learning Out-comes**	R/S configuration of enantiomers

	Specific Learning field	Organic Chemistry
	Soft skills developed	No data
	Resources used in the activity	Smartphone, VR HMD Quest II
	Assessment tasks (if any)	Usability Test to assess
OTHER	**URL of reference**	https://maridany.itch.io/chemxp-factory
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://youtu.be/zJ5mttZwCd8 https://ria.ua.pt/handle/10773/42094 https://www.youtube.com/watch?v=KIEOCaAw65o https://link.springer.com/chapter/10.1007/978-3-031-51452-4_23
	Any other comments	No

02 Case study - University of Aveiro		
GENERAL	**Name of the initiative**	ANNA - InterActive Narrative for Virtual Reality Reminiscence Therapy
	Year(s) of activation	2021- present (to be concluded in 2025)
	Country/city/university	University of Aveiro, Aveiro (UA) Portugal
	Discipline	Doctoral Thesis Research - Doctoral Program in Information and Communication in Digital Platforms
	Devices and software used	Meta Quest 2 with Application developed in Unity
	Platform hosting the activity	No platforms.
	Number of students involved	The doctoral student researcher, Pedro Reisinho, supervised by Rui Raposo, Nelson Zagalo and Óscar Ribeiro, has involved various students in multiple stages and tasks of the project (i.e.: literature and state-of-the Art revision, prototype testing, field trials with people with Dementia). He has also conducted therapeutical sessions with 8 people and exploratory sessions with another 8.
VR	**Brief description of the initiative**	ANNA - InterActive Narrative for Virtual Reality Reminiscence Therapy explores the potential of using immersive 360º VR videos about personal stories with people with Dementia as a non-pharmacological solution for stimulating oral communication, through storytelling, in people with mild Dementia.

	Brief description on how on boarding activity is organized	The students who participated and are participating in the study are either associated through curricular undergraduate and post-graduate projects (master dissertations). In the case of the participants with Dementia, these are initially interviewed and assessed as to the clinical profile with the help of a trained Psychologist personal stories are also collected. The stories collected are used to create content for the personal immersive experience for the therapeutical sessions. Each user is then introduced to the technology used and the experience prepared with content regarding their personal memories. The users explore the content and are asked to share stories regarding the content. Through a set of sessions users share their stories and their oral communication capabilities are stimulated. With this project Pedro Reisinhos expects to prove that by using 360º VR videos to stimulate the sharing of stories, the loss of communication capacities will slow down and help keep, for as long as possible
	Software and Hardware	2 Meta Quest 2 + 2 workstation (PC, mouse, monitor, gamepad).
EDUCATION	**Intended Learning Outcomes**	Understand the state of the art in UX design for VR applications. Develop proposals for UX, interface and interaction components of the ANNA application. Develop UX evaluation skills in immersive VR experiences. Identify and explore current trends in the context of immersive VR experiences.
	Specific Learning field	Human-Computer Interaction, Pshychology, Interaction and UX Design
	Soft skills developed	Communication, design thinking
	Resources used in the activity	None
	Assessment tasks (if any)	No assessment tasks for the students involved except the Doctoral Student that has to hand in his thesis.
OTHER	**URL of reference**	https://dl.acm.org/doi/abs/10.1145/3673971.3674011
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	
	Any other comments	This project has the potential to become an interesting therapeutical tool for working with people with Mild Dementia and Mild Cognitive Disorders.

03 Case study - University of Aveiro		
GENERAL	**Name of the initiative**	Phobias VR - Use of Virtual Reality Storytelling game to help user overcome specific phobias
	Year(s) of activation	2017 - present day
	Country/city/university	Portugal, Aveiro, University of Aveiro
	Discipline	Clinical and behavioural psychology, Serious Games
	Devices and software used	Unity 3D, XR Interaction Toolkit, Oculus GO, Meta Quest II, Meta Quest Pro.
	Platform hosting the activity	Various platforms
	Number of students involved	~30
VR	**Brief description of the initiative**	This line of research involves a multidisciplinary team, with researchers from DigiMedia (Multimedia Communication area), the Department of Psychology, the University of Aveiro and a private Clinical Psychology office in the city of Aveiro. The objective is to investigate and carry out a set of activities to study the potential of narrative and playful immersive environments, in VR, in teaching psychology and treating phobias. The results obtained are a set of functional VR prototypes, which can be used by teachers, students and clinical psychology professionals in the treatment of specific phobias.
	Brief description on how on boarding activity is organized	The prototypes are developed and subjected to different types of evaluation, involving students, teachers and Clinical Psychology professionals. So far, 3 different games have been created for different types of specific phobias: - Fear of the dark, 2020-2021 - Animal Phobia (Bees), 2022-2024 - Airplane phobia, 2021 - present These prototypes are used as examples of serious games in curricular units of the Master in Digital Game Development at the University of Aveiro and in pedagogical initiatives in the field of psychology.
	Software and Hardware	Unity 3D, Blender, XR Interaction Toolkit, Quest II, Quest Pro & Quest III
EDUCATION	**Intended Learning Outcomes**	Psychology area (students, teachers and clinical psychology professionals): Familiarize with progressive exposure therapy as a therapeutic strategy in the treatment of phobias and anxiety conditions. Multimedia Students: Study the use of storytelling and ludology in VR simulation environments.
	Specific Learning field	Clinical and behavioural psychology, Serious Games
	Soft skills developed	Teamwork, social and communication skills

	Resources used in the activity	Computer, VR Headset - Quest II, Pro, III
	Assessment tasks (if any)	No data
OTHER	**URL of reference**	No data
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://doi.org/10.21125/inted.2021.1621 https://doi.org/10.3390/virtualworlds2040018 https://doi.org/10.1109/SeGAH61285.2024.10639582
	Any other comments	No data

04 Case study - University of Aveiro		
GENERAL	**Name of the initiative**	Just Another Cooking Game
	Year(s) of activation	2020 - present (to be concluded in 2025)
	Country/city/university	University of Aveiro, Aveiro (UA) Portugal
	Discipline	Doctoral Thesis Research - Doctoral Program in Information and Communication in Digital Platforms
	Devices and software used	Meta Quest 2 with Application developed in Unity
	Platform hosting the activity	Side Quest, Meta Store, itch.io
	Number of students involved	The doctoral student researcher, Rúben Carvalho, supervised by Rui Raposo and Mário Vairinhos, has not involved students aside from the doctoral student. It is relevant to outline that it has been download over 280000 times all over the world.
VR	**Brief description of the initiative**	Just Another Cooking Game is a game developed with a research purpose where the goal is to understand what variables (i.e.: sound, quality of the graphics, gameplay, etc) influence the sense of immersion and presence. The game includes a questionnaire split into 4 moments that provides information regarding the users' experience of playing the game. It is relevant to outline that each time the same user starts the game one of the above-mentioned variables is randomly chosen and changed.
	Brief description on how on boarding activity is organized	The game was made available on multiple platforms such as Side Quest, Meta Store and itch.io for users all over the world to download and use the game on their own HMD. After the game was installed users were informed that by accepting the conditions presented in the term of agreement some data would be collected for research purposes. Each time the user begins a new game the application randomly changes a variable that would be tested as to its influence on the sense of immersion and presence. After playing a level the user is asked to answer a small set of questions. This happens during the first 4 levels and then the

		user is granted access to the rest of the 12 levels of the game for free. The data collected is then compiled for analysis by the researcher on an excel sheet that guarantees user anonymity through the random attribution of a 8 character non-retractable code.
	Software and Hardware	Unity for development and compatible with Quest HMD
EDUCATION	**Intended Learning Outcomes**	Understand the state of the art in UX design for VR applications. Understand the implications the GDPR has on the collection of data from applications hosted in non-European servers. Understand the influence of specific variables on the sense of immersion and presence in VR games. Understand the potential and limitations of integrating questionnaires withing immersive experiences.
	Specific Learning field	Human-Computer Interaction, Psychology, Interaction and UX Design
	Soft skills developed	Communication, design thinking
	Resources used in the activity	Users' own HMD device
	Assessment tasks (if any)	Questionnaire that collects the user's opinion regarding multiple issue linked to immersion and presence
OTHER	**URL of reference**	https://sidequestvr.com/app/23468/just-another-cooking-game
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://www.youtube.com/watch?v=EOL2UuQCdi8 ; https://www.altlabvr.com/just-another-cooking-game
	Any other comments	The number of downloads has surpassed 280k and the number of completed questionnaires (4 parts) has surpassed 100k. This clearly shows that the methodology used is worth looking into for other projects with a research purpose.

05 Case study - University of Aveiro		
GENERAL	**Name of the initiative**	Extended Reality Lab
	Year(s) of activation	2024
	Country/city/university	Aveiro
	Discipline	Various Disciplines
	Devices and software used	4 Workstations, Unity, Unreal Engine, Godot, Blender, Substance Painter
	Platform hosting the activity	No data
	Number of students involved	30

VR	**Brief description of the initiative**	The laboratory functions as a space for the confluence of research and teaching interests in the area of immersive environments, especially VR.
	Brief description on how on boarding activity is organized	Equipped with several workstations that allow modelling, animating and producing Virtual Reality environments, undergraduate students coexist with master's and doctoral students, teachers and senior researchers. The space is conceptually divided into two functional areas. The arena consists of a free area, measuring 18 m^2, without any furniture, ideal for students, researchers and teachers to carry out user tests or present demonstrations in VR. In the adjacent area, there are several workstations and cabinets for accessing VR equipment.
	Software and Hardware	No data
EDUCATION	**Intended Learning Outcomes**	The program content involved in labXR teaching activities is diverse and includes several Disciplines/Courses: - Immersive 3D Environments (Undergraduate, Multimedia) - 3D Modelling and Animation (Undergraduate, Multimedia, Master in Digital Game Development) - New Media (Ph.D. in New Media) - Cyberculture (Undergraduate, Multimedia) - Education and Technology (Ph.D., Education) - Audiovisual Production for New Media (Master)
	Specific Learning field	Various fields, grom education, IT, Human-Computer Interaction, Psychology, Interaction and UX Design, Multimedia, New Media
	Soft skills developed	Teamwork, social and communication skills
	Resources used in the activity	4 Workstations, VR systems (HTC Vive, Quest I, II, III, Pro, Holense, Dreamworld, Oculus GO), Aging Simulation Suit, GERT, Vuze 360 Sterescopic Camera, Insta 360 Pro2.
	Assessment tasks (if any)	
OTHER	**URL of reference**	No data
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	No data
	Any other comments	No data

06 Case study - University of Cádiz		
GENERAL	**Name of the initiative**	Virtual visits to practice laboratories for chemical engineering degree
	Year(s) of activation	2021-ongoing
	Country/city/university	University of Cádiz, Puerto Real, Spain
	Discipline	Chemical Engineering
	Devices and software used	360° camera One X, recording accessories, drone, Insta360 Studio software
	Platform hosting the activity	You tube
	Number of students in-volved	High school students visiting the Faculty in an open-day for orientation about the UCA grades.
VR	**Brief description of the initi-ative**	Organisation of virtual reality specific workshop in the Hall of Faculty of Sciences.
	Brief description on how on boarding activity is orga-nized	Instructors involved are divided into several task forces in-volved in the organizational process: - 1 structure dedicated to the methodological and educational aspects of the virtual visit experiences. - 1 structure dedicated to prepare a leaflet with VR instructions to set their mobile phone and VR glasses for the VR activity. - 1 other structure to the recording videos in the laboratories (general views and focus on different experimental plants) - 1 dedicated to the technical support (editing, assembly and supervision of content) -1 structure dedicated to organization of the specific seminar VR with the high school students
	Software and Hardware	360° camera One X, Virtual Reality Head-Mounted-Display (HMD SHINECON 3D) and mobile phone
EDUCATION	**Intended Learning Out-comes**	The student should be able to: - View the Campus and Faculty of Sciences from the viewpoint of a drone. - Have immersion in different facilities where undergraduates of the chemical engineering grade are carrying experimental work during their lab practices. - Gain basic information about the Grade and learning areas in practices.
	Specific Learning field	Chemical Engineering
	Soft skills developed	Spatial visualization and Motivation
	Resources used in the ac-tivity	UCA Dron service
	Assessment tasks (if any)	final survey about specific content showed
OTH ER	**URL of reference**	https://youtu.be/2GTQ1kEOfjY

	Any other external resource (initiative, evaluation reports of the initiative, etc...)	This VR activity is one of the results obtained from the UCA sol-202100203746-tra project.
	Any other comments	This activity was included in the communication in the congress EDULEARN22 "Virtual reality activities to promote the chemical engineering degree to high school audiences. The 14th annual International Conference on Education and New Learning Technologies. Palma de Mallorca (Spain), 4-6th of July, 2022. This activity was included in the paper "Manuel J. Díaz, Casimiro Mantell, Ildefonso Caro, Ignacio de Ory, Jezabel Sánchez, Juan R. Portela. Creation of Immersive Resources Based on Virtual Reality for Dissemination and Teaching in Chemical Engineering. Education Science. 2022, 12(8), 572; https://doi.org/10.3390/educsci12080572".

07 Case study - University of Cádiz		
GENERAL	**Name of the initiative**	Virtual visits to research laboratories related to the Chemical Engineering Master
	Year(s) of activation	2021-ongoing
	Country/city/university	University of Cádiz, Puerto Real, Spain
	Discipline	Chemical Engineering
	Devices and software used	360° camera One X, recording accessories, drone, Insta360 Studio software
	Platform hosting the activity	You tube
	Number of students involved	Undergraduate and graduate students can use VR as an extra activity during a seminar for orientation about the UCA Chemical engineering Master
VR	**Brief description of the initiative**	Organisation of virtual reality specific activity after a Seminar for information about de Chemical Engineering Master
	Brief description on how on boarding activity is organized	Instructors involved are divided several task forces involved in the organizational process: - 1 structure dedicated to the methodological and educational aspects of the virtual visit experience - - 1 structure dedicated to prepare a leaflet with VR instructions to set their mobile phone and VR glasses for the VR activity. - 1 other structure to the recording videos with general views in the laboratories - 1 dedicated to the technical support (editing, assembly and supervision of content) -1 structure dedicated to organization of the specific seminar VR with the undergraduate and graduate students
	Software and Hardware	360° camera One X, Virtual Reality Head-Mounted-Display (HMD SHINECON 3D) and mobile phone

EDUCATION	**Intended Learning Outcomes**	The student should be able to: - Have immersion in different research laboratories related to the subjects of the chemical engineering Master. - Gain basic information about the research areas carried out in those labs
	Specific Learning field	Chemical Engineering
	Soft skills developed	Spatial visualization and Motivation
	Resources used in the activity	No data
	Assessment tasks (if any)	Final survey about specific content showed
OTHER	**URL of reference**	https://www.youtube.com/watch?v=JB4F32qm280
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	This VR activity is one of the results obtained from the UCA sol-202100203746-tra project.
	Any other comments	This activity was included in the paper "Manuel J. Díaz, Casimiro Mantell, Ildefonso Caro, Ignacio de Ory, Jezabel Sánchez, Juan R. Portela. Creation of Immersive Resources Based on Virtual Reality for Dissemination and Teaching in Chemical Engineering. Education Science. 2022, 12(8), 572; https://doi.org/10.3390/educsci12080572"

08 Case study - University of Cádiz

GENERAL	**Name of the initiative**	Virtual visit to the Faculty of Sciences for diffusion in the European Night of Researchers
	Year(s) of activation	2021-ongoing
	Country/city/university	University of Cádiz, Puerto Real, Spain
	Discipline	Science, technology and Engineering
	Devices and software used	360° camera One X, recording accessories, drone, Insta360 Studio software
	Platform hosting the activity	You tube
	Number of students involved	General public of all ages visiting the activities of the European Night of Researchers
VR	**Brief description of the initiative**	Organisation of virtual reality specific activity at the street
	Brief description on how on boarding activity is organized	Instructors involved are divided several task forces involved in the organizational process: - 1 structure dedicated to the methodological and educational aspects of the virtual visit experiences - - 1 structure dedicated to prepare a leaflet and two posters for the VR activity and with the outline of the content to be seen. - 1 other structure to the recording videos in the campus and Faculty facilities

		- 1 dedicated to the technical support (editing, assembly and supervision of content) -1 structure dedicated to organization of the activity in the street
	Software and Hardware	360° camera One X, Virtual Reality Head-Mounted-Display (HMD SHINECON 3D) and mobile phone
EDUCATION	**Intended Learning Outcomes**	The student should be able to: - View the Campus and Faculty of Sciences facilities, practices laboratories and research laboratories - First contact with the University and basic information about the studies and the environment that would use as students
	Specific Learning field	A contact with facilities related to Science, Technology and Engineering
	Soft skills developed	Spatial visualization and Motivation
	Resources used in the activity	UCA Dron service
	Assessment tasks (if any)	None
OTHER	**URL of reference**	https://youtu.be/jPR58gs118I?si=02YFlcvHS9gs72tw
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	This VR activity is one of the results obtained from the UCA sol-202100203746-tra project.
	Any other comments	This activity was included in the communication in the congress EDULEARN22 "Virtual reality activities to promote the chemical engineering degree to high school audiences. The 14th annual International Conference on Education and New Learning Technologies. Palma de Mallorca (Spain), 4-6th of July, 2022.

09 Case study - University of Cádiz		
GENERAL	**Name of the initiative**	Virtual visits to wastewater treatment plant
	Year(s) of activation	2023-ongoing
	Country/city/university	University of Cádiz, Puerto Real, Spain
	Discipline	Chemical Engineering and Environmental Technologies
	Devices and software used	360° camera One X, recording accessories, drone, Insta360 Studio software
	Platform hosting the activity	You tube
	Number of students involved	Students enrolled in different subjects and levels in the Degrees of Chemical Engineering, Biotechnology and Industrial

		Engineering. Total impact in one academic course more than 100 students.
VR	**Brief description of the initiative**	Organization of virtual reality specific seminars in the classroom
	Brief description on how on boarding activity is organized	instructors involved are divided several task forces involved in the organizational process: - 1 structure dedicated to the methodological and educational aspects of the virtual visit experiences - 1 other structure dedicated to the contact with the wastewater company - 1 other structure to the recording images in the wastewater plant - 1 dedicated to the technical support (editing, assembly and supervision of content) -1 structure dedicated to selection of subjects and organization of specific seminars de VR with the students, where virtual visits are showed.
	Software and Hardware	360° camera One X, Virtual Reality Head-Mounted-Display (HMD SHINECON 3D) and mobile phone
EDUCATION	**Intended Learning Outcomes**	The student should be able to: - recognise the main steps of the process in the correct sequence. - identify the equipment involved in the wastewater treatment process.
	Specific Learning field	Chemical Engineering and Environmental Technologies
	Soft skills developed	Spatial visualization; Creativity and Motivation; Environmental awareness
	Resources used in the activity	
	Assessment tasks (if any)	Final survey about specific content showed
OTHER	**URL of reference**	Still in editing process (expected date for finalisation and organisation of seminars during the academic year 24/25).
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	This case study is one of the results obtained from the UCA sol-202300256882-tra project.
	Any other comments	some of the references used in this study: https://doi.org/10.1021/acs.jchemed.8b00728; https://doi.org/10.1016/j.ece.2018.11.005

10 Case study - University of Cádiz		
GENERAL	**Name of the initiative**	Virtual visits to winery industry
	Year(s) of activation	2023-ongoing
	Country/city/university	University of Cádiz, Puerto Real, Spain
	Discipline	Chemical Engineering and Food Technologies
	Devices and software used	360° camera One X, recording accessories, drone, Insta360 Studio software
	Platform hosting the activity	You tube
	Number of students involved	Students enrolled in different subjects and levels in the Degrees of Ecology, Biotechnology and Chemical Engineering. Total impact in one academic course more than 100 students.
VR	**Brief description of the initiative**	Organization of virtual reality specific seminars in the classroom
	Brief description on how on boarding activity is organized	instructors involved are divided several task forces involved in the organizational process: - 1 structure dedicated to the methodological and educational aspects of the virtual visit experiences - 1 other structure dedicated to the contact with the winery company - 1 other structure to the recording images in the plant - 1 dedicated to the technical support (editing, assembly and supervision of content) -1 structure dedicated to selection of subjects and organization of specific seminars de VR with the students, where virtual visits are showed.
	Software and Hardware	360° camera One X, Virtual Reality Head-Mounted-Display (HMD SHINECON 3D) and mobile phone
EDUCATION	**Intended Learning Outcomes**	The student should be able to: - recognise the main steps of the process in the correct sequence. - identify the equipment involved in the wine production.
	Specific Learning field	Chemical Engineering and Food Technology
	Soft skills developed	Spatial visualization; Creativity and Motivation;
	Resources used in the activity	No data
	Assessment tasks (if any)	Final survey about specific content showed
OTHER	**URL of reference**	Still in editing process (expected date for finalization and organization of seminars during the academic year 24/25).

	Any other external resource (initiative, evaluation reports of the initiative, etc...)	This case study is one of the results obtained from the UCA sol-202300256882-tra project.
	Any other comments	

11 Case study - Cracow University of Technology		
GENERAL	**Name of the initiative**	Laboratory VR WIL
	Year(s) of activation	2024-now
	Country/city/university	Poland / Cracow / Cracow University of Technology
	Discipline	Civil engineering
	Devices and software used	13 VR stations, Core i7 13700K/32GB RAM/1TB SDD/nVidia RTX A2000 12GB RAM workstations, plus two monitors and 13 Quest 2 256MG
	Platform hosting the activity	Revit, Navisworks Manage
	Number of students involved	From 10 to 50 (early stage of cooperation with students)
VR	**Brief description of the initiative**	Various teaching scenarios will be implemented for the BIM specialization, e.g. for visualizing projects in 3D, verifying design assumptions and checking how the designed object will look like and whether it is simply well designed.
	Brief description on how on boarding activity is organized	No data
	Software and Hardware	Oculus Quest 2 256MG, Revit, Navisworks Manage, BIM360 Design
EDUCATION	**Intended Learning Outcomes**	Familiarizing the audience with new technologies for designing and managing building information in Building Information Modelling (BIM) processes using the most popular BIM in VR systems
	Specific Learning field	BIM (Building Information Modelling)
	Soft skills developed	teamwork, spatial orientation, dealing with design problems, team communication; responsiveness; creativity
	Resources used in the activity	3D plans of construction objects
	Assessment tasks (if any)	Checking industrial installations for correct alignment, searching for collisions, spatial visualization of objects, spatial mapping, point cloud usage
OTHER	**URL of reference**	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=5332:na-politechnice-krakowskiej-powstalo-laboratorium-vr-kolejna-pracownia-wspomagajaca-nowoczesne-ksztalcenie&catid=49&lang=pl&Itemid=1152

	Any other external resource (initiative, evaluation reports of the initiative, etc...)	No data
	Any other comments	No data

12 Case study - Cracow University of Technology

GENERAL	**Name of the initiative**	Virtual Welding Simulator VRTEX 360
	Year(s) of activation	2021-now
	Country/city/university	Poland / Cracow / Cracow University of Technology
	Discipline	Civil engineering; Materials engineering; Mechanics and machine construction
	Devices and software used	1 station VRTEX® 360 Compact K4914-1
	Platform hosting the activity	Lincoln electric
	Number of students involved	About 50 every academic year
VR	**Brief description of the initiative**	The simulator helps in learning the basics of the arc welding process and enables the acquisition of so-called muscle memory, i.e. practicing correct hand movements, in order to, among other things, maintain the correct angle of the torch and the direction of its movement. The device gives users the opportunity to familiarize themselves with advanced welding processes, several process techniques using many types of welded materials - basic and additional. Students learn about different types of joints and settings of welding devices, etc. And all this at a low cost, because without actual consumption of materials and with reduced energy consumption. A very useful function of the simulator is also the possibility of using several training modes: presentation of the settings of the "real" device, job instructions, lesson mode, so-called demo welding (showing a perfectly made joint), hint mode during virtual welding, virtual bending test (allows immediate assessment of the correctness of the welded joint) or repetition mode. - Thanks to this last functionality, the student and his supervisor can follow the virtual welding process from the beginning, check where he made mistakes and easily correct them.
	Brief description on how on boarding activity is organized	No data
	Software and Hardware	VRTEX® 360 Compact K4914-1; REDWELD Welding Simulator
EDUCATION	**Intended Learning Outcomes**	Learning welding techniques, learning the basics of the arc welding process; learn about different types of welding equipment connections and settings

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	Specific Learning field	Welding processes; Materials Science
	Soft skills developed	Process data analysis; Creativity; Results-oriented; Planning from settings and finding mistakes;
	Resources used in the activity	VRTEX® 360 Compact K4914-1; REDWELD Welding Simulator
	Assessment tasks (if any)	Practicing correct hand movements during welding, selecting welding process parameters, analysing welding errors like: - Insufficient penetration, - Slag containment, - Undercut, - Porosity, - Poor bead placement, - Convex, Concave, - Wrong welding size, - Excess Spatter, - Melt/Blow through.
OTHER	**URL of reference**	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=3734:wirtualny-symulator-spawania-pomaga-studentom-politechniki-krakowskiej&catid=49&lang=pl&Itemid=944
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://www.youtube.com/watch?v=iBwKd6fIRH0 https://www.weldsimulator.com/?gad_source=1&gclid=CjwKCAiA6t-6BhA3EiwAltRFGJgNPR_9r7IgsHXz-mAFfpPY3vIKm6_sSX5G4dL2G98rWI3izMWI23RoCY-WEQAvD_BwE
	Any other comments	No

13 Case study - Cracow University of Technology		
GENERAL	**Name of the initiative**	Grundfos Water Laboratory
	Year(s) of activation	2024 - ongoing
	Country/city/university	Poland / Cracow / Cracow University of Technology
	Discipline	Environmental engineering
	Devices and software used	Quest 2 256MG; Grundfos SynergyXR
	Platform hosting the activity	No data
	Number of students involved	25 (every academic year)

VR	**Brief description of the initiative**	The stand allows for the simulation of the operation of installations for the transport of sewage and the distribution of water. It can be used to test digital solutions in the field of water supply regulation prepared by Grundfos. The lab is fully adapted to virtual reality training. Students, female and male students and other users will be able to, for example, virtually visit various water installations from Poland and beyond. The VR software also includes a package of Grundfos product models and the systems that manage them, in order to train new employees of the company and the company's partners.
	Brief description on how on boarding activity is organized	No data
	Software and Hardware	Oculus Quest 2 256MG, Grundfos SynergyXR
EDUCATION	**Intended Learning Outcomes**	Develop advanced knowledge of the principles of environmental engineering; Investigate, analyse and synthesise complex information, problems, concepts and theories and to apply established theories to different bodies of knowledge or practice in environmental engineering; Model and evaluate complex ideas and concepts; Well-developed problem-solving abilities in in Environmental Engineering
	Specific Learning field	Environmental engineering, process control, water supply systems
	Soft skills developed	Teamwork, dealing with design problems, team communication
	Resources used in the activity	Grundfos SynergyXR
	Assessment tasks (if any)	In preparation…
OTHER	**URL of reference**	https://www.facebook.com/reel/880275327470235
	Any other external resource (initiative, evaluation reports of the initiative, etc…)	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=5399:laboratorium-wodociagowe-grundfos-dla-politechniki-krakowskiej-tu-teoria-spotyka-praktyke&catid=49&lang=pl&Itemid=1152
	Any other comments	No data

14 Case study - Cracow University of Technology		
GENERAL	**Name of the initiative**	VR in Project Based Learning
	Year(s) of activation	2022 - ongoing
	Country/city/university	Poland / Cracow / Cracow University of Technology
	Discipline	Industrial design engineering
	Devices and software used	Oculus Quest 2 256MG
	Platform hosting the activity	no data
	Number of students involved	25 (every academic year)

VR	**Brief description of the initiative**	The initiative aims to create a space for students of industrial design engineering to work on projects in the Project Based Learning formula.
	Brief description on how on boarding activity is organized	No data
	Software and Hardware	Oculus Quest 2 256MG
EDUCATION	**Intended Learning Outcomes**	Student will be able to individually formulating the problems criteria and setting connections with other research groups; Student will be able to work with others in task-orientated groups participating and interacting in the group in a productive manner and lead and manage design or production projects
	Specific Learning field	Industrial design engineering
	Soft skills developed	Teamwork, dealing with design problems, team communication, Creativity; Results-oriented;
	Resources used in the activity	Quest 2 256MG
	Assessment tasks (if any)	No data
OTHER	**URL of reference**	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=4286:studenci-inzynierii-wzornictwa-przemyslowego-moga-od-dzis-korzystac-z-wielofunkcyjnej-nowoczesnej-sali&catid=49&lang=pl&Itemid=1152
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	No data
	Any other comments	No data

15 Case study - Cracow University of Technology		
GENERAL	**Name of the initiative**	Accessibility training ground
	Year(s) of activation	2024 - ongoing
	Country/city/university	Poland / Cracow / Cracow University of Technology
	Discipline	Architecture
	Devices and software used	Oculus Quest 2 256MG
	Platform hosting the activity	No data
	Number of students involved	25 (every academic year)

VR	**Brief description of the initiative**	Accessibility Training Ground is an educational path that is a compendium of information for architects on the biggest and most common infrastructural obstacles faced by people with disabilities. The main assumption of the "Accessibility Training Grounds" was to create an educational space in the form of a kind of obstacle course, where students could check, as part of the classes, which solutions improve, and which worsen the use of the designed space.
	Brief description on how on boarding activity is organized	No data
	Software and Hardware	Oculus Quest 2 256MG
EDUCATION	**Intended Learning Outcomes**	Ability to make thoughtful decisions in the fields of architecture; Student knows and understands structural, constructional, and engineering problems associated with designing buildings; Student knows problems of physics, technology, and functions of buildings in the scope enabling to guarantee comfort of their utilisation
	Specific Learning field	Accessibility in architecture
	Soft skills developed	Empathy and Cultural Awareness; Planning and organizing; Creativity and Design Thinking; Problem-Solving; Attention to Detail; Adaptability and Flexibility
	Resources used in the activity	Oculus Quest 2 256MG
	Assessment tasks (if any)	Accessibility testing
OTHER	**URL of reference**	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=5453:tor-przeszkod-ktory-pomoze-architektom-projektowac-bardziej-dostepne-miejsca-studentki-pk-stworzyly-poligon-dostepnosci&catid=49&lang=pl&Itemid=1152
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	No data
	Any other comments	No data

16 Case study - Lodz University of Technology		
GENERAL	**Name of the initiative**	Polish-Japanese Hackathon for Autism Rehabilitation
	Year(s) of activation	2024
	Country/city/university	Poland (Lodz University of Technology) and Japan (Shibaura Institute of Technology)
	Discipline	Robotics, Immersive Technologies, Autism Rehabilitation
	Devices and software used	- Devices: VR Headsets (Meta Quest Pro, 3), robotic components (Raspberry Pi, Arduino kits, sensors)

		- Software: Unity 3D, Blender, Python, Arduino IDE, proprietary robotics control software
	Platform hosting the activity	Design4All, Building A7, Lodz University of Technology
	Number of students involved	42 (6 teams of 7 students)
VR	**Brief description of the initiative**	The hackathon focused on designing innovative solutions using robotics and immersive-interactive VR technologies to support children with autism spectrum disorder (ASD). Students collaborated in mixed teams, creating prototypes aimed at improving motor skills and social interactions.
	Brief description on how on boarding activity is organized	Participants underwent an onboarding session introducing VR and robotics basics, team collaboration tools, and the project goals. This included tutorials on using VR development software (Unity) and hardware setup for robots and sensors.
	Software and Hardware	- Software: Unity 3D, Blender, Oculus SDK, Arduino IDE - Hardware: Meta Quest 3 VR headsets, robotic arms, motorized platforms, motion sensors (IMU), and custom-built controllers
EDUCATION	**Intended Learning Outcomes**	- Develop an understanding of how immersive technologies and robotics can address therapeutic challenges for individuals with ASD - Learn to design user-centered solutions based on target user needs - Integrate VR and robotics systems into cohesive prototypes
	Specific Learning field	- Robotics and mechatronics - Virtual Reality application development - Therapeutic and assistive technology design
	Soft skills developed	- Cross-cultural teamwork - Problem-solving and creativity - Communication and user-centered design thinking
	Resources used in the activity	- Tutorials and documentation for Unity and Oculus SDK - Online databases for research on ASD - Feedback from therapists, educators, and parents
	Assessment tasks (if any)	- Final presentation of prototypes with live demonstrations - Peer and mentor evaluations based on innovation, usability, and therapeutic impact
OTHER	**URL of reference**	https://design4all.p.lodz.pl
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://p.lodz.pl/uczelnia/aktualnosci/na-pl-polsko-japonski-hackathon
	Any other comments	This hackathon exemplified the potential of international collaboration and interdisciplinary approaches in addressing real-world challenges. It showcased the synergy between technology, creativity, and empathy, with the ultimate goal of making a meaningful difference in the lives of children with autism.

17 Case study - Lodz University of Technology

GENERAL	**Name of the initiative**	Immersive Testing Sessions with PhD Students
	Year(s) of activation	2023
	Country/city/university	Portugal (University of Aveiro)
	Discipline	Virtual Reality Applications in Scientific Research and Education
	Devices and software used	- Devices: Meta Quest 2, high-performance VR-ready PCs - Software: Unity 3D, academic VR applications for scientific visualization
	Platform hosting the activity	DigiMedia Research Center, University of Aveiro
	Number of students involved	15 (PhD students from various disciplines)
VR	**Brief description of the initiative**	The testing sessions aimed to explore the application of VR in enhancing research methodologies, educational practices, and experimental simulations across diverse scientific fields. Immersive environments were tailored to specific disciplines, enabling participants to evaluate the potential of VR in their academic work.
	Brief description on how on boarding activity is organized	Participants attended introductory sessions to familiarize themselves with VR hardware and software, including hands-on training in using immersive environments relevant to their research fields. The onboarding also included a demonstration of best practices for interacting with virtual environments.
	Software and Hardware	- Software: Unity 3D and custom-developed VR tools - Hardware: Meta Quest 2 headsets, motion controllers, and desktop VR systems
EDUCATION	**Intended Learning Outcomes**	- Understand the practical applications of VR in scientific research - Evaluate the usability and impact of immersive environments in experimental simulations - Identify opportunities for interdisciplinary collaboration through VR
	Specific Learning field	- Virtual Reality and Simulation Technologies - Data Visualization in Scientific Research - Interactive Learning Environments
	Soft skills developed	- Critical thinking and feedback analysis - Collaboration across diverse academic disciplines - Adaptation to emerging technologies
	Resources used in the activity	- Customized VR environments specific to each participant's research focus - Online documentation and tutorials for Unity and Unreal Engine - Access to the University of Aveiro's VR labs and DigiMedia resources
	Assessment tasks (if any)	- Qualitative feedback from participants on the relevance and usability of VR environments

		- Post-session surveys and group discussions to evaluate the impact of VR on research methodologies
OTHER	**URL of reference**	
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://dimendx.wordpress.com/
	Any other comments	This initiative showcased the transformative power of VR as a tool for scientific research and interdisciplinary collaboration. The feedback from participants will drive further development and integration of VR technologies in academic settings, paving the way for innovative advancements in research and education.

18 Case study - Lodz University of Technology		
GENERAL	**Name of the initiative**	Summer School on Empathetic and Universal Design (Mr. UD Project)
	Year(s) of activation	2022
	Country/city/university	Portugal (Porto, Instituto Superior de Engenharia do Porto)
	Discipline	Universal Design, Accessibility, Empathy in Design
	Devices and software used	- Devices: Meta Quest 2 headsets, Standard design tools and assistive technologies (e.g., accessibility simulators) - Software: Adobe Creative Suite, Figma, prototyping tools, and accessibility testing platforms
	Platform hosting the activity	On-campus facilities and design labs of Instituto Superior de Engenharia do Porto
	Number of students involved	25 (designers and engineers)
VR	**Brief description of the initiative**	The summer school introduced participants to the principles of universal design, emphasizing the importance of empathy in understanding user needs using VR experiences. Hands-on workshops and collaborative projects explored accessibility challenges and solutions in real-world contexts.
	Brief description on how on boarding activity is organized	Participants began with an introduction to the fundamentals of universal design, followed by interactive demonstrations of accessibility tools and techniques. Onboarding also included empathy exercises, such as simulations of physical and sensory limitations, to build understanding.
	Software and Hardware	- Software: Accessibility testing tools, digital design platforms (e.g., Figma, Adobe XD) - Hardware: HMD Meta Quest 2, Assistive devices and simulators for accessibility challenges

EDUCATION	**Intended Learning Outcomes**	- Develop a deeper understanding of universal design principles - Learn to create inclusive, user-friendly solutions that address diverse user needs - Foster empathy and human-centered thinking in design practices
	Specific Learning field	- Universal Design and Accessibility - Human-Centered Design - Empathy in Engineering and Architecture
	Soft skills developed	- Collaborative problem-solving - Empathy and user perspective analysis - Communication of inclusive design concepts
	Resources used in the activity	- Real-world case studies in accessibility challenges - Interactive workshops and group exercises - Materials on universal design principles and best practices
	Assessment tasks (if any)	- Design challenges and presentations focusing on accessible solutions - Peer and mentor evaluations of empathy-driven design approaches
OTHER	**URL of reference**	https://mrud.p.lodz.pl/
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://voxellab.pl/mrud/
	Any other comments	This summer school bridged technical expertise with a human-centered approach, empowering participants to design for inclusivity and equality. By fostering empathy and collaboration, the program highlighted how design can create a positive societal impact and ensure accessibility for all.

19 Case study - Lodz University of Technology

GENERAL	**Name of the initiative**	Summer School on Immersive Soft Skills Training (ATOMIC Project)
	Year(s) of activation	2021
	Country/city/university	Croatia (Šibenik, Hosted by ATOMIC Consortium)
	Discipline	Immersive Technologies, VR/AR for Education, Soft Skills Development
	Devices and software used	- Devices: VR headsets (Meta Quest, HTC Vive), AR glasses, motion tracking systems - Software: Custom VR training applications, collaborative AR platforms, Unity 3D
	Platform hosting the activity	On-site immersive labs in Šibenik
	Number of students involved	30 (diverse group of professionals and students)

VR	**Brief description of the initiative**	The summer school focused on testing immersive VR and AR tools designed for soft skills training. Participants engaged in hands-on sessions exploring dynamic scenarios to improve communication, teamwork, and problem-solving abilities.
	Brief description on how on boarding activity is organized	Participants were introduced to the VR and AR tools through an onboarding session that included a tutorial on using immersive hardware and software. This was followed by a guided walkthrough of the training scenarios to ensure familiarity with the environment and objectives.
	Software and Hardware	- Software: Custom-built VR applications for soft skills scenarios, AR collaboration platforms, Unity-based simulations - Hardware: Meta Quest, HTC Vive Pro, AR glasses, motion tracking systems
EDUCATION	**Intended Learning Outcomes**	- Evaluate the effectiveness of VR/AR tools in enhancing soft skills such as communication, teamwork, and problem-solving - Gain hands-on experience in immersive environments replicating real-world challenges - Provide feedback to improve the usability and effectiveness of immersive tools
	Specific Learning field	- Soft skills training through immersive technologies - VR/AR applications in professional development and education - Scenario-based learning in virtual environments
	Soft skills developed	- Communication and interpersonal skills - Collaboration in team-based settings - Problem-solving in complex, dynamic scenarios
	Resources used in the activity	- Immersive VR and AR environments tailored to specific training scenarios - Feedback forms and focus groups for participant evaluation - Academic resources on VR/AR integration in education
	Assessment tasks (if any)	- Performance evaluations during VR/AR scenarios (e.g., decision-making and collaboration outcomes) - Feedback collection through surveys and post-session discussions
OTHER	**URL of reference**	https://atomic.p.lodz.pl/
	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://atomic.p.lodz.pl/man/ https://p.lodz.pl/en/about-tul/press-releases/virtual-reality-real-education
	Any other comments	This summer school demonstrated the transformative potential of VR and AR in training critical soft skills. By providing participants with engaging, interactive, and realistic scenarios, the program underscored the value of immersive technologies in revolutionizing education and professional development. Insights from this initiative will drive future improvements and broaden the integration of VR/AR tools into diverse learning and training contexts.

20 Case study - Lodz University of Technology

GENERAL	**Name of the initiative**	Immersive Technology Workshops for High School Students
	Year(s) of activation	2023
	Country/city/university	Poland, Lodz, Lodz University of Technology
	Discipline	Virtual Reality, Augmented Reality, Educational Technology
	Devices and software used	- Devices: VR headsets (Meta Quest Pro/2, HTC Vive), AR-capable devices (smartphones, AR glasses) - Software: Unity 3D, educational VR/AR applications
	Platform hosting the activity	Voxel Research Lab, TUL
	Number of students involved	50+ high school students
VR	**Brief description of the initiative**	This initiative introduced high school students to the transformative potential of immersive technologies in education. The workshops provided hands-on experiences with VR and AR, showcasing how these tools can make learning more interactive and engaging across various subjects.
	Brief description on how on boarding activity is organized	Students participated in an introduction to immersive technologies, including tutorials on using VR and AR devices. This was followed by guided exploration of educational simulations and virtual environments, along with creative exercises to design basic VR/AR content.
	Software and Hardware	- Software: custom-built educational VR apps - Hardware: Meta Quest Pro/2, HTC Vive, AR glasses, and smartphones
EDUCATION	**Intended Learning Outcomes**	- Develop an understanding of the practical applications of VR and AR in education - Explore immersive simulations in fields such as science, history, and creative arts - Cultivate digital literacy and a creative mindset
	Specific Learning field	- Educational applications of VR and AR - Digital content creation and interaction - Technological innovation in education
	Soft skills developed	- Creativity and critical thinking - Problem-solving and exploration skills - Collaboration and digital confidence
	Resources used in the activity	- Pre-designed educational simulations and virtual environments - Basic tutorials for VR/AR content creation - Access to online platforms like CoSpaces EDU for hands-on exercises
	Assessment tasks (if any)	- Creative projects using VR/AR tools - Feedback on learning outcomes and engagement levels
O H	**URL of reference**	

	Any other external resource (initiative, evaluation reports of the initiative, etc...)	https://www.facebook.com/VoxelResearch-Lab/posts/pfbid02Q3ZwS69bv5isGmaoi6paJuTsHiH6jrhBP-SnYvhzMjoUhp6mC4Nfd6734VgDTvaRel https://www.interschool.uni.lodz.pl/
	Any other comments	These workshops provided a platform to inspire young minds and demonstrate the potential of immersive technologies in reshaping education. By engaging students with hands-on experiences, the initiative emphasized the importance of innovation, creativity, and digital literacy in preparing the next generation for a technology-driven future.

8. Links/materials that can be used in VR Booklet

In collaboration with the consortium project partners, links/materials that can be used in the prepared curriculum are listed below:

No.	Link:
1	https://youtu.be/iBwKd6fIRH0
2	https://www.pk.edu.pl/index.php?option=com_content&view=article&id=3734:wirtualny-symulator-spawania-pomaga-studentom-politechniki-krakowskiej&catid=49&lang=pl&Itemid=944
3	https://hyresponder.eu/
4	https://www.sciencedirect.com/science/article/pii/S0925753523002205?ref=pdf_download&fr=RR-2&rr=8df658245821bf49
5	https://www.ixrlabs.com/individual-module/thermal-power-plant#
6	https://www.uploadvr.com/sideloading-quest-how-to/
7	https://charming-etn.eu/2022/03/21/charming-apps/
8	https://www.sciencedirect.com/science/article/pii/S1093326323002048
9	https://zenodo.org/records/8252314
10	https://www.sciencedirect.com/science/article/pii/S1749772821000324
11	https://www.sciencedirect.com/science/article/pii/S1749772821000142
12	https://www.sciencedirect.com/science/article/pii/S2666188824001734
13	https://www.meta.com/pl-pl/experiences/the-vr-chemistry-lab/3919613214752680/
14	https://www.meta.com/pl-pl/experiences/mimbus-chemistry/25650020844613280/
15	https://www.meta.com/pl-pl/experiences/surrey-vr-chemical-plant/5841022942613827/
16	https://www.x-visual.com/en/visio-3d/
17	https://link.springer.com/chapter/10.1007/978-3-031-51452-4_23
18	https://doi.org/10.1016/j.ece.2021.05.002
19	https://doi.org/10.1039/D1RP00317H
20	https://doi.org/10.1007/978-3-031-05675-8_4
21	https://doi.org/10.1007/978-3-030-78361-7_2
22	https://doi.org/10.3390/educsci11110709
23	MoleculARweb
24	Possibilities of Learning Contemporary Chemistry via Virtual Reality