Revealing: Realisation of Virtual Reality learning environments for higher education

Manual for VR-powered lessons

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Manual for VR-powered lessons

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INTRODUCTION

Welcome to the "Manual for VR-powered Lessons", a comprehensive guide developed as part of the Erasmus project REVEALING. This manual represents the culmination of extensive research and collaboration among partner institutions, aimed at empowering Higher Education Institutions (HEIs) with the tools and knowledge to effectively integrate Virtual Reality Learning Environments (VRLEs) into their teaching practices.

The manual is designed for HEI instructors and educators who are either new to VR technology or seeking to deepen their expertise. It provides clear, detailed instructions on how to utilize various VR tools, such as VRChat, VRLE 3D models, and Head-Mounted Displays (HMDs). With almost 200 pages of content divided into 10 modules, this manual covers all aspects necessary for implementing VR in educational settings.

Each module serves as a learning unit, offering step-by-step guidance on the technical and pedagogical aspects of VRLEs. You will find basic technical information about foundational VR technologies, including their capabilities and limitations, as well as instructions on using VRLE-related equipment. The manual covers essential topics such as accessing and navigating VR environments, interacting with virtual objects, and performing common classroom activities in a virtual setting.

Beyond technical skills, the manual also addresses social and behavioral guidelines for VRLEs. It provides insights into acceptable social behavior, communication strategies, and managing personal space within virtual worlds. Additionally, there are practical tips for adapting traditional teaching materials for VR use, ensuring that lectures and presentations are both effective and engaging in a virtual context.

The development of this manual aims to enhance the digital skills of both VR-literate and non-literate instructors, enabling them to seamlessly transition their teaching practices into VRLEs. By offering concrete guidelines and practical examples, this manual will help educators create high-quality learning experiences that leverage the unique affordances of virtual reality.

One of the key objectives of this manual is to fill a significant gap in the availability of comprehensive, practical information on VRLEs for HEI instructors. By making this manual publicly available, we aim to support the wider adoption of VR technology in education, contributing to the sustainability and transferability of the project's results across various educational contexts.

We hope that this manual will serve as a valuable resource for educators looking to innovate their teaching practices and enhance their students' learning experiences through the power of virtual reality.


MODULES – CONTE

MODULE 1
Introduction to the VRLEs

Virtual Reality

Virtual Reality and Mixed Reality are nowadays widely used for the creation of Virtual Reality Learning environments (VRLEs). According to Milgram and Kishino (1994), both Virtual Reality and Mixed Reality are part of the Reality-Virtuality Continuum, which is a scale for categorizing the combination of digital information and the real world. In the Reality-Virtuality Continuum, the real environment is placed at its left-hand end, while the virtual environment, which refers to a fully synthetic computer-generated environment, is placed at its right-hand end.

Starting at the left end of the continuum, moving towards the virtual environment, and gradually increasing the involvement of digital information in the real world, the first region to emerge from the combination of the two is that of Augmented Reality. Augmented reality applications are based on the real environment, in which a digital overlay is then applied. Starting from the virtual environment this time, moving towards the real environment, the next area of the continuum refers to Augmented Virtuality. The area between these two extremes refers to any combination of the real and the virtual environment. environment, thus defining the area of Mixed Reality.

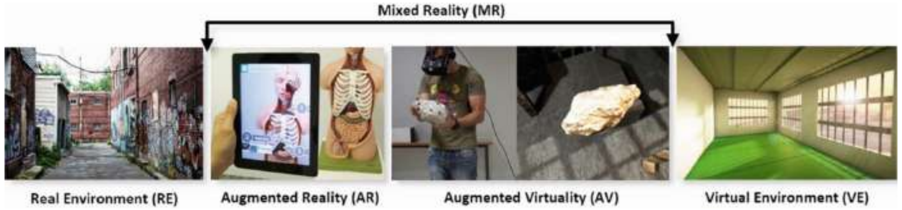

Figure 1. Reality-Virtuality Continuum

The aforementioned technologies often promise to provide high levels of user immersion. User immersion can be broadly defined as the subjective feeling of being immersed in a virtual or mixed reality environment. Nevertheless, a more objective scale for measuring immersion is based on the system itself and its ability to engage human senses to make users feel immersed in a virtual world. Thus, Virtual Reality can be further categorized in non-immersive, semi-immersive, and immersive systems.

Non-immersive Virtual Reality

In non-immersive virtual reality, users experience a virtual world through a window while still being aware of their real-world surroundings. Examples include interactions through desktop computers and gaming consoles, where the virtual environment is displayed on a screen while users remain connected to their physical environment.

Semi-immersive Virtual Reality

Semi-immersive virtual reality expands the window to the virtual world, offering larger and more sophisticated displays and interaction technologies. For instance, pilot training systems utilize large screens and joysticks to simulate aircraft control, providing a more immersive experience than non-immersive VR while still allowing users to maintain some awareness of their surroundings.

Immersive Virtual Reality

Immersive virtual reality fully immerses users in the virtual environment, typically achieved through the use of head-mounted displays (HMDs) with integrated screens that track the user's head movements in real-time. Additionally, motion controllers enable users to interact with objects in the virtual world, mirroring their hand movements in the real world. This level of immersion creates a sense of presence where users feel fully immersed in the virtual environment, with minimal awareness of their physical surroundings.

Virtual Reality Learning Environments (VRLEs)

VRLEs refer to applications that utilize virtual reality technology to offer interactive learning experiences. Suck environments employ VR headsets, computer-generated simulations, and other related technologies to transport learners into digital worlds where they can explore, interact with objects, and engage in educational activities.

Typical VRLEs include the design and development of:

Virtual Labs: simulating laboratory environments, allowing students to conduct experiments and learn about scientific concepts without needing physical lab equipment. Virtual labs are common in science and engineering education.

Language Learning VRLEs: immersing students in virtual environments where they can practice speaking and listening in different languages.

Historical and Cultural Exploration VRLEs: allowing students to explore historical periods or cultural settings by virtually visiting for example ancient civilizations, historical events, or famous landmarks.

Simulations for Professional Training VRLEs: widely used for professional training in fields like healthcare, aviation, military, and first responders.

Soft Skills and Leadership Training VRLEs: increasingly used for developing soft skills like communication, leadership, and teamwork. Users can practice scenarios involving negotiation, conflict resolution, and public speaking.

Special Education VRLEs: Customized to cater to the needs of students with disabilities. These environments can provide a more inclusive and accessible learning experience.

MODULE 2
Introduction to the VRLEs in VRChat

VRLEs Development – Social Virtual Reality

One methodology for creating effective Virtual Reality Learning Environments (VRLEs) involves custom development. This approach utilizes advanced platforms such as Unity and Unreal Engine, which require coding skills and the creation of custom-made assets. Despite the steep learning curve, these platforms offer the capability to develop high-quality VRLEs with sophisticated interactions and high-end graphics. Custom development empowers developers to tailor VRLEs to specific educational objectives and requirements, resulting in immersive and engaging learning experiences for users.

Figure 1. VRLE Created with custom development for language learning

Recently, Social Virtual Reality has emerged as a prominent category within virtual reality applications and games. Social Virtual Reality platforms facilitate immersive virtual environments where multiple users can simultaneously participate, communicating through real-time voice communication and interacting with each other and the virtual world. This development paved the way for the design and development of various platforms for creating such shared worlds., widely used for designing and developing VRLEs as well.

These platforms target both experienced and inexperienced developers, featuring, however, different affordances and interaction fidelity levels. For example, platforms as Mozilla Hubs[1] and FrameVR[2] include their own engines for designing, developing, and publishing VRLEs. These engines can be used by individuals with little or no experience in creating VRLEs, as they are relatively easy to learn and use.

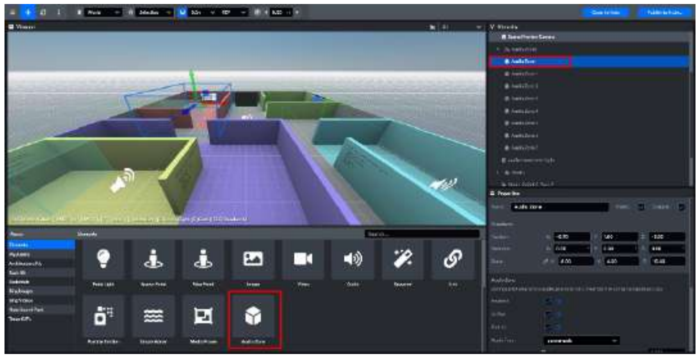

Figure 2. Mozilla Hubs Spoke Engine

Browser-based platforms such as Mozilla Hubs and FrameVR support simplified avatars representing users inside the virtual world. They allow for real-time voice communication and low polygon virtual worlds, while users can access the virtual world through PCs, HMDs, and even their mobile phones.

Figure 3. Mozilla Hubs

Nevertheless, Virtual Reality offers a lot more interaction and projection capabilities, which triggered the design and development of platforms such as VRChat[3]. These platforms allow for more sophisticated VRLEs to be developed. For example, VRChat supports high fidelity avatars which can follow users' motion while simulating non-verbal communication such as lips motion and gaze.

[1] https://hubs.mozilla.com/
[2] https://learn.framevr.io/
[3] https://hello.vrchat.com/

Figure 4. VRChat Avatar

Also, VRChat supports several interaction modalities which can be rather helpful during VRLEs design and development such as grabbing and manipulating objects, writing on whiteboards, and delivering PowerPoint Presentations.

Figure 5. VRChat interaction

VRChat can integrate newly developed technologies supported by most commercial HMDs to allow real-time finger motion tracking, facial expressions, and gaze tracking, transferring non-verbal cues from the real to the virtual world, while supporting high quality/polygon graphics.

Figure 6. VRChat Communication/Graphics

Nevertheless, utilizing platforms like VRChat for designing and developing high-end VRLEs entails increased costs and a lengthy development process. Specifically, VRChat is accessible only through PCs or HMDs as it does not support mobile phones or browsers due to its increased requirement in computational power.

Additionally, VRLEs developed using VRChat are based on Unity and require advanced skills in programming languages (e.g., C#) and knowledge of computer networks.

Figure 7. Pipeline for developing VRChat worlds

MODULE 3
How to prepare a VR Learning Scenario

Introduction

The overall objective of the REVEALING project is to create a VRLE Model using the VRChat platform, adapted to the learning needs of HEIs. This Model can be adapted to different learning situations and contexts according to the needs of the end users. Within the scope of the project, this chapter presents the guidelines for the design of a learning scenario considering the affordances and limitations of the VRLE, aiming at supporting engaging immersive experiences and meeting predefined learning objectives.

It is important to emphasize that the immersive experiences provided by VRChat platform must have an adequate pedagogical framework. The activities taking place in the virtual environment must be integrated into teaching and learning processes that allow the teacher and the student to clearly understand the learning objectives to be achieved and the procedures to be followed, so that this immersive experience effectively results in an added value in terms of learning.

The design of the planning matrix for lesson planning in VRChat focuses on the application of several norms and pedagogical base principles. The main reference elements are: (1) the creation of scenarios proposed by Carroll (2000); (2) Merrill's principles of instruction (2002); (3) Pedagogical methods (Ghirardini, 2011;

Gouveia *et al*., 2007; Morgado *et al*., 2022); and (4) competency-based assessment: skills, knowledge, and attitudes (UNESCO, s.d.).

1. Pedagogical Design: VRChat Classes

For the development of pedagogical planning, two phases should be pursued: (1) Define the learning objectives for the session or set of sessions; (2) Setting the learning scenario.

1.1. Defining the Learning Objectives

The formulation of learning objectives can be described in five essential steps:

1. Outline the theme of the class or session.
2. Identify the target audience and duration of the session.
3. Define the essential learning to be achieved in the class/session.
4. Select the operative verbs to use.
5. Write the learning objectives.

The learning objectives are written from the student's perspective and the verb is in the infinitive. They must be articulated with the general objective(s), presenting a greater degree of detail. The learning objectives are also combined with the learning content, the activities and evaluation.

For the definition of objectives and the selection of operative verbs, Bloom's taxonomy (revised version, Anderson & Krathwohl, 2001; Krathwohl, 2002) is followed because it is widely known and recognized, easy to apply and associated with a competency-based approach. This taxonomy is structured in two dimensions, knowledge, and cognitive process (cf. Table 1). Objectives related to other dimensions, such as the affective or psychomotor domain, can also be considered, if relevant for a class with VR.

Table 1. Bloom's revised Taxonomy (Anderson & Krathwohl, 2001).

Knowledge dimension	Cognitive processes dimension
1. Factual knowledge	1. Remember
2. Conceptual knowledge	2. Understand
3. Procedural knowledge	3. Apply
4. Metacognitive knowledge	4. Analyse
	5. Evaluate
	6. Create

For each dimension of the cognitive process, there are associated verbs, which act as mnemonic support towards definition of the objectives (cf. Table 2).

Table 2. Operative verbs.

Cognitive processes dimension	Operative verbs (examples)
Remember	Cite; Define; Describe; Draw; Enumerate; Identify; Recognise
Understand	Add; Approximate; Articulate; Associate; Characterize; Clarify; Compare; Exemplify; Observe; Summarise
Apply	Apply; Adapt; Ascertain; Assign; Avoid; Examine; Implement; Project; Provide
Analyse	Analyse; Compare; Confirm; Contrast; Correlate; Diagnose; Explain
Evaluate	Appraise; Assess; Compare; Determine; Interpret; Judge; Select.
Create	Categorize; Combine; Compile; Compose; Construct; Create; Relate; Reorganize.

To facilitate the understanding of these processes, we present an example that illustrates the steps mentioned above (table 3), based on one of the Learning Scenarios developed for the project.

Table 3. Example of the process of writing objectives.

Example:
1st step – Theme: Impact of global change on sea urchins: understanding the oceans of the future. **2nd step – Target Audience:** Higher Education Students; Duration of session: 35 min. **3rd step – Essential Learnings:** Students can recognize and interpret changes in sea urchins caused by water acidification. **4th step – Operative Verbs:** Observe; Verify; Analyse; Relate. **5th step – Wording of learning objectives:** • Observe and verify if differences occur in the size of sea urchins in two distinct periods (current year and year 2100) through measurement of dimensions followed by statistical analysis. • Analyse the results obtained. • Relate how water acidification affects the size of sea urchins.

1.2. Setting the Learning Scenario

The definition of a learning scenario, according to Caroll (2000) and Matos (2014), includes a set of decision-making, namely: (a) Define the design of the environment, its organization, and contextual elements; (b) Stipulate the agents or actors, each agent or actor typically has goals or objectives. Changes that the agent wishes to achieve in the circumstances of the setting; (c) Outline the plot. The plot includes sequences of actions and events, things that actors do, things that happen to them, and changes in the circumstances; (d) Establish the process of monitoring actors and context, i.e., reflection and regulation (see Table 4).

Remember that prior to a scenario definition it is important to define the location and learning objectives.

Table 4. Learning Scenario (Carrol, 2000; Matos, 2014).

Environmental design	**Description:** Describe the arrangement of the used spaces (e.g., moving chairs beforehand, loading a presentation, writing something on the whiteboard…). **Example:** Landing space: adapting space; Escape space: underwater world.
Agents or actors	**Description:** Define the interventions, their roles, and behaviours. **Example:** Students and the teacher with free clothing.
Session script	**Description:** Describe the sequence of actions; the working strategies and activities.
Reflection and regulation	**Description:** Strategies for monitoring actors in the teaching-learning process; critical reflection and adjustments

1.2.1. Environmental Design

The tool used in the project to build virtual reality scenarios - VRChat - allows the integration of a set of elements that can be used to support the teaching and learning process. A summary of VRChat's potential is presented in table 5.

When designing the VRChat environment where classes will take place, two pedagogical contexts can be considered. First, the **Landing Space**, i.e., an area where the teacher and students meet when they enter the virtual space. This landing space is intended, for example, for introductory dynamics, initial explanations, or expository classes.

The second pedagogical context, **Escape Space**, refers to a single space or multiple spaces that are adjusted to the learning content. In these spaces, it is possible to immerse the student in a specific place/environment for the practical activity, such as an art gallery, a castle, an underwater world, or even a hospital. In this second context, it is possible to use previously developed spaces or, in particular cases, request their development.

Table 5. Elements that can be added to VRChat scenarios.

Element	What can be done	Specifications/ Examples
Images	It is possible to place preloaded images in the virtual chat.	• Screenshots • Photograph • Schematics • Maps
Videos	It is possible to upload videos. YouTube streaming is not possible.	• Videos • Audio slideshows
Animations	It is possible to upload animations.	•
3D models	It is possible to upload 3D models.	• Tables • Desks • Chairs • Screens • Projectors • Educational activity-related objects
Slideshows	It is possible to upload slideshows.	• PowerPoint files
Sounds	It is possible to upload sounds. It is possible to control them (play, pause, stop, volume control, etc).	
Whiteboard	It is possible to write and erase on a whiteboard using markers of different colours	
Mirror	It is possible to place a mirror so participants can see their avatar	
Screens	Users may control the display, e.g., to slide images back and forth.	

Landing Space

The example of Landing Space presented in figure 1 was developed with features that refer to a traditional classroom: chairs, tables, and a whiteboard, among other objects. This scenario allows presentation of audio, video, slideshows, and 3D models (cf. table 5).

Figure 1. Example of a Landing Space – Classroom
Source: https://www.youtube.com/watch?v=WsRipYSrZYQ

In two of the scenarios developed for the project, specific landing spaces were created: in one case, a mountain hut where everyone initially meets; and in the other, a dark room where students begin by listening to a brief narration that introduces the activity to be carry out in the virtual world. The other two scenarios do not integrate a landing space, the participants are immediately in the virtual space/context where the activity takes place.

When planning a class session, the teacher must consider the resources and materials needed. The following checklist was developed to assist in the preparation of the learning scenario.

Table 6. Check List: "Landing Space".

Element	Resources (Description)
Images	
Videos	
Animations	
3D models	
PowerPoints	
Sounds	
Objects	

Escape Space

There is no restriction on the number of "escape spaces". Access to these spaces is made through the creation and availability of portals. The spaces created must be appropriate to the context of the class, as illustrated in the example presented in the planning matrix.

For this process, it is possible to contact the technical team for assistance in developing the desired space for the session(s). Nevertheless, to facilitate the process of planning the learning sessions, the use of previously developed spaces presents itself as a favourable alternative, enabling the teacher to have greater autonomy in the process.

To plan the development of a new escape space a checklist was prepared to provide relevant data for the technical team to develop resources based on the teacher's idea and concept.

Table 7. Check List: "Escape Spaces".

Environmental design	Description
Context	
Location/ Terrain	
Buildings/structures	
Textures	
Assets	
Indoor/outdoor walls	
Dimensions	

When developing a new escape space or using a previously developed one, the same checklist that was developed for the landing space can be used to plan and structure the resources for the learning space.

Table 8. Check List: "Escape Spaces" - Resources.

Elements	Resources (Description)
Images	
Videos	
Animations	
3D models	
Slideshows	
Sounds	
Objects	

1.2.2. Agents or Actors

The agents or actors correspond to those involved in the educational process. They can acquire distinct forms and outfits (costumes). The following table shows the interactions they can have in the VRChat.

Table 9. Exploring the Educational Process in VRChat: Agents and Interactions.

Subjects	Interactions
Whiteboard/Markers	Write and erase
Objects	Pick up, drag'n'drop objects like furniture
Voice	Communicate with other users through voice in real-time

1.2.3. Session Script

The moment of plot definition, working strategies, actions, and proposals can be described as the development and structuring of activities.

Schematized planning (cf. Matrix of the VR Lesson "Impact of global change on sea urchins: understanding the oceans of the future") includes eight categories: (i) Phase/Time; (ii) Learning objectives; (iii) Key Contents/Points; (iv) Instructional Principles; (v) Methodology; (vi) Resources; (vii) Student activity; (viii) Assessment.

(i) Phase/Time

In each session, the time that will be dedicated to each activity must be considered, so the total duration must be divided into different phases of work. It is recommended that the time allocated to activities in the virtual world not be too long, due to the potential exacerbation of discomfort.

It will also be important to divide the activities into several phases or moments, to facilitate their development and the targeted learning objectives.

Table 10. Effective Time Management: allocating time for different phases of work.

Example (These durations are just examples, not recommendations):	
Total time in VR: 45 min • 1st step/phase: 10 min (for example, meeting in the landing space; presentation of activities and learning objectives) • 2nd step/phase: 20 min (carrying out the activity) • 3rd step/phase: 10 min (summarising and reflecting) • 4th step/phase: 5 min (follow up activities)	Total time in VR: 20 min • 1st step/phase: 5 min • 2nd step/phase: 10 min • 3rd step/phase: 5 min

(ii) Learning Objectives

As mentioned above, the learning objectives are targets that have a greater degree of detail concerning the overall objectives.

(iii) Key Contents/Points

To store and organize the concepts and contents to be presented, the topic Key Contents/Points appears in the matrix.

(iv) Instructional Principles

Merrill's instructional principles (2002) were selected as a supporting Instructional Design Model. This model with five principles focuses on promoting learning and presents guidelines to improve and facilitate this process. Not all five principles require implementation in the same session. Table 11 describes the principles and steps for applying them.

Table 11. Merrill's principles of instruction (Merrill, 2002).

Model phases	Task
Principle 1 – Problem	**Learning is promoted when students are involved in solving real-world problems.** (1) Show the Task, an example of the task or problem that students will have to be able to solve for the completion of the module or course. (2) Task level, involvement of students at the problem or task level, not just at the operation or action level. (3) Progression of the problem, solving a progression of problems, starting with a basic problem that then becomes complex.
Principle 2 - Activation	**Learning is promoted through the valorisation of previous experiences.** (1) Previous experiences, guide students to remember, report, describe or apply knowledge of a relevant experience that can be used as a basis for new knowledge. (2) New experience, reception by the student of new relevant experiences that can be used as a basis for new knowledge. (3) Structure, incentive to recall a structure that can be used to organize the new knowledge.

Principle 3 - Demonstration	**Learning is promoted when instruction allows you to demonstrate what must be learned.** (1) Consistency of demonstration, demonstration of tasks, procedures, and examples. (2) Relevant media, the media plays a relevant instructional role and the multiple forms. (3) Student guidance.
Principle 4 - Application	**Learning is promoted when students are required to use the knowledge and skills in problem solving.** (1) Consistency of practice, promotion of learning through the practical application of objectives. (2) Decreased follow-up, guidance of students to solve problems through feedback. This follow-up should be gradually withdrawn. (3) Encountering diverse problems offers students opportunities to engage in problem-solving and gain varied experiences.
Principle 5 - Integration	**Encourage the integration of new knowledge into everyday life.** (1) Watch me, promote the opportunity for students to publicly demonstrate their new knowledge or skill. (2) Reflection, foster spaces for students to share, reflect and defend their new knowledge or skill. (3) Creating, encouraging students to create, invent and explore new ways to use new knowledge or skill.

(v) Methodology

Educational pedagogy is supported by pedagogical methods during the learning and teaching process. These methods help to describe the role of teachers and students during instruction (cf. Table 12)

Table 12. Pedagogical methods (Ghirardini, 2011; Gouveia et al., 2007; Morgado et al., 2022).

Expositive methods	**Application:** Oral transmission of a knowledge or concept. **Role of the teacher:** Content presentation. **Student role:** Slight participation (listening to what is being presented). **Examples (VRChat):** 1. The teacher exposes new content with the help of a whiteboard to indicate key words and terms. 2. The teacher presents an informative video. 3. Teachers use images to expose a new concept.

Inquiry methods	**Application:** Inclusion of questions that foster sharing of knowledge or of a concept. **Role of the teacher:** Propose issues, dilemmas, and moments for reflection. **Student role:** Participate by trying to respond to the raised issues. **Examples (VRChat):** 1. The teacher uses a whiteboard to present issues for debate. 2. The teacher presents a cloud of words to incite questioning.
Demonstration methods	**Application:** It consists of Explaining - Demonstrating - Applying, with the intent of supporting its repetition by the students. **Role of the teacher:** Explain and demonstrate a technique/task. **Student role:** Actively listen and replicate teacher guidance. **Examples (VRChat):** 1. Demonstrate how you interact with objects in VRChat. 2. Demonstrate how a mathematical calculation is performed on the whiteboard. 3. Enhance the escape space scenario to demonstrate specific characteristics of a
	4. location or context with the goal of the student identifying the characteristics. 5. Demonstrate the steps required to make a video independently.
Active methods (participatory)	**Application:** Student takes the main role on the learning process. **Role of the teacher:** Orchestration role. Provide resources and motivational messages, as well as assistance. 1. Methodologies such as: 2. Project-based learning. 3. Problem-based learning. 4. Flipped classroom. **Student role:** Active role in the construction and search of one's knowledge. **Examples (VRChat):** 1. Present material for students to study before class (Flipped Classroom). 2. Propose that students carry out a project. 3. Propose that students perform a task independently
Collaborative methods	Online guided discussion; Collaborative work; Peer tutoring.

	Application: Stimulate critical thinking, reflection, interpersonal communication among students. **Role of the teacher:** Foster and guide discussion. **Student role:** Active participation in group discussion. **Examples:** Forum Discussion (in Moodle)

(vi) Resources

Resources are the instruments, objects, or tools necessary for carrying out the scheduled activities.

Table 13. Resources for Activity Execution

Example:
Pedagogical auxiliary means: 1. Virtual Reality Headset 2. VRChat 3. Illustrative images 4. Supporting texts 5. Others

(vii) Student Activities

This category describes the role of students during the learning process.

Table 14. The role of students during the learning process.

Example:
Active methods **Role of the teacher:** The teacher will monitor students' behaviours and guide task execution from within the virtual world. **Student Activity:** Students will identify and record the physical characteristics of the sea urchins they observe in the virtual world (underwater scenario).

(viii) Assessment

For the assessment of activities and proposed tasks in a VR environment, the focus will be on attitudes (observation of the student involvement in the activities), knowledge (short quizzes on the contents presented) and skills/competences (e.g., accomplishment of the final task).

Assessment must take into consideration a set of dimensions that different authors have already highlighted. Boud (2005) has developed the idea of "sustainable assessment", with a focus on the importance of formative assessment and feedback that support students' autonomy in different settings, and which can be important for VR contexts (Boud & Falchikov, 2005). Universidade Aberta also proposes the PrACT model, that considers e-assessment based on 4 dimensions: Authenticity, Consistency, Transparency and Practicability (Tinoca *et al*., 2014).

Table 15. Dimensions of PrACT model for e-assessment (Tinoca et al., 2014).

Dimension	Description
Practicability	Related with the feasibility of the assessment strategy. It implies an effective management in terms of time and cost/efficiency balance for both assessors and organizations.
Authenticity	Related to the degree of similarity between the competences being assessed and the ones required in real/professional life.
Consistency	Takes into account that the assessment of competences requires the implication of a variety of assessment methods, in diverse contexts, by different assessors, as well as the adequacy of the employed strategies.
Transparency	Intends to make the entire competence assessment program visible and comprehensible for all participants.

2. Matrix for planning the Learning Scenario

Based on the elements that were presented in the explanation of the Pedagogical Design, and which can be taken into consideration when planning classes that include the use of Virtual Reality, a model was developed to support this planning. An example of applying this matrix to one of the scenarios developed for the project is presented in Appendix 1.

Theme		
Date/Time		
Local		
Duration		
Teacher		
Targeted audience		
Prerequisites		
Materials		
Learning objectives		
Scenario	**Environmental design:**	
	Landing space:	**Escape space:**
	Agents and actors:	
	Reflection and regulation:	
Steps of the session		
Competences to develop		
Transfer task		

Session planning

Step 1	Time
	Learning objectives: Contents/Key Points: Principle(s): Methodology: Resources: Student activities: Assessment:
Step X	**Time**
	Learning objectives: Contents/Key Points: Principle(s): Methodology: Resources: Student activities: Assessment:

Literature

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Appendix 1. Matrix for planning the learning scenario – Using a VRChat class in the didactic sequence "Impact of global change on sea urchins: understanding the oceans of the future"

Presentation

In the context of a curricular unit integrated into a degree in Environmental Sciences, an underwater scenario was developed that allows students an immersive learning experience through VR. The session planned with VRChat is integrated into a broader plan, which is why it was decided to present the entire didactic sequence here, and not just the VR-based part. Thus, it is also possible to understand how VR learning experiences can be articulated with a broader learning planning and objectives.

Theme	**Impact of global change on sea urchins: understanding the oceans of the future**
Date/Time	In this example, the sequence is composed by 4 sessions/classes. Session 2 takes place in the underwater world, using VRChat. Session 1 — Preparatory task (self-learning) **Session 2** — **Tutorial + Group field trip to an underwater virtual reality immersive environment** Session 3 — Statistical analysis of collected field data (classroom activity) Session 4 — Group discussion of the results obtained (classroom activity)
Local	Moodle + Zoom + VRChat
Duration	Session 1 — 30 min **Session 2** — **10 min + 25 min** Session 3 — 25 min Session 4 — 15 min
Teachers	Célia Dias Ferreira + Rosário Ramos (session 3)
Targeted audience	Higher Education Students in the fields of environmental or biological sciences or engineering
Prerequisites	• To be enrolled as a student in a higher education degree in environmental, biological sciences, or similar • To have previously taken the start-up immersive VRChat training (20 min) •

Materials	• 1 Virtual Reality (VR) headset for teacher and 1 VR headset for each student • 1 Computer with internet access • Software for statistical analysis (ex: MS Excel, SPSS, etc.) • Software for remote meeting (ex: Zoom) (Specific resources for each session are listed in PART B of this document)	
Learning objectives	Verify if differences occur in the size of sea urchins in two distinct periods (current year and year 2100) through measurement of dimensions followed by statistical analysis. Relate how water acidification affects the size of sea urchins. Explore how changes in the size of sea urchins affect the ecosystem. Reflect on how human activities can affect marine ecosystems.	
Scenario (Session 2: Underwater world)	**Environmental design:**	
	Landing space: Dark room with a screen showing a movie/presentation.	**Escape space:** (1) Underwater scenario year 2100 The scenario incudes both interactive and non-interactive features. List of non-interactive background features: fishes and a shark swimming by; a sunken old caravel; kelp; air bubbles,

		moving up; underwater sound; sunlight effect through the water. List of non-interactive features related to the activity: A pH meter, displaying the value 7,8; 4 large rocks laying on the see floor; 8-9 red-brownish sea-urchins of varying sizes laying on top of each large rock; 4 wooden writing board (one near each rock) with a reference on the upper left corner (composed by the year and a number between 1 and 4. Example 2100-1, 2100-2, 2100-3, 2100-4). List of interactive features: Next to each board there is a yellow 30-cm ruler, a pencil, and an eraser. These objects can be picked up and used. There is a time portal to the present year (bright blue, 2m wide, circle). (2) Underwater scenario for the present year This setting is similar to the Underwater Scenario year 2100, but it occurs in the present, when the sizes of the sea urchins are bigger. The boards' reference code is: P1, P2, P3, P4. The pH meter displays the value 8,1.

		A time portal allows to go back to the year 2100 and another portal allows to leave the underwater scenario.
	Agents and actors:	
	• Students • Teacher • Assistant/helper (outside of the immersive learning environment) – might be a teacher, a technician, or a student.	
	Reflection and regulation:	
	Prior to the beginning of the immersion: • The physical boundaries of each participant will be defined. • Each participant will be given basic etiquette protocols to be followed in the virtual world. *During the immersion:* • The teacher will monitor student's behaviours and guide task execution from within the virtual world. • An external (not in immersion) assistant/helper will provide any additional technical assistance required on the use of equipment (headset, microphone) and physical boundaries. In case a participant feels nausea or sickness (unusual, but possible), he/she will remove the headset and will seat down in a relaxed place for a few minutes until the symptoms disappear.	

Steps of the sessions	*Session 1: Preparatory task (self-learning)* Study of the material available on Moodle about ocean acidification and its impact on marine calcifying organisms, including sea urchins. Reading the rules of ethics in Virtual Reality. ***Session 2: Group field trip to an underwater virtual reality immersive environment*** **Tutorial on getting accustomed to virtual reality.** **Observation of sea urchins in their natural habitat.** **Measurement of sea urchins' body size.** *Session 3: Statistical analysis of collected field data (classroom activity)* Brief recapitulation of the field data collection carried out. Organization of the collected data and preparation for analysis. Comparative statistical analysis of the datasets collected at the two different time points. *Session 4: Group discussion of the results obtained (classroom activity)* Correlation between the dimensions of sea urchins and ocean acidification. Exploring the cascading effects of changes in the dimensions of sea urchins on the marine ecosystem.
Competences to develop	1. Data Collection: Students will develop their ability to collect data and analyse information related to sea urchins and the impact of ocean acidification. 2. Ability to Draw Conclusions Based on Evidence/Observations: Students will be encouraged to analyse data, compare findings, and draw conclusions about the cause-and-effect relationships between ocean acidification and changes in sea urchin size. 3. Promotion of Critical Thinking: Students will be encouraged to debate the limitations of the collected data and assumptions of the conclusions they have reached, promoting critical thinking. 4. Environmental Awareness: By studying the effects of ocean acidification on sea urchins, students will develop a deeper understanding of environmental issues and their impact on marine ecosystems. This will increase awareness of the importance of conservation efforts.
Transfer task	Students will be challenged to apply their knowledge of ocean acidification and its effects on sea urchins by writing a reflection on how human activities can affect marine ecosystems. This task will promote advanced competencies in analysis, critical thinking, and environmental awareness, contributing to a deeper understanding of the role of humans in altering ecosystems and the challenges posed by global changes. They will also research other situations (potentially current) where this acidification has already had effects.

Detailed description of THE LEARNING PLAN

SESSION 1 – Preparatory task (self-learning)	
Step 1	**Time:** 30 minutes
	Learning objectives: • Enumerate introductory concepts about ocean acidification. • Understand the integration of the sea urchin into the marine ecosystem. • Become familiar with the etiquette rules of the virtual world. **Contents/Key Points:** • Concept of pH of a solution and pH values of seawater. • Introduction to ocean acidification and its causes (anthropogenic emissions of CO2 into the atmosphere, chemical equilibrium reaction between atmospheric CO2 and CO2 dissolved in water). • Effect of water acidification on marine calcifying organisms, including sea urchins. • Placement of the sea urchin in the marine trophic chain and the role played by this organism in the ecosystem. • Basic etiquette rules applicable to immersive virtual reality. **Principle(s):** Demonstration. **Methodology:** Expositive methods – The teacher presents the objectives of the activity and the content related to acidification of the oceans. **Resources:** (1) Educational material about ocean acidification and the ecology of sea urchins, available on Moodle or other online learning platforms, such as texts, videos, or animations. (2) Compilation of etiquette rules applicable to immersive virtual reality. **Student activities:** Exploration of the material available on Moodle: Students will access educational resources about ocean acidification on Moodle, such as texts, videos, infographics, or animations, to gain an initial understanding of the topic. **Assessment:** Knowledge verification: self-testing (quiz with Socrative or another similar tool) [tool available in Moodle].

SESSION 2 – Group field trip to an underwater virtual reality immersive environment for observation of sea urchin populations and measurement of body size	
Step 1 Dark room	**Time:** 1m30s
	Learning objectives: • Engage actively in the field trip activity. **Contents/Key Points**: A fictional narrative setting the context for the upcoming activity. **Principle(s):** Demonstration.

	Methodology: Expository method **Resources:** (1) dark room scenario, (2) presentation (narrated video) **Student activities:** Listening to what is being transmitted while reading the sentences on the screen. **Assessment:** Not applicable
Step 2 Observation of sea urchin populations and measurement of individual body sizes	**Time**: 20-25 minutes
	Learning objectives: • Identify and record the physical characteristics of sea urchins at two different times points. • Collect data on the pH of the water and the dimensions of sea urchins in their natural habitat, at two different time points, for later comparison. **Contents/Key Points:** Students will have the opportunity to observe a simulation of sea urchin populations in their natural habitat through the use of VR technology. Students will be encouraged to identify and record the physical characteristics of the sea urchins they observe (diameter). This interactive activity will allow students to actively engage in the learning process, developing their observation skills. **Principle(s):** Activation (Reception by the student of new relevant experiences that can be used as a basis for new knowledge) **Methodology:** 1. Demonstration method: teacher demonstrate how to interact with ruler in VRChat to measure sea urchins' diameter and how to use a pen to register the values on the board. 2. Active method (students measure and register the sea urchins' diameter). **Resources:** (2) underwater scenario in 2100; (2) underwater scenario for the present time **Student activities:** • Observe the surroundings. • Listen to the objectives of the practical activity to be carried out. • Watch the demonstration on how to measure and record the diameter of a sea urchin. • Measure and record the diameter of a certain number of individuals in the year 2100 (the number of measurements will be indicated by the instructor). • Transition to the present year (through the portal) and measure and record the diameter of a certain number of individuals in this second moment. **Assessment**: • Attitudes (Perception if students participate in the activities)

	• Behaviour Observation (Observe whether students actively interact with the teacher in case of doubt); Collection tool – field notes relating to the search for help from students (audio recording while in Immersion).

SESSION 3 – Statistical analysis of collected field data (classroom activity)	
Step 1 A brief recapitulation of the field data collection conducted in the previous session	**Time:** 3-5 minutes
	Learning objectives: • Summarise the previous session. **Contents/Key Points:** • Review of the data collection process used in the session of exploring the seabed. • Presentation of the set of field data obtained. **Principle(s):** Activation. **Methodology**: 1. Expository method: The teacher will provide a brief review of the activity conducted in the previous session and present the collected data. 2. Inquiry method: During the review, students will be asked specifically to explain how they performed certain tasks or to enumerate any problems that arose. **Resources:** Images of the scoreboards written by the class during the field activity (previous session) in the present year and in the year 2100. **Student activities:** • Listening to the review of the activity carried out by teacher and colleagues. • Answer questions posed by the teacher related to the problems encountered and tasks performed in the previous session. **Assessment**: • Behaviour (involvement in dialogue and discussion).
Step 2 Organize the data and prepare it for subsequent analysis	**Time:** 7-8 minutes
	Learning objectives: • Organize the data and prepare it for subsequent analysis. **Contents/Key Points:** • **Classification and Organization**: Presentation of techniques and strategies for classifying, formatting, and organizing data efficiently, ensuring they are accessible and prepared for subsequent analysis. We will discuss methods for categorizing data according to relevant variables, establishing coding systems, and creating a structure that facilitates understanding and manipulation of the data. • **Tools and Resources**: Introduction and explanation of tools and resources that can facilitate data organization, such as spreadsheets and built-in statistical functions. This includes the use of spreadsheet software like Excel or Google Sheets to store and manipulate data in an organized manner. Additionally, we will cover the built-in statistical functions in these tools that can assist in exploratory data analysis, pattern identification, and generation of summary graphs and reports.

	Principle(s): Demonstration. **Methodology:** • Exhibition method: The teacher will explain to the students the basic concepts of how to classify and organize data to make it possible for subsequent analysis. **Resources:** Educational materials such as texts, images, and videos. **Student activities:** • Listening **Assessment:** • Behaviour (involvement in dialogue and discussion).
Step 3 Statistical analysis	**Time:** 15 minutes
	Learning objectives: • Identify and analyse differences between the two datasets collected on the diameter of sea urchins, one for the current year and the other for the year 2100. **Contents/Key Points:** 1. Statistical analysis method: Explanation of the statistical method(s)/technique(s) that will be used for statistical analysis. 2. Data analysis using tools. 3. Interpretation of Results: Discussion on how to interpret the results of the statistical analysis. **Principle(s):** Application; Demonstration.

	Methodology: 1. Demonstration method (teacher): The teacher will exemplify how to determine if two distinct groups of data are significantly different. 2. Active method (students): Statistical analysis of the data. **Resources:** Spreadsheet software like Excel or Google Sheets; Interactive board. **Student activities:** Statistical analysis of the data. **Assessment**: Practical exercises: application of statistical analysis methods.

SESSION 4 - Group discussion of the results (classroom activity)	
Step 1 Presentation and discussion of conclusions	**Time:** 15 minutes
	Learning objectives: • Collaborate with colleagues (work in pairs and in the whole class). • Develop critical thinking, through group discussions and in-depth reflections on the topic. **Contents/Key Points:** Correlation between sea urchin dimensions and ocean acidification. Cascade effect of sea urchin size changes on the marine ecosystem. 1. Guided Discussion: Participants are encouraged to share their interpretations of the results and contribute individual insights and perspectives. 2. Feedback and Debate: Fostering a healthy debate environment where participants can question, challenge, or complement conclusions presented by their peers. **Principle(s):** Activation (Previous experience and information acquired during previous stages guide students to apply this knowledge as the basis for creating new knowledge).
	Methodology: (1) Active method (students – presentation and discussion of the results of the statistical analysis). (2) Inquiry method (Teacher creates moments of thought by posing questions about the impacts of acidification on the trophic web). **Resources:** Interactive board; discussion forum. **Student activities:** (1) Presentation and discussion of the results of the statistical analysis. (2) Group discussion on the effect of acidification on sea urchin's size and on cascade effects through the marine ecosystems caused by these changes. **Assessment**: 1. Attitudes (Students are motivated about the session and the resources presented). 2. Results of small group work. 3. Discussion in forum.

Transfer task (individual task)	Written text: How human activities can affect marine ecosystems. Conduct research and identify other situations where ocean acidification is already happening and affecting the ecosystem.

MODULE 4
How to use the VRLE Resource Directory

1. Introduction

The Resource Directory for VRLE (Virtual Reality Learning Environments) was developed with the aim of facilitating the adoption and implementation of VRLEs in the teaching practices of Higher Education Institutions. This chapter aims to provide guidance on how to use the Resource Directory, with a primary focus on the use of resources for the VRChat platform, where REVEALING classes take place.

2. Overview of the Resource Directory

The Resource Directory for VRLE was created as a central repository of educational tools for virtual reality environments. It houses a variety of resources, such as 3D models, interactive materials, virtual worlds, and other tools that can be used in the creation of virtual reality learning materials. The main goal of this directory is to provide educators with easy access to resources, making the incorporation of virtual reality-compatible elements in higher education more accessible, practical, and user-friendly.

3. Accessing and Navigating the Resource Directory

To use the Resource Directory for VRLE (Figure 1), one must be able to access the REVEALING project website at https://revealing-project.eu. There, users can browse the resource categories, such as 3D models, virtual worlds, interactive tools, and more. The directory is designed intuitively with a user-friendly interface to facilitate searching and accessing desired resources.

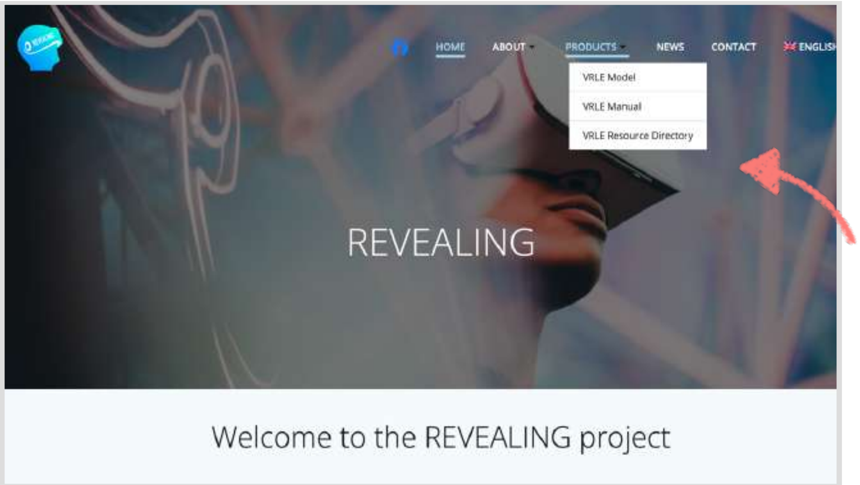

Figure 1. Homepage: Resource Directory

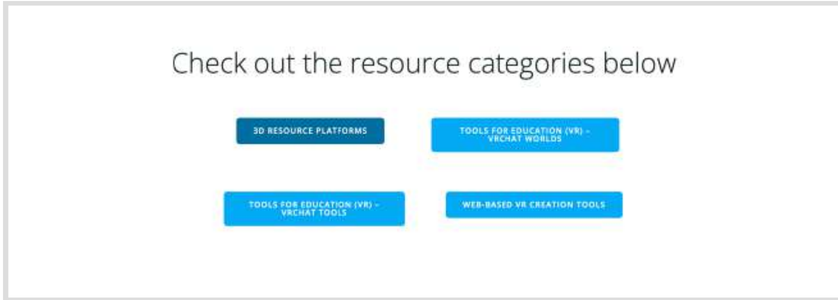

Figure 2. Categories: Resource Directory

4. Searching for Resources

The Resource Directory allows users to search for specific tools. Educators can, based on their needs, find the most suitable websites to locate 3D models or tools with the types of resources they intend to include in their teaching practice. This allows for an assessment of whether the resource meets the requirements of their class or teaching activity. Additionally, they can read additional information provided about the tools, such as descriptions.

4.1. 3D Resource Platforms

In this section, you can find a collection of platforms where 3D resources can be gathered (Figure 3). These platforms include a brief description (Figure 4), as well as some additional information (Figure 5) about the format in which the resources are available.

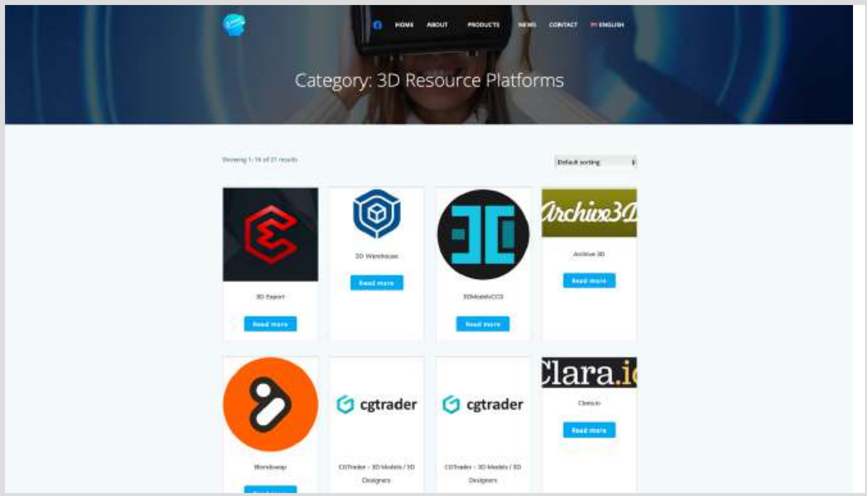

Figure 3. Tools: 3D Resource Platforms

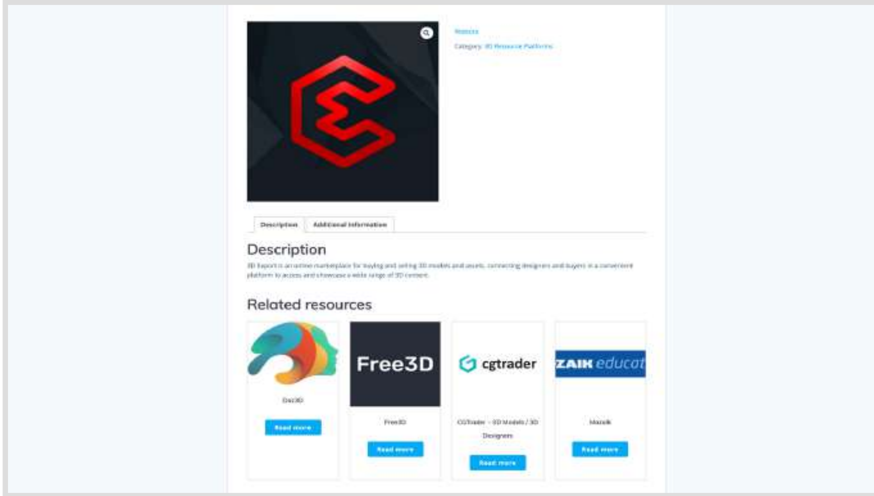

Figure 4. 3D Resource Platforms: Tool Descriptions

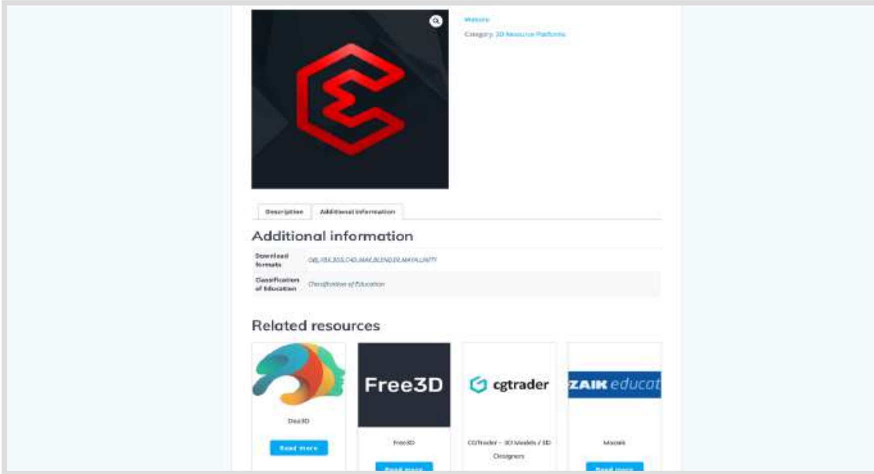

Figure 5. 3D Resource Platforms: Tool Additional information

4.2. Tools for Education (VR) - VRChat Worlds

In this section, you can discover a collection of pre-existing virtual worlds available in VRChat (Figure 6), which can serve as resources for teaching in Virtual Reality. Similar to the previous category, it also includes a description of what you can expect to find within each world.

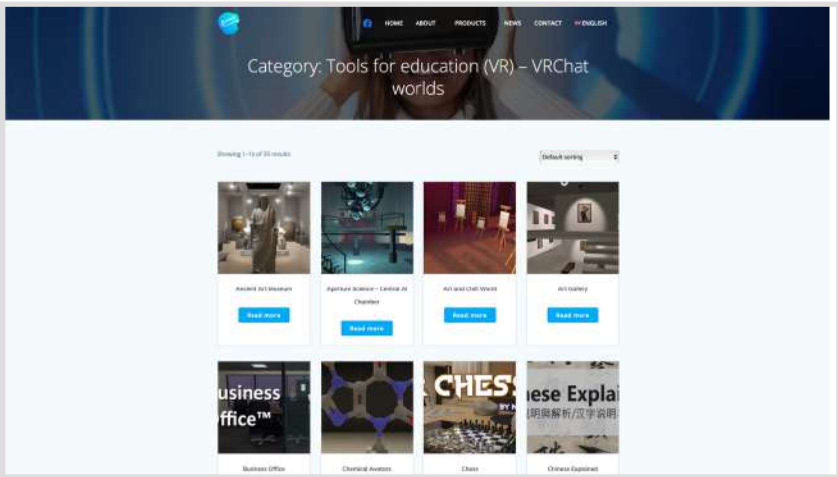

Figure 6. VRChat worlds

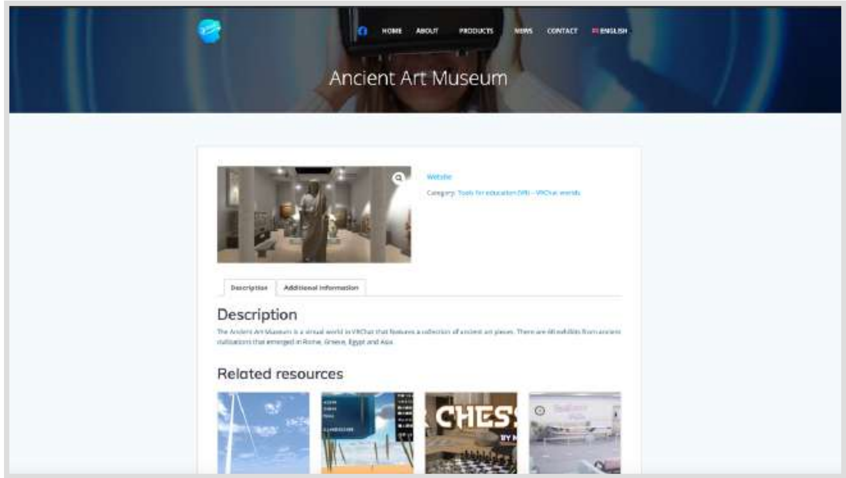

Figure 7. VRChat worlds: Example

4.3. Tools for Education (VR) - VRChat Tools

This section features a set of tools (Figure 8) that can be used as supplements to VRChat, including avatar editors and tools for sharing videos, images, and music within VRChat. These resources can enable a more personalized and comprehensive experience tailored to the user's needs. Similar to the other sections, it provides a brief description of each tool (Figure 9) and some additional information.

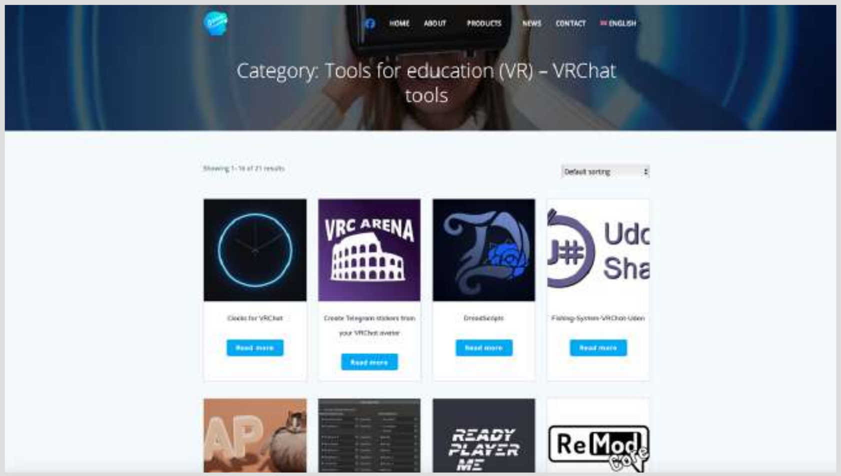

Figure 8. VRChat Tools

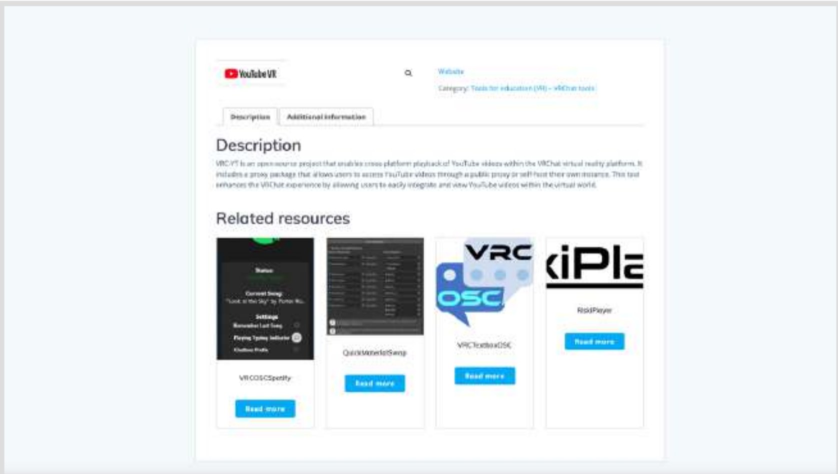

Figure 9. VRChat Tools: Example

4.4. Web-Based VR Creation Tools

In this category, you can find tools with three different purposes: 1) 3D model creation; 2) VR application development; 3) Virtual world creation for VR. As creation tools (Figure 10), they require users to have some knowledge about them to create resources, unlike the previous categories where resources are already created. In this category, each tool also includes a description and additional details such as compatibility and the possibility of their use with various VR headsets.

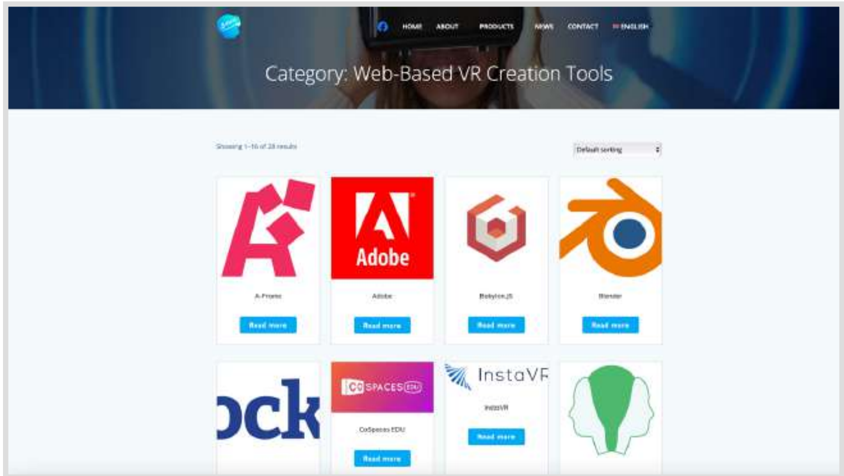

Figure 10. Web-Based VR Creation Tools

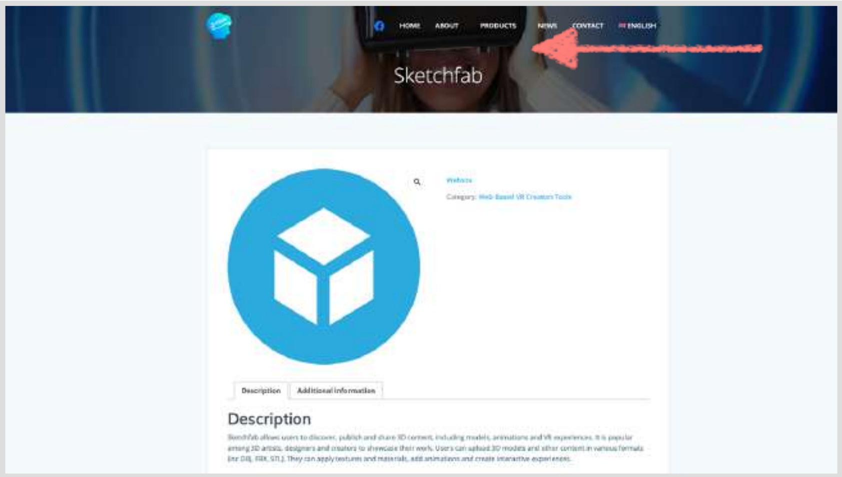

Figure 11. Web-Based VR Creation Tools: Example

5. Viewing and Downloading Resources

After locating a platform with the suitable or interesting resources for teaching practices, hyperlinks are provided that direct you to the platform.

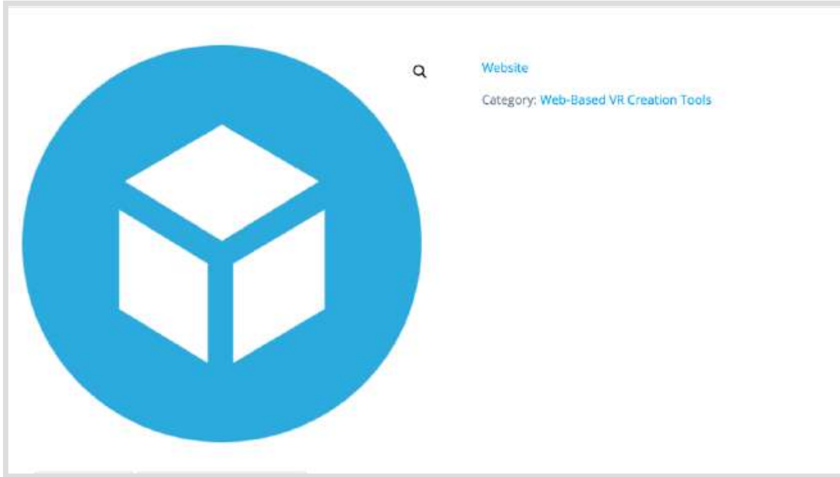

Figure 12. Website access

6. Using Resources in VRChat

The resources from the Resource Directory can be utilized and integrated into VRChat for use in teaching practices (cf. Chapter 2: Introduction to VRChat). VRChat provides an interactive platform where you can create and customize virtual worlds, conduct virtual classes, interact with students, and explore content in virtual reality.

7. Conclusion

The Resource Directory for VRLE is a valuable tool for educators interested in incorporating virtual reality into their teaching practices. Through this directory, educators can easily find and access a wide range of resources, such as 3D models, virtual worlds, and interactive tools, which can be used in the creation of virtual learning materials.

MODULE 5
Design of VR based learning environments

1. The role of didactics in virtual learning environments

As early as the 1990s, there were initial considerations about how virtual learning environments should be didactically structured (Aiello et al., 2012), although the technology required for this was still far removed from today's developments. Actually, it was less didactic than learning methodological considerations that were at play. When we talk about didactics (at least in the German-speaking tradition), we are always talking about the relationship between three factors: the subject matter, the teacher and the learners. We call this the didactic triangle. While didactics has always played a major role in school pedagogy, it is only in recent decades that the model has been supplemented by the aspect of media in a non-traditional sense, namely electronic or digital. Today we refer to this as media didactics (Kron & Sofos, 2003; Petko, 2020) . More recently, an approach has developed from this that calls itself a 'design-oriented media didactics' (Kerres, 2021; Kerres & de Witt, 2011). This approach is not only about conveying content with the help of media, but also about designing the media themselves. This is intended to better trigger and promote learning and educational processes in learners.

Kerres (2005) has differentiated this as follows:

"There remains the potential of digital media for:

- other teaching-learning methods: they support learning and teaching that promotes (a) clarity, situationality and thus application orientation (e.g. through images, video, multimedia, simulation) and (b) the cognitive and/or emotional activation of learners through elaborate learning tasks (such as cases, problems or projects);
- a different organisation of learning: they allow for a higher temporal-local flexibility of learning and thus support the use of flexible learning times, the addressing of new target groups and the inclusion of alternative learning locations;
- Shorter learning times: Individual adaptation of media use and learning pace can result in shorter learning times on average. However, there may be increased drop-out rates, which put this advantage into perspective." (p. 6; own translation)

The crucial question, however, is whether these provisions of media didactics can also apply to virtual learning environments. For this reason, some of these newer approaches will be presented. But it is not easy to define the term virtual learning environments more precisely. Sometimes it is simply understood to mean an e-learning offering or multimedia applications localized on the WWW. In a narrower sense, however, only those applications that present a virtual learning environment that can only be explored through virtual glasses are actually to be understood in the following. There are several potential applications of virtual reality in education and training. For example, VR-based learning environments can provide opportunities for learners to visit places and do things that are not otherwise possible or are too expensive or dangerous. VR can also allow learners to manipulate information from multiple sources and shift their cognition from representational learning to conceptual learning. Additionally, VR can be used to create immersive and interactive simulations, scenarios, and games that require learners to apply their knowledge and skills in realistic and complex situations. Other potential applications of VR in education and training include customized learning, challenging learning environments, multi-sensory effects, engagement, and motivation towards the content and technology.

(Hamilton et al., 2021) identified several limitations and challenges associated with the use of VR as a pedagogical tool. One major challenge was the lack of VR learning content, experiences, and teaching tools in certain subject areas, such as the arts, humanities, and social sciences. According to Hamilton et al. (2021), the most common subjects explored using VR were science and engineering, which made up almost 70% of the studies reviewed. Other subjects were marginally represented, with medical disciplines making up a small proportion of the studies included (14%). Additionally, most studies relied heavily on multiple-choice questions and test scores to assess learning outcomes, and VR interventions were typically short and isolated, which may have impeded the learning experience of the user. However, despite these limitations, most studies did find a significant advantage of using VR over less immersive methods of learning, particularly when the subject area was highly abstract or conceptual, or focused on procedural skills or tasks.

It is suggested that VR has the potential to be an effective pedagogical tool in education, particularly in subject areas that are highly abstract or conceptual, or focused on procedural skills or tasks. However, the authors also highlights the need for a sound theoretical basis to guide the development and implementation of VR interventions, as well as the need for more comprehensive analyses of learning outcomes that go beyond simple test scores.

Overall, the findings of Hamilton et al. (2021) may encourage educators and researchers to explore the use of I-VR as a pedagogical tool in a wider range of subject areas and to develop more sophisticated and comprehensive methods for evaluating the effectiveness of VR interventions. This could lead to the development of more immersive and engaging learning experiences for students,

which could ultimately improve learning outcomes and enhance the overall quality of education.

The authors define VR as either a completely computer-generated environment or the viewing of captured 360° video through the use of a head-mounted display (HMD). Head-mounted displays (HMDs) have been in development since the 1960s. The first notable instance was the Telesphere Mask, patented in 1960 by Morton Heilig, marking the inception of HMD technologies. Since then, HMDs have evolved significantly, incorporating various technological advancements:

- Early HMDs (1960s-1990s): The initial HMDs, like the Telesphere Mask, were rudimentary and primarily experimental. In the 1990s, advancements led to more sophisticated devices like the VFX-1, which featured stereoscopic displays, 3-axis head-tracking, and stereo headphones.
- Advancements in the 2000s: Companies like Sony introduced more refined HMDs, such as the Glasstron in 1997. These devices started to integrate better display technology and improved tracking capabilities.
- Modern HMDs (2010s-present): The most significant leap in HMD technology came with the introduction of devices like the Oculus Rift in 2013. Modern HMDs feature high-resolution displays, advanced motion tracking, immersive audio, and integration with various input devices for interactive experiences.

Today, HMD technologies available include:

- Virtual Reality (VR) Headsets: Offering fully immersive experiences, these headsets use motion tracking, high-resolution displays, and integrated audio for gaming, simulations, and virtual interactions.
- Augmented Reality (AR) Headsets: These devices overlay digital information onto the real world, used in applications like navigation, information display, and interactive learning.
- Mixed Reality (MR) Headsets: Combining elements of both VR and AR, MR headsets provide immersive experiences that interact with the real-world environment.

Each type of HMD caters to different applications, ranging from entertainment and gaming to professional and educational uses. In recent years, more and more application scenarios using virtual glasses have emerged, particularly in the educational sector. This raises the question of how these virtual learning environments should be designed so that they are pedagogically effective and, above all, conducive to learning. The following literature review is intended to highlight the key design elements that serve precisely this purpose.

In a first step, important contributions to the didactic design of virtual learning environments will be presented in order to bundle the most important findings and to make them fruitful for practice. This is followed by a chapter that reports on the potential learning effects of such virtual learning environments. Finally, the most important results from both areas are summarized.

2. Design principles of virtual learning environments

According to the study by Holopainen et al. (2020, p. 17), the proposed design principles for virtual reality learning environments include customized learning, challenging learning environments, multi-sensory effects, immersion, interactivity, 3D-dimensionality, engagement, and motivation towards the content and technology. These principles were suggested based on the results of comparing three virtual learning environments: VR, 3D videos, and 2D videos, and measuring their perceived affordances and learning outcomes in terms of understanding, remembering, and ability to apply.

However, based on the proposed design principles for virtual reality learning environments, we can infer that challenging learning environments should be designed to provide a level of difficulty that is appropriate for the learners' abilities and encourages them to engage in problem-solving and critical thinking. This can be achieved by incorporating interactive and immersive elements, such as simulations, scenarios, and games, that require learners to apply their knowledge and skills in realistic and complex situations.

In the study by Goodwin et al. (2015), incorporating techniques aligned with embodied and enactive cognition can enhance instructional efficacy in VRLEs by reconceptualizing the interaction between the learner and the learning environment. This approach emphasizes the treatment of knowledge as action by applying cognitive science research on embodied and enactive cognition to conceptualize an instructional strategy that capitalizes on the dynamics and interactive nature of VRLEs. By leveraging theory in cognitive science and developing concepts in the learning sciences, the SEEL ("Structured Enactive Engagement in Learning") approach was developed to facilitate increased instructional efficacy within these environments.

The authors suggest that VRLEs can leverage interactive approaches such as those used in computer-based learning, such as interactive algebra, to make learning more engaging through full-body interaction and foster deeper learning. Additionally, the SEEL approach, which was developed based on research in cognitive science and the learning sciences, provides a set of design practices that are better aligned with the learning dynamics provided by VRLEs.

Nelson et al. (2013) discusses several design principles for creating educational virtual worlds, including modality, signaling, contiguity, and personalization. These principles are based on cognitive processing theory and offer guidelines for how text, pictures, sounds, animations, etc. can be arranged to best support learning. The guidelines focus on lowering a learner's perceived extraneous cognitive load while supporting germane load.

Here is a brief description of each design principle:

- Modality: This principle suggests that cognitive load can be reduced and learning improved when words presented with graphics in a learning environment are spoken rather than printed. This is based on an assumption that use of spoken words in conjunction with visuals allows more information to be processed in working memory by reducing a "split attention" effect in which a learner must switch focus between multiple areas of information on a screen.
- Signaling: This principle suggests that cues or signals can be used to highlight important information in a learning environment. For example, using arrows or highlighting to draw attention to key concepts or information can help learners focus on what is most important.
- Contiguity: This principle assumes that related words and pictures should be presented close together in a learning environment. This can help learners better understand the relationship between concepts and reduce cognitive load.
- Personalization: This principle supposes that learning can be improved when learners feel a personal connection to the material. This can be achieved by using examples or scenarios that are relevant to the learner's interests or experiences.

These principles offer guidelines for how text, pictures, sounds, animations, etc. can be arranged to best support learning.

Chris Fowler (2015) has developed two conceptual frameworks to support the design and evaluation of learning systems. The first is the "learning relationships" framework, which emphasizes the importance of understanding the relationships between different components of the learning environment, including learners, teachers, content, and context. The second is the "design for learning" framework, which focuses on the design of e-learning systems and identifies generic and specific learning requirements that should be considered when designing effective learning activities.

According to Chris Fowler, generic learning requirements are those that apply to all learning activities and should be considered when designing any learning system. Examples of generic learning requirements include engagement, motivation, and feedback. On the other hand, specific learning requirements are those that are unique to a particular learning activity or context. These requirements may be related to the subject matter being taught, the learning objectives, or the learners themselves. For example, a specific learning requirement for a virtual reality simulation of a chemistry lab might be the ability to manipulate virtual equipment in a realistic way. Fowler argues that both generic and specific learning requirements should be considered when designing effective learning activities, and that the design of e-learning systems should take into account both types of requirements.

The theory of Digital Didactical Design (DDD) by Nopriana et al. (2023) is a framework that contains components of learning objectives, learning activities, process-based assessment, social relations, and integrated technology. It helps in developing a digital module for vocational students by analyzing student learning obstacles and compiling digital modules that are easily accessible to students. The DDD framework ensures that the digital module is designed with good conditions, typography of contents, textual and visual elements, interactivity, material content, didactical situation, and user interest.

In the analysis stage, several instruments such as tests, interviews, and documentation were used to encounter some learning obstacles in solving the combination problems faced by the vocational high school students. Learning obstacles are factors that hinder or prevent students from achieving their learning goals. These obstacles can be caused by internal factors such as cognitive limitations, lack of motivation, or prior knowledge, or external factors such as poor teaching methods, inadequate learning resources, or lack of support from family and friends. The learning obstacles were identified as didactical obstacles, ontological obstacles, and epistemological obstacles. Didactical obstacles were identified by analyzing the textbooks and notes used by the teacher and students. Ontological obstacles were identified by conducting interviews to determine the students' learning readiness. Epistemological obstacle analysis was done by analyzing the students' answer sheets and confirming them through interviews. These obstacles were addressed in the design of the digital module by creating learning objectives based on basic competency descriptions and indicators of competency achievement. The digital module was designed using DDD components and the theory of the didactical situation.

The ADDIE (Analysis, Design, Development, Implementation, Evaluation) model was used by (Nopriana et al., 2023) in the development and evaluation of a digital module for vocational students. In the analysis stage, learning obstacles are identified through tests, interviews, and documentation. In the design stage, the digital module is created using the DDD framework and the theory of the didactical situation. In the development stage, the digital module is compiled in PDF format and structured based on the five DDD components. In the implementation stage, the digital module is presented using a suitable application. Finally, in the evaluation stage, the validity and practicality of the digital module are tested by experts and students. The ADDIE model ensures that the digital module is developed systematically and evaluated effectively.

According to Kerres et al. (2022) immersion is not generated by a specific technology, but is a dimension of the experience of visually presented information. The experience of immersion is placed in relation to other dimensions of visual perception in order to work out the special features of the experience of immersion. A model of the experience of visual information during learning is presented, which separates the characteristics of the technology, the experience, the learning process and the learning outcome and clarifies their relationship. It is pointed out that media techniques only develop their effect on learning through the specifically prepared content that they communicate. A high level of immersion can support the learning process by making certain perspectives visible in which interactive action can take place. However, dealing with the presentation and familiarizing oneself with the VR technology can also be associated with an undue burden on the working memory and must therefore be justified in more detail with regard to the intended learning processes.

The authors make it clear that immersion is not redeemed by a specific technology and does not automatically contribute to learning success. The various dimensions of the experience of visual information must be examined very closely with regard to the learning process and learning outcomes and specifically stimulated by the design of learning environments and tasks. It is pointed out that media techniques only develop their effect on learning through the specifically prepared content that they communicate. A high level of immersion can support the learning process by making certain perspectives visible in which interactive action can take place. However, it is also pointed out that dealing with the presentation and familiarizing oneself with the VR technology can be associated with an undue burden on the working memory and must therefore be justified in more detail with regard to the intended learning processes.

The experience of immersion is placed in relation to other dimensions of visual perception in order to work out the special features of the immersion experience. Specifically, the dimensions of spatial, reality, movement and presence experience are mentioned. The model of the experience of visual information during learning separates the characteristics of technology, experience, the learning process and the learning outcome and clarifies their relationship to each other. It is pointed out that the various dimensions of the experience of visual information must be examined very closely with regard to the learning process and learning outcomes and must be specifically stimulated by the design of learning environments and tasks (Mulders et al., 2020).

With reference to Tahiri et al. (2022), the use of virtual space can support the understanding of spatial relationships, especially in three-dimensional spaces. By linking different virtual and physical tools in mathematics lessons, students can achieve their goal in new, additional or further ways than before. The article derives design principles from the psychomotor domain according to (Atkinson, 2013) to ensure intuitive operation of the tools by learners The aim of the article is to design the application in such a way that it is easy to learn how to use the tools. The design principles are explained using examples and comparisons of existing planar and spatial geometry systems.

The authors explain the main design principles for a VRLE derived from the individual stages of the psychomotor domain:

1. low-threshold access to tool use through imitation: tools should be designed to be easy to understand and simple to use. One way to achieve this is to use imitation, i.e. the tools should be designed to resemble the real tools that the learners already know;
2. support conceptualization: The application should support learners in understanding and internalizing the mathematical concepts and terms. For example, visual representations or explanations of the tools and construction steps can be used for this purpose;
3. instructions for carrying out construction steps: The application should provide clear instructions on how to perform construction steps to help learners successfully complete the tasks;
4. consistent and authentic operation of tools: the operation of tools should be consistent and authentic, i.e. it should resemble real tools and be designed consistently to avoid confusion and frustration for learners;
5. continuous feedback when using the VRLE: The application should provide continuous feedback to learners to help them track their progress and correct their mistakes. This can be done, for example, through visual representations or acoustic signals.

These design principles should help to ensure that the application is intuitive and easy to understand, helping learners to understand and internalize the mathematical concepts and terms.

The authors Hartmann and Bannert (2022) from the Technical University of Munich have examined conceptual foundations and implications for future research. Immersive media are characterized by the fact that they represent spatial-situational or episodic information and can thus fully represent visual and verbal information of a situation. Learners can thus perceive spatial-situational stimuli directly without having to imagine them. Immersive media offer numerous design options and can represent interactive, problem-oriented and authentic situations that support learners in better understanding the context of relevant learning content and transferring it to new situations.

One difficulty with the theoretical version of learning with immersive media is that different aspects of a learning situation are often implemented together in one application, i.e. different features of the learning environment, such as interactivity or authenticity, are not examined separately or manipulated experimentally. Another important research question regarding the potential of immersive media to promote learning is the extent to which learners are able to mentally imagine spatial-situational information without having visually perceived this information in an immersive learning environment.

The implications for the practice of teaching and learning can be summarized in the following key questions:

- What media features characterize the immersive learning environment and can the content be presented using comparable "traditional" media? What are the essential differences in the media presentation?
- What spatial-situational episodic content is presented in an immersive learning environment and what kind of mental model do learners form of this content?
- What additional semantic information is presented to learners and in what modality (e.g. verbal or visual) is it presented?
- What are the learning objectives of the immersive learning environment? What is the relationship between the representations presented in the immersive learning environment? How coherent is the spatial-situational and semantic information?

The results of the research show that immersive learning has the potential to promote learning processes, but can also entail difficulties. It is therefore important to consider the above questions when designing learning environments and to clearly define the learning objectives.

In addition to the design principles for virtual, immersive learning environments, the following other aspects should also be considered when developing them (see (Zender et al., 2022). Medical aspects: all forms of epilepsy, pre-existing eye conditions, developmental disorders from the early childhood autism spectrum. "Cybersickness and motion sickness have been described (Kim et al. 2021), which are roughly comparable to classic seasickness on a ship in motion. VR applications can therefore trigger dizziness, headaches, nausea and/or vomiting and occasionally lead to short-term visual impairment during or after use (Sharples et al. 2008). According to Munafo et al. (2017), women are more frequently affected by this than men." (32). Accessibility, culture and gender. "For cultural or religious reasons, the use of VR can be an obstacle for students if they do not want to be physically touched or have a critical attitude towards VR technology (Southgate et al. 2019). There are also gender-specific differences: among other things, girls have less access to and less experience with VR compared to boys. In contrast to boys, they show discomfort/shame when they are observed during the VR experience (Southgate 2020)." (34)

Radianti et al. (2020) in this study propose using systematic mapping to identify design elements of existing research dedicated to the application of VR in higher education that considers the usage of both high-end and budget head-mounted displays (HMDs). However, the specific ways in which researchers have applied immersive VR for higher education purposes using both high-end and budget HMDs are not mentioned. According to the auhtors the "realistic surroundings" and "basic interaction" design elements occur in all types of VR applications in the sample studied, and can be seen as the basic design requirements for educational VR applications. Additionally, the text mentions that most applications for declarative knowledge use only these two basic design elements, and that VR applications that aim to improve declarative knowledge can be recommended for initiating VR in courses. "Realistic surroundings" refers to a design element in which the virtual environment is of high graphic quality and has been designed to replicate a specific environment in the real world. For example, this applies to medical students who develop their surgery skills in an authentic-looking operation room. "Basic interaction with objects" refers to a design element in which students can select virtual objects and interact with them in different ways. This includes retrieving additional information about an object in written or spoken form, taking and rotating it, zooming in on objects to see more details, and changing an object's color or shape.

Krüger and Bodemer (2022) explore the ways in which digital media have transformed educational instructions and how augmented reality can enhance learning experiences. While AR is not easily comparable to VR, as explained above, overall design elements in AR environments can also be significant for VRLEs. For this reason, another study on this topic will be presented. According to the authors, augmented reality (AR) differs from other learning environments in that it combines physical environments and virtual elements. This combination of real and virtual elements can involve four potential information origins: real visual elements, virtual visual elements, real auditory elements, and virtual auditory elements. In addition, AR technologies can leverage AR-specific spatiality potentials and contextuality potentials. By uniting multiple aspects of presentation modes, sensory modalities, and realities, AR can provide more complex information and potentially enhance learning experiences.

The authors state that multimedia learning principles can generally be applied to augmented reality (AR) scenarios that combine physical environments and virtual elements. Specifically, the article describes two basic multimedia learning principles that can be applied to AR-specific occurrences: (1) the spatial contiguity principle with visual learning material, leveraging AR-specific spatiality potentials, and (2) the coherence principle with audiovisual learning material, leveraging AR-specific contextuality potentials. The studies described in the article examine the effects of integrated and separated visual presentations of virtual and physical elements, as well as the effects of the omission or addition of matching or non-matching sounds, on cognitive load, task load, and knowledge.

The spatial contiguity principle is a multimedia learning principle that suggests that corresponding pictures and words in multimedia presentations should be presented in a visuo-spatially integrated way instead of a separated presentation. This means that when material is presented in a separated way, more visual searching is necessary and cognitive resources need to be used to keep the individual elements

in working memory before being able to integrate them mentally. This increases extraneous processing, using up resources that are then not available for essential and generative processing. In AR, this principle can be followed for combinations of virtual and physical pictorial as well as textual representations, which can be displayed in an integrated way, e.g., through video or optical see-through technology in AR systems.

The coherence principle is another multimedia learning principle that suggests that extraneous processing can be reduced by presenting information in a coherent way. This means that when audio and visual elements are presented together, they should be related to each other in a meaningful way. In AR, this principle can be followed for audiovisual learning material, leveraging AR-specific contextuality potentials. For example, matching sounds can be added to virtual and physical visuals to create a more coherent and meaningful learning experience.

The authors describe several potential benefits of using AR in educational settings. According to the article, AR can provide a more engaging and interactive learning experience, as it combines physical environments and virtual elements. AR can also provide more complex information and potentially enhance learning experiences by uniting multiple aspects of presentation modes, sensory modalities, and realities. Additionally, AR can help learners visualize abstract concepts and understand spatial relationships more easily. AR can also provide learners with opportunities to practice skills in a safe and controlled environment. Finally, various reviews of research on AR in formal and informal educational settings have established its positive effects on learning outcomes, motivation, engagement, attitudes, and cognitive load in comparison to non-AR implementations.

3. Learning outcomes of virtual learning environments

Cao et al. (2023) present in a systematic literature review, that recent research on immersive VRLEs has shown promising results in terms of improving self-efficacy, self-regulation, student engagement, and participation in curriculums and institutional communities. The review also identified several key factors related to learning performance, including the design, method, process, and evaluation of outcomes. Specifically, the review emphasized the importance of careful design and development of immersive virtual reality learning environments, including considerations of user experience, pedagogical goals, and ethical concerns. The review also highlighted the need for rigorous evaluation of learning outcomes, including measures of knowledge or skill achievement, motivation, concentration, memory, and self-efficacy. In addition, the review noted the potential impact of high immersion and enjoyment on users' concentration and learning performance and suggested that these factors should be carefully considered in the design and evaluation of immersive virtual reality learning environments. Overall, the review suggests that a holistic approach to the design, development, and evaluation of immersive virtual reality learning environments is essential for optimizing learning outcomes and engagement. Based on these findings, the authors suggest that immersive virtual reality technology has the potential to enhance student engagement and learning outcomes, but that further research is needed to fully understand its impact and potential limitations. The review also highlights the importance of careful design and evaluation of immersive virtual reality learning environments, including considerations of user experience, pedagogical goals, and ethical concerns. Overall, this systematic review provides valuable insights for educators and developers seeking to create effective and engaging immersive virtual reality learning environments.

The results of this systematic literature review on immersive virtual reality learning environments can be applied in various educational contexts to enhance student engagement and learning outcomes. For example, educators and developers can use the findings to design and develop immersive virtual reality learning environments that are tailored to specific pedagogical goals and student needs. The review also highlights the importance of careful evaluation of learning outcomes, which can help educators and developers to identify areas for improvement and optimize the effectiveness of immersive virtual reality learning environments.

However, there are also some potential challenges and limitations to consider when applying the results of this review. For example, immersive virtual reality technology can be expensive and may require specialized technical expertise to develop and maintain. In addition, there may be ethical concerns related to the use of immersive virtual reality technology in educational contexts, such as issues of privacy, safety, and accessibility. Furthermore, the effectiveness of immersive virtual reality learning environments may depend on various individual and contextual factors, such as prior knowledge, motivation, and learning style. Therefore, educators and developers should carefully consider these challenges and limitations when designing and implementing immersive virtual reality learning environments in different educational contexts.

Helbo and Knudsen (2004) found that there was a problem with self-regulation in ICT-based distance learning, and that didactic adjustments were required. Véliz Salazar and Gutiérrez Marfileño (2021) emphasize that the characteristics of successful virtual education must include continuous feedback, interactivity, knowing the student's needs, multisensory teaching materials, and promoting active learning. Qvist et al. (2015) underline that virtual learning environments can be used for authentic and deep learning. However, none of the papers explicitly address the question "What are the best research results on the topic of didactics of virtual learning environments?" so it is difficult to say definitively what the best research results are. Based on the findings of these papers, some possible best practices for virtual learning environments include continuous feedback, interactivity, knowing the student's needs, multisensory teaching materials, and promoting active learning.

Aiello et al. (2012) emphasize that VLE „take on the same characteristics of learning environments since they reproduce the complexity of the reality, presenting complete tasks, which are mainly based on the interaction rather than on pre-determined instructional sequences, and they allow a construction of knowledge strongly determined by the context" (320). They further refer to Kolb and Fry's (1975) learning circle, which distinguishes four phases of a cyclical structure of the learning process and should, in their view, also be used in VLEs: a) abilities based on concrete experience, b) reflective observation abilities, c) abstract conceptualisation abilities, and d) active experimentation abilities.

The study from Holopainen et al. (2020) compared the learning outcomes of three different virtual learning environments: VR, 3D videos, and 2D videos. The results suggest that VR has the potential to provide new teaching methods on higher levels of learning, such as applying, analyzing, and evaluating, compared to the other two technologies. Moreover, the study found that the perceived affordances of different technologies, such as customized learning, challenging learning environments, multi-sensory effects, immersion, interactivity, 3D-dimensionality, engagement, and motivation towards the content and technology, significantly explained the differences of VR compared to the other two technologies. However, the study also notes that there is a need for more research on different learning technologies and their learning outcomes.

The authors note that traditional instructional strategies and design practices were developed for learning contexts lacking the dynamic nature and capabilities of technology-rich, immersive learning environments. As a result, current approaches to the design and delivery of instruction in VRLEs draw heavily from traditional methods that tend to emphasize technological capabilities at the expense of the actual learning experience. This creates a dichotomy between the learning interface, which emphasizes knowledge as an object, and the learning environment, which can emphasize knowledge as action. The factors influencing undesirable effects stem from an over-reliance on learning technologies, a lack of focus on the manner in which those technologies affect the critical factors that facilitate learning, and/or the absence of instructional strategies that are better aligned with the learning dynamics provided by VRLEs.

The SEEL approach by Goodwin et al. (2015) as mentioned above is an instructional strategy that was developed to guide learning experiences in VRLEs. It codifies and formalizes a set of testable instructional design approaches to facilitate increased instructional efficacy within these environments. The SEEL strategy provides an iterative approach to enactive learning engagement based upon theory and empirical research. It consists of five distinct phases that provide a comprehensive approach to enactive instructional design, development, and application. The five phases of the SEEL approach are: (1) Analyze/Determine Instructional Context, (2) Develop Learning Outcomes, (3) Design and Develop Learning Activities, (4) Implement and Facilitate Learning Activities, and (5) Evaluate Learning Outcomes. (288)

Phase	Focus/Goal	References
Analyze/Determine Instructional Context	• Establish the instructional context of the learning experience. • Identify the learning objectives that can be enacted and embodied.	[24–26, 35]
Analyze/Identify Instructional Resources	• Determine the tools, technologies, and settings used to create the learning experience. • Identify instructional artifacts that ground target concepts in embodied action.	[9, 11, 34]
Establish/Revise the Learning Environment	• Design the learning experience through the integration of the environment, context, and instructional artifacts. • Establish and instantiate how the learner's interaction with artifacts and the environment can make the learning content more apparent.	[34, 39, 40]
Implement/Guide Learning	• Facilitate ongoing exploration of enactive experiences. • Promote sense-making through the use and expansion of action possibilities within the learning space.	[38, 39, 41–44]
Analyze/Assess/Revise Learning Outcomes	• Establish qualitatively or quantitatively derived evaluations to assess the instructional efficacy of implemented approaches. • Modify the instructional approach as required to address learning issues or meet changing needs.	[34, 35]

The 4E Cognition approach by Christ et al. (2022) emphasizes the role of the physical body (embodied cognition), the interaction between the individual and its environment (extended cognition), as well as aspects of acting in social interaction (enactive cognition) and the situatedness of cognition (embedded cognition). In the context of virtual didactic settings, the 4E Cognition approach can be used to create a more holistic approach to the complexity of cognitive phenomena in everyday life. The article "Learning in Immersive Virtual Reality: How Does the 4E Cognition Approach Fit in Virtual Didactic Settings?" explores this topic in more detail.

The 4E Cognition approach consists of four dimensions, each represented by an "E":

1. Embodied cognition: This dimension emphasizes the role of the physical body in cognition. It suggests that our bodies and the way we interact with the world around us play a crucial role in shaping our thoughts and experiences.

2. Extended cognition: This dimension emphasizes the interaction between the individual and its environment. It suggests that our cognitive processes are not limited to our brains but can extend to the tools and technologies we use to interact with the world.
3. Enactive cognition: This dimension emphasizes the role of acting in social interaction. It suggests that our cognitive processes are shaped by our interactions with others and the social context in which we operate.
4. Embedded cognition: This dimension emphasizes the situatedness of cognition. It suggests that our cognitive processes are shaped by the specific context in which they occur, including the physical, social, and cultural environment.

Generally, educators can consider using immersive virtual reality to create engaging and interactive learning experiences that allow students to explore complex concepts in a more hands-on way. They can also use virtual reality to simulate real-world scenarios and provide students with opportunities to practice skills in a safe and controlled environment. However, it is important to ensure that the use of virtual reality is pedagogically sound and aligned with learning objectives.

The article identified several limitations and challenges associated with the use of VR as a pedagogical tool. One major challenge was the lack of VR learning content, experiences, and teaching tools in certain subject areas, such as the arts, humanities, and social sciences. Additionally, most studies relied heavily on multiple-choice questions and test scores to assess learning outcomes, and VR interventions were typically short and isolated, which may have impeded the learning experience of the user. However, despite these limitations, most studies did find a significant advantage of using VR over less immersive methods of learning, particularly when the subject area was highly abstract or conceptual, or focused on procedural skills or tasks.

The authors suggest that VR has the potential to be an effective pedagogical tool in education, particularly in subject areas that are highly abstract or conceptual, or focused on procedural skills or tasks. However, the review also highlights the need for a sound theoretical basis to guide the development and implementation of VR interventions, as well as the need for more comprehensive analyses of learning outcomes that go beyond simple test scores.

Overall, the findings of this study may encourage educators and researchers to explore the use of VR as a pedagogical tool in a wider range of subject areas and to develop more sophisticated and comprehensive methods for evaluating the effectiveness of VR interventions. This could lead to the development of more immersive and engaging learning experiences for students, which could ultimately improve learning outcomes and enhance the overall quality of education.

According to the study by Parong and Mayer (2018), adding a generative learning strategy of summarizing to the existing VR lesson significantly improved learning outcomes compared to the original VR lesson. Creating summaries during breaks in the VR lesson prompted the learners to select, organize, and integrate the information from the lesson into their existing knowledge structures. This work shows that generative learning strategies that have been shown to be effective in non-VR environments can also apply to immersive VR.

The review by Beck et al. (2023), an extensive analysis of 47 literature surveys, identified 45 strategies and 21 practices for immersive learning environments. These practices and strategies were clustered around their conceptual proximity and relatedness, resulting in five clusters: "Active context", "Collaboration", "Engagement and Scaffolding", "Presence", and "Real and virtual multimedia learning". The article provides a descriptive framework for pedagogical interventions that can be used to bring clarity to the results and provide guidance, not prescribe actions. For example, an instructor

attempting to teach their students how to solve scientific problems might seek out help from the "Real and virtual multimedia learning" cluster.

The authors suggest that the educational metaverse promises fulfilling ambitions of immersive learning, leveraging technology-based presence alongside narrative and/or challenge-based deep mental absorption. The immersive nature of the metaverse can provide students with a sense of presence and engagement that is not possible with traditional learning environments. The article also notes that the metaverse can provide opportunities for collaboration and active learning, as well as the use of real and virtual multimedia learning strategies. However, it is important to note that the effectiveness of the metaverse for education is still an area of ongoing research and development, and there are also challenges and limitations to its use in education.

Beck et al. (2023) note that there are several challenges and limitations to using immersive learning environments in education. One of the main challenges is the lack of a comparable way to describe the educational approaches that led to the learning outcomes. This makes it difficult to evaluate the effectiveness of immersive learning environments and to replicate successful approaches. Additionally, the diversity of aspects of concern for educators and researchers, such as the technological, administrative, and pedagogical aspects, can make it difficult to identify the most effective strategies for using immersive learning environments. Other challenges include the need for specialized technical skills and resources, the potential for distraction and disorientation, and the potential for unequal access to technology and resources among students.

According to the authors, there are several potential benefits of using immersive virtual reality for learning, including:

- Multi-layered representation in virtual space
- Interaction with 3D models
- Building self-confidence and familiarity
- Fun of learning
- Self-directed exploration

Positive effects on subjective measurements such as commitment, enjoyment, usefulness, and learner motivation

However, there are also some potential drawbacks to consider, such as:

- High cost of equipment and development
- Technical difficulties and limitations

- Potential for motion sickness or other negative physical effects
- Limited social interaction and collaboration
- Limited transferability of skills to real-world contexts

It is important for educators to carefully consider these factors when deciding whether to incorporate immersive virtual reality into their teaching practices.

Wang et al. (2020) paper explores the impact of task complexity on learning styles in virtual reality technology. The research presented in this paper suggests that task complexity does not have a significant influence on how people learn in virtual reality technology for construction education. However, there is ongoing debate on the role of computers and VR technology as tools in learning and teaching. While the majority of current research focuses on the utilization of immersive visualization as an aid to improve students' understanding of building and to aid design tutors to explore students' projects to detect flaws, there have been limited studies investigating the development of virtual environments in response to different learning and cognitive styles of their users. Therefore, further investigation is needed to establish guidelines on designing Virtual Learning Environments (VLEs) for different learning contexts. The educational experiment conducted in this study involved 253 undergraduate construction students who were randomly assigned one of three tasks of different complexity levels. The tasks were designed to represent different levels of cognitive processes that one might expect to be included in different roles in the construction industry. The low complexity task required the cognitive process of remembering, the medium complexity task required the cognitive processes of applying and analyzing, and the high complexity task required the cognitive processes of evaluating and creating. The hypothesis that students would adopt different learning styles when engaged in learning tasks of different complexities was rejected, as no significant difference in the preferred learning styles was identified among the three experimental groups. Therefore, it was concluded that when using virtual reality technology for construction education, there is no evidence to suggest that the level of task complexity has a significant influence on how people learn.

In this study, learning styles were measured using Kolb's Learning Style Inventory (LSI). The LSI is a widely used questionnaire that assesses an individual's preferred learning style based on four dimensions: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). The LSI was administered to the participants after they completed each of the three tasks of different complexity levels. However, due to incomplete questionnaires, some of the responses were counted as invalid. The number of valid responses from each task was 78, 76, and 74, respectively. The scores for each learning style dimension were calculated for each participant, and the mean values for the six learning style dimensions for each task complexity group were analyzed.

Reference was made to Bloom's taxonomies in this study. Howard et al. (1996) mapped Bloom's taxonomy onto Kolb's Experiential Learning Model (ELM). According to the authors, when learning, people usually start with the "why" quadrant, then move to the "what" quadrant, which represents the first and second level of Bloom's taxonomy (knowledge and comprehension), then move into the "how" quadrant, which provides students with the challenges of application and analysis, and finally move to the "what if" quadrant, where the last two levels of Bloom's taxonomy are addressed (synthesis and evaluation). Howard et al. suggest that teaching should be organized around this "circle" to accommodate multiple learning styles and to achieve better learning outcomes. However, Howard et al. did not establish any empirical evidence to support this mapping. Murphy also identified similarities between the first four levels of Bloom's taxonomy and the four dimensions of Kolb's Experiential Learning Model.

Processes	Sub-processes	Definitions	Examples
Remember	Recognizing Recalling	Retrieve relevant knowledge and/or information from long-term memory.	Recognize the type of a building. Recall the name of a place.
Understand	Interpreting Exemplifying Classifying Summarizing Inferring Comparing Explaining	Construct meanings from given information.	Interpret the meanings of given texts. Give examples of a concept. Put things into categories (e.g. types of buildings, patterns). Compare and explain the difference between two objects.
Apply	Executing Implementing	Carry out a procedure in a given situation	Apply a procedure to a given task.
Analyse	Differentiating Organizing Attributing	Separate given material into its constituent parts. Investigate the inter-relationship between parts and the overall structure or purpose.	Distinguish important elements from unimportant elements of the given task or material. Establish a point of view relative to given material.
Evaluate	Checking Critiquing	Make judgments and critiques based on criteria and standards.	Determine if a conclusion is valid in terms of observed data. Determine if a method is effective.
Create	Generating Planning Producing	Assemble elements to form a new pattern, structure or procedure.	Establish hypotheses. Plan a procedure. Invent a product.

Table 1: The six cognitive levels in the revised framework [42]

Adams et al. (2021) take the view that the integration of VR in teaching and learning becomes more affordable when these technologies become more readily available to the general public. Additionally, the authors mention that features of the current and emerging VR environments indicate promises to provide a more precise representation of reality for learning, supporting learners to discover knowledge, and improving learners' motivation and attention in subjects such as information technology, engineering education, geometry, mathematics, and medical education. However, the article does not provide specific examples of recent advancements in VR technology that make it more feasible for formal and informal learning.

But the authors suggest that future directions for research would be to enlist stakeholders to design with considerations of VR as an activity system. In addition, it is mentioned that foci need to be geared toward investigating the content-specific skill and assessment with reflective learning in a VR environment and designing and building libraries or methods to share content and use these platforms, developing authoring tools to enhance efficiency in instructional design, and exploring alternative assessment and feedback mechanism in these VR environments. Therefore, instructional designers can apply their skills to optimize the use of emerging VR technologies by designing and building libraries or methods to share content and use these platforms, developing authoring tools to enhance efficiency in instructional design, and exploring alternative assessment and feedback mechanisms in these VR environments.

It is mentioned that VR presents challenges such as high cost, the complexity of management and support, and cognitive overload. also highlights some challenges, including safety concerns in the physical environment, potential neural and physiological impact to users, and alternative solutions to ensure ethical and inclusive applications. Adams et al. (2021) raises five issues that educators should consider when using a virtual reality-based environment, including technical challenges, cost factors, and the need to explore the effectiveness of the VR learning environment further. To address these challenges and limitations, stakeholders can work together to design with considerations of VR as an activity system, investigate content-specific skill and assessment with reflective learning in a VR environment, develop authoring tools to enhance efficiency in instructional design, and explore alternative assessment and feedback mechanisms in these VR environments. Additionally, collaborations between disciplines, such as those between educational institutions and entrepreneurial education, can be considered as applied research to mutually benefit the teaching and learning on and off-campus.

4. Conclusion

Virtual reality has the potential to impact the teaching and learning experience in several ways. Some potential benefits of virtual reality for education include:

- Enhanced engagement and motivation: Virtual reality can provide immersive and interactive learning experiences that can help to engage learners and increase their motivation to learn.

- Improved knowledge acquisition: Virtual reality can provide learners with opportunities to practice and apply their knowledge in realistic and challenging environments, which can help to improve their understanding and retention of the material.
- Increased accessibility: Virtual reality can provide learners with access to learning experiences that might not be possible in the physical world, such as simulations of complex or dangerous environments.
- Support for collaboration: Virtual reality can support collaborative learning by allowing learners to interact with each other and with virtual objects in shared virtual spaces.

However, there are also some potential drawbacks to using virtual reality in education, including:

- Cost and accessibility: Virtual reality technology can be expensive and may not be accessible to all learners.
- Technical issues: Virtual reality systems can be complex and may require specialized technical expertise to set up and maintain.
- Potential for distraction: Virtual reality environments can be highly immersive, which may lead to learners becoming distracted from the learning objectives.
- Potential for negative effects: Some studies have suggested that virtual reality can have negative effects on learners, such as causing motion sickness or disorientation.

In order to create these effects, however, the virtual learning environments must be designed accordingly. The overview above (Chapter 2) has shown various approaches and results in this regard. They can be summarized as follows:

- user-friendly design: The VR learning environment should be easy to navigate and provide clear instructions for students. It should allow users to easily perform common actions such as rewinding, pausing and playing. Brief instructions on how to use the VR goggles and navigate the virtual space can be of great benefit to students.
- engaging content: The best way to ensure that students are interested in the virtual content is to make it engaging and interactive. Include animations, simulations, puzzles or quizzes that require student participation.
- clear learning objectives: Just like traditional teaching, virtual learning should have clear objectives. Make sure that the VR content aligns with these learning objectives and helps to achieve them.
- 4safety: Ensure that the virtual environment is safe for students. Provide support for those who may suffer from motion sickness or discomfort when in VR for extended periods of time.
- structured and guided learning: Although self-directed learning can be an important aspect of VR learning, some form of structured and guided learning can also be beneficial, especially for complex concepts.
- realistic environments: Create a realistic and relevant learning environment. For example, if you are teaching about historical events, a virtual environment that transports students back in time can promote engagement and understanding.
- feedback mechanisms: Implement feedback mechanisms, whether in the form of programmed feedback through the VR software or in the form of feedback from the teacher.
- integration with other learning formats: VR lessons should ideally not stand alone, but be integrated with traditional online and physical teaching methods to ensure a well-rounded learning experience.
- accessibility: Ensure that the VR environment is accessible to all students, including those with disabilities. It is crucial to consider how students with visual or hearing impairments can navigate the environment.

Overall, while virtual reality has the potential to enhance the teaching and learning experience, it is important to carefully consider the potential benefits and drawbacks before implementing virtual reality in educational settings.

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MODULE 6
Methodology of the VR environment (teacher perspective)

1. Creating a positive VR classroom atmosphere

Do's:

1. **Set Clear Expectations:** Clearly communicate behavioral expectations within the virtual classroom. This helps create a respectful and orderly environment where students understand the standards of conduct.
2. **Foster Collaboration:** Emphasize the importance of collaboration and teamwork within the VR environment. Encourage students to work together, share insights, and learn from one another.
3. **Promote Inclusivity:** Ensure that your VR classroom is accessible to all students, including those with disabilities. Provide alternative means for participation if VR is not accessible to certain individuals.
4. **Use Icebreakers:** Begin VR sessions with icebreakers or team-building activities to help students feel more comfortable and connected in the virtual space. This can promote a sense of community.

Don'ts:

1. **Don't Ignore Social Dynamics:** Be mindful of social dynamics within the VR environment. Address issues like exclusion, cliques, or conflicts promptly to maintain a positive atmosphere.
2. **Avoid Overloading Content:** Avoid overwhelming students with too much content or information in a single VR session. This can lead to cognitive overload and reduced engagement.
3. **Don't Ignore Feedback:** Listen to student feedback and concerns, even if they seem minor. Addressing these issues promptly shows that you value their input and are committed to their learning experience.

2. Ensuring even participation

Do's:

1. **Assign Roles:** Assigning specific roles or tasks within the VR experience ensures that each student contributes actively. For example, one student can be responsible for navigation, while another focuses on data collection.
2. **Rotate Roles:** Regularly rotate the assigned roles to give all students the opportunity to take on different responsibilities. This prevents any single student from monopolizing a specific role.
3. **Use Gamification:** Incorporate gamification elements like points, rewards, or leaderboards to motivate participation. Recognize and reward students who actively contribute.
4. **Provide Equal Opportunities:** Ensure that each student has an equal opportunity to explore and lead within the VR environment. Encourage shy or quieter students to take on leadership roles.

Don'ts:

1. **Avoid Favoritism:** Be impartial and avoid favoring specific students or groups. Ensure that all students are treated fairly and receive equal opportunities to participate.
2. **Don't Let One Student Dominate:** Prevent a single student from dominating the VR experience to the detriment of others. Encourage balanced participation and contributions from everyone.

3. Dealing with potential issues and frictions

Do's:

1. **Conflict Resolution:** Be prepared to mediate conflicts or disagreements among students in a constructive manner. Encourage open communication to resolve issues.
2. **Seek Feedback:** Actively seek feedback from students regarding their experiences in the VR classroom. Regular surveys or discussions can help you identify and address problems early.
3. **Provide Technical Support:** Ensure that technical support is readily available to assist students with VR equipment issues, software glitches, or connectivity problems.

Don'ts:

1. **Don't Ignore Issues:** Address any issues or frictions among students promptly. Ignoring problems can lead to a negative classroom atmosphere and reduced engagement.
2. **Avoid Blaming:** When technical issues arise, avoid blaming individual students. Focus on finding solutions and providing support rather than assigning blame.

4. Assisting students with health issues (e.g., seizures)

Do's:

1. **Medical Records:** Request students with known health issues, such as epilepsy, to share relevant medical records and guidelines. This information will help you make informed decisions regarding VR experiences.
2. **Emergency Protocol:** Establish a clear emergency protocol for dealing with health-related incidents. Ensure that all students, teaching assistants, and technical support staff are aware of this protocol.
3. **Provide Warnings:** Display epilepsy warnings and ensure that all VR content used complies with accessibility guidelines and includes proper warnings regarding potentially triggering content.

Don'ts:

1. **Don't Ignore Health Concerns:** Never disregard health concerns or fail to take appropriate precautions for students with medical conditions. Safety should always be a top priority.
2. **Avoid Inadequate Warnings:** Never use VR content without adequate epilepsy warnings or fail to provide necessary accommodations for students with specific health needs.

5. Making VR lessons entertaining

Do's:

1. **Use Immersive Storytelling:** Create VR experiences that incorporate immersive storytelling elements. Engage students with compelling narratives that make the content more relatable and memorable.
2. **Interactive Elements:** Include interactive elements such as quizzes, puzzles, or challenges within the VR environment. Interactive activities keep students engaged and encourage active participation.
3. **Varied Environments:** Offer diverse VR environments to keep lessons visually stimulating and prevent monotony. Varying the settings can enhance engagement and retention of information.
4. **Encourage Exploration:** Allow students the freedom to explore and interact with the virtual world. Encourage

them to discover and learn by doing within the VR environment

Don'ts:

1. **Avoid Repetition:** Refrain from creating repetitive or monotonous VR experiences that can lead to disinterest and boredom. Maintain a balance between content and engagement.
2. **Don't Overload:** Avoid overloading the VR environment with excessive information or tasks. Keep content manageable to prevent cognitive overload, which can hinder learning.

6. Motivating students to explore VR further

Do's:

1. **Showcase Possibilities:** Share success stories and examples of how VR technology has positively impacted students' academic and professional journeys. Real-life examples can inspire further exploration.
2. **Assign VR Projects:** Encourage students to create their own VR projects or research topics related to their course. Assignments that require VR development or research can stimulate interest.
3. **Provide Resources:** Offer additional resources, tutorials, or links to VR communities and events for students interested in exploring VR beyond the classroom. Show them the wealth of opportunities available.

Don'ts:

1. **Don't Force Exploration:** Avoid pressuring students to explore VR if they are not interested. Instead, provide incentives and opportunities for those who are genuinely curious.
2. **Avoid Neglect:** Don't neglect students who may not initially express interest in VR. Maintain an inclusive approach and provide resources for exploration should they change their mind

MODULE 7

How to implement a learning scenario in the VRLE model

1. Registration

The first step of the VRChat registration process requires users to navigate to its official website https://hello.vrchat.com/.

Figure 1. VRChat Website

Next, users should select the *Login* menu located at the top right corner of the website.

Figure 2. VRChat Login Menu

The next step of the registration process requires users to provide their registration details through the registration form provided by VRChat website.

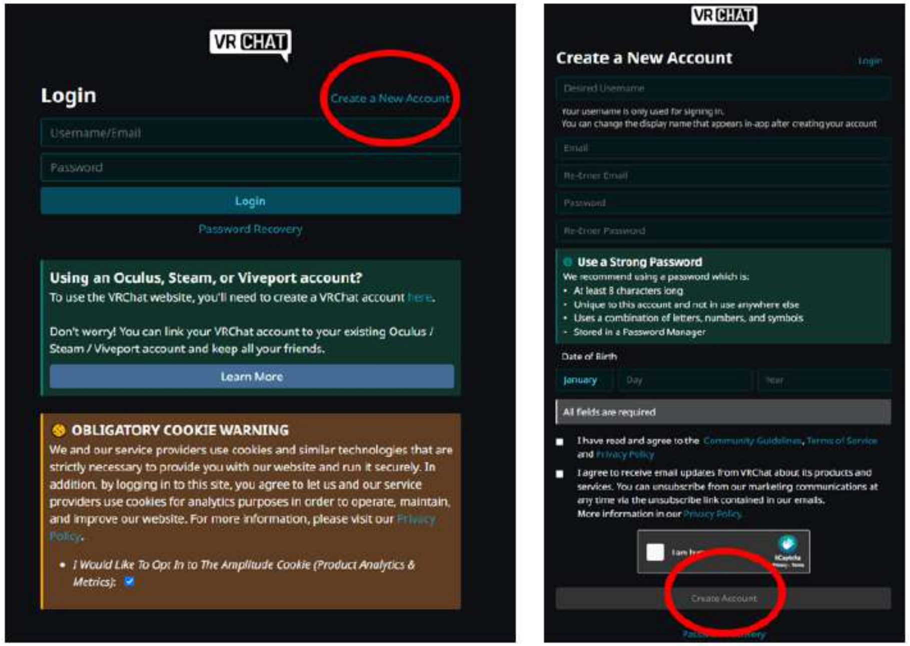

Figure 3. VRChat Account Creation

2. Desktop Version

Installation

To access any version of the VRChat platform, users have to download, install, and register to STEAM. To do so users must visit https://store.steampowered.com/ and download STEAM by selecting the Install Steam option located at the top right corner of the website.

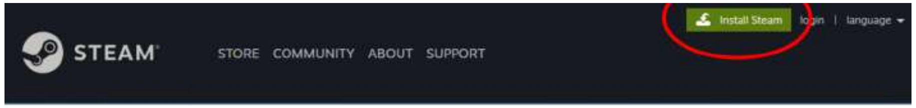

Figure 4. STEAM installation menu

After installing STEAM, users have to launch it and create a new STEAM account. This account requires users to select a username and password along with an e-mail address which will have to be later verified. To do so, STEAM will send an automated e-mail upon registration for users to verify their account.

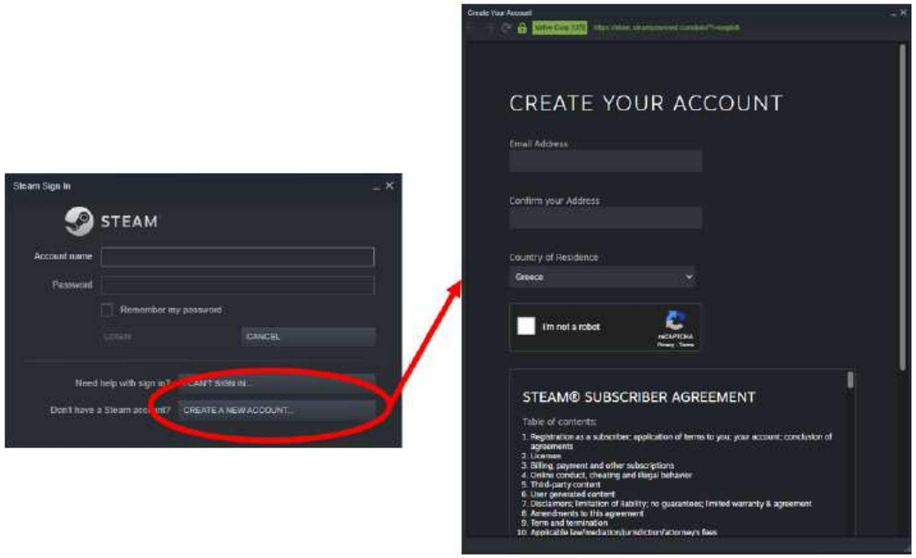

Figure 5. STEAM account creation

Finally, users have to launch STEAM found in their personal computers, log into their newly created account, search for VRChat into the *Store* option of STEAM and select it.

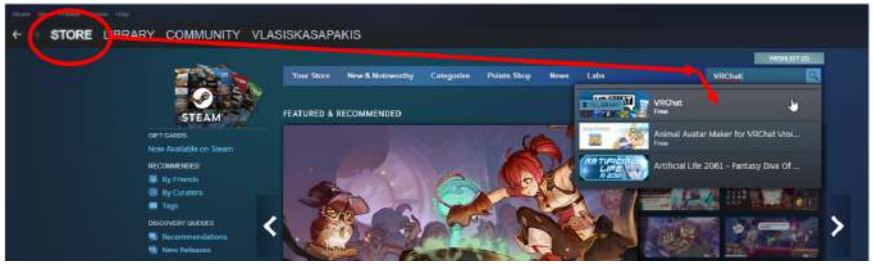

Figure 6. VRChat selection into STEAM

After selecting VRChat, users have to select the *Play Now* option and install VRChat by choosing the installation location and selecting *Next*. It is recommended to install VRChat at the default location.

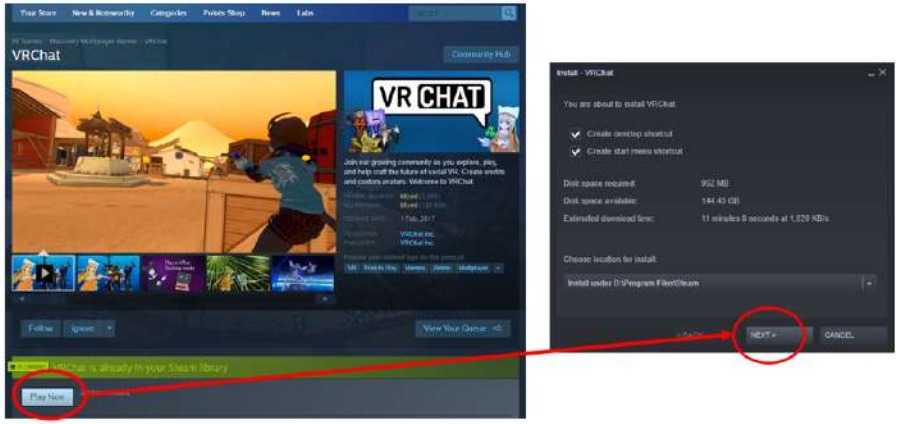

Figure 7. VRChat Installation using STEAM

Upon completing the installation process, users can select VRChat in their *LIBRARY* option of STEAM and select *Play* to launch it.

Figure 8. VRChat launch through STEAM

VRChat offers two separate access options for desktop computers. One refers to *STEAM VR Mode* which supports Head Mounted Displays requiring a connection with a desktop VR-Ready computer (e.g., HTC Vive, Oculus Rift S etc.). The other option refers to desktop access and is labeled as *Non-VR*. Here it must be noted that it is recommended <u>to familiarize with the specifics of VRChat using the desktop version prior to accessing it through a Head Mounted Display</u>, as they only differ in terms of equipment used and not core functionality. In order to access the Non-VR version of VRChat users have to select it and press *PLAY*.

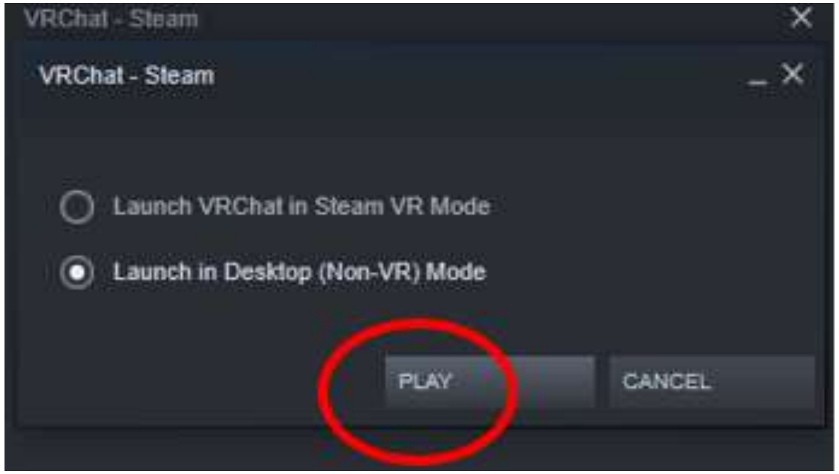

Figure 9. VRChat Non-VR Mode selection in STEAM

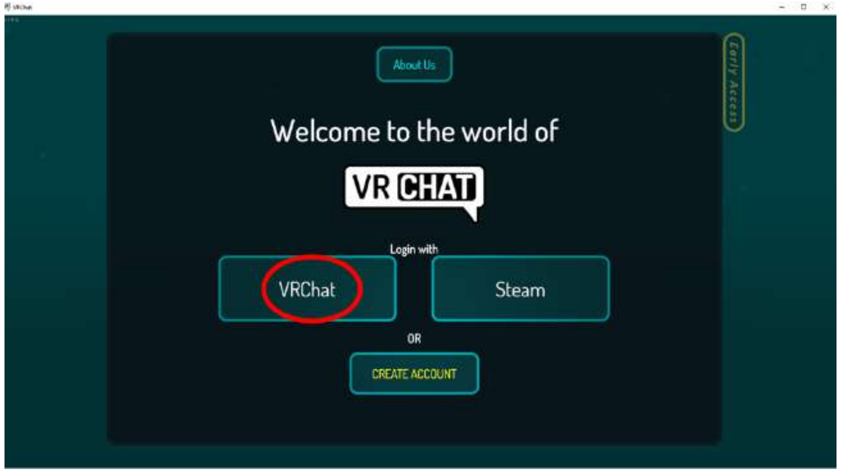

Figure 10. VRChat account selection

Login Process

In order to login into VRChat users have to select the *VRChat* account option and provide their username and password selected during the registration process described above. Keep in mind that STEAM account and VRChat account are two separate accounts. The reason behind not using STEAM account for registration into VRChat is that having two separate accounts increases security as if STEAM account is lost, VRChat account can be still accessed. Moreover, STEAM accounts do not support accessing VRChat using a standalone Head Mounted Display such as the Oculus Quest 2.

Figure 11. VRChat Usename

Figure 12. VRChat Password

By successfully logging into VRChat, users will have to press *Go!* In order to visit home world of VRChat and start using it. Here it must be noted that it may take some time for the home world of VRChat to download before the Go! option becomes available.

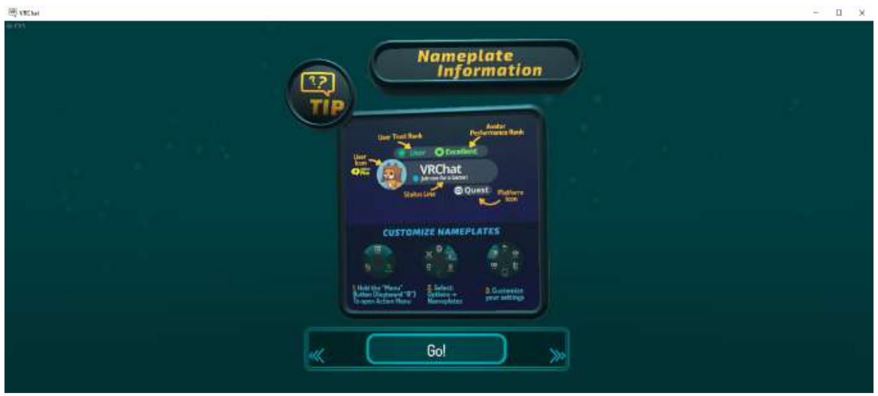

Figure 13. VRChat home world visit

Navigation, Avatar Selection & Launch Pad

The aforementioned process will allow users to visit the VRChat Home world. This is the first world every VRChat user visits and includes basic VRChat tools. Users have to go through those tools in order to effectively use VRChat in the future. When using the Non-VR version of VRChat users can use their Keyboard buttons (W, A, S, D) to move around, and their mouse to look-around. VRChat Non-VR version is designed to function as a simplified First-Person Game were the field of view of the users is their moving direction too. In simple terms users move towards the direction they look into the VR world. Moreover, users can press and hold the “V” button on their keyboards to talk to other users through their desktop computer microphone.

Figure 14. VRChat Home world

The first thing a user has to do in VRChat home world is to observe their *Avatar*. To do so users have to move in front of the mirror located at the VRChat home world and their reflection will appear automatically.

Figure 15. VRChat mirror

Users can then use their mouse to select a different avatar from the *Avatars* menu next to the mirror of the VRChat home world. This will result to an immediate change of the users' appearance which will be visible to the mirror and other users as well.

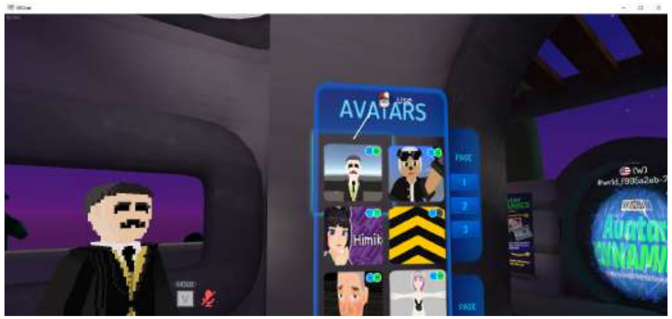

Figure 16. VRChat avatars

Avatars can be also selected through the *Launch Pad*, which is the main menu option of VRChat. Launch Pad can be toggled by pressing the *Escape* button on the desktop computer keyboard.

Figure 17. VRChat Launch Pad

After opening the Launch Pad users can select an Avatar category (it is recommended to use public Avatars available to all players), and then select an avatar and apply it using the *Change into Avatar* option.

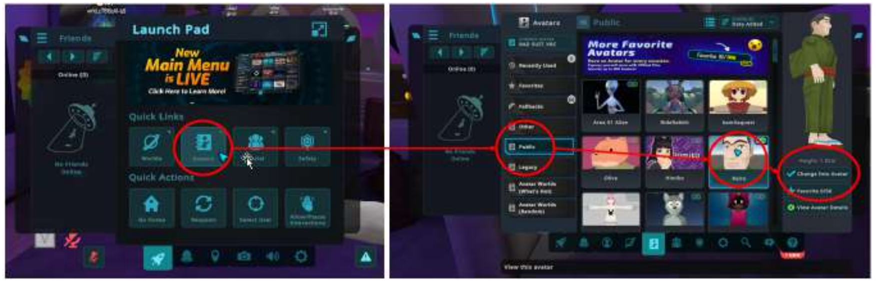

Figure 18. VRChat avatar selection through VRChat

Each Avatar icon features a PC and/or Quest option at its top right corner. This icon indicates the ability of an Avatar model to be shown in both PC and Oculus Quest platforms. Thus, it is strongly recommended that users choose an Avatar which is supported in both platforms to be able to communicate with users of both PC and Oculus Quest platforms.

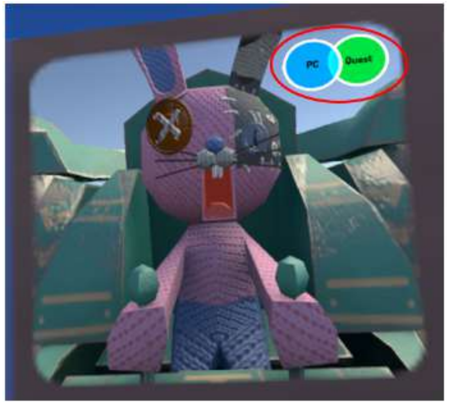

Figure 19. VRChat PC/Quest Avatar Support

Safety & Settings

Another important factor of VRChat is safety. VRChat offers players different trust levels (*Visitors -> New User –> User -> Known User – Trusted User)* based on the time users spent in VRChat and their overall behavior. It then allows users to select which features will be visible from each trust category. In order to receive the full VRChat experience, users have to toggle the Launch Pad, select *Safety*, select *Custom*, select each user category (*including the Friends category*), and allow every feature such as *Voice*, *Avatar* etc. Finally, to apply those changes, users have to select the *Use This Shield Level* option.

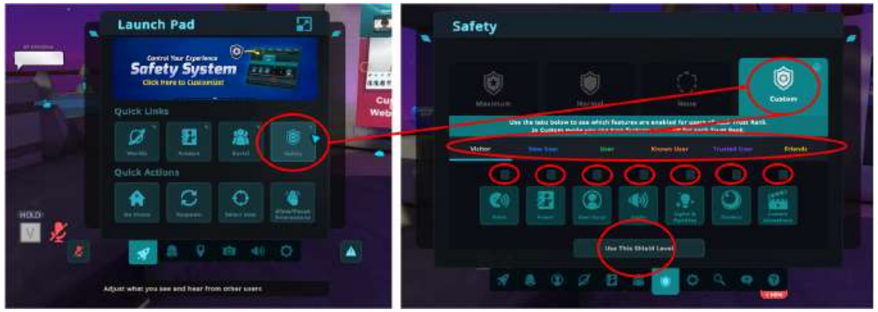

Figure 20. VRChat desktop version selection in STEAM

VRChat audio options can be also accessed from the Launch Pad. There, users can adjust their microphone sensitivity or select a different microphone to use inside VRChat.

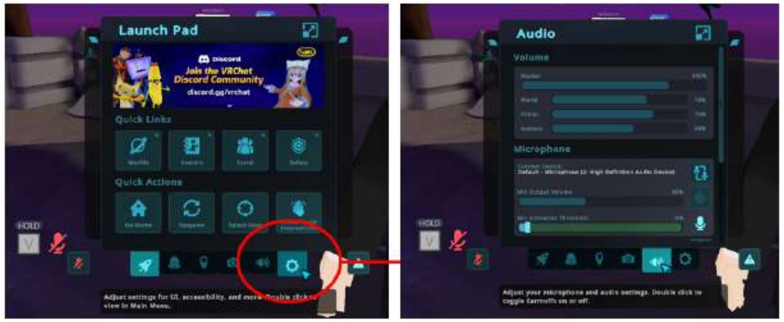

Figure 21. VRChat Audio settings

Visiting Worlds

VRChat features hundreds of different worlds for its users to visit. In order to visit a world, users have to toggle their Launch Pad, selected the *Worlds* option, select an available world, and finally press *Join* to visit it.

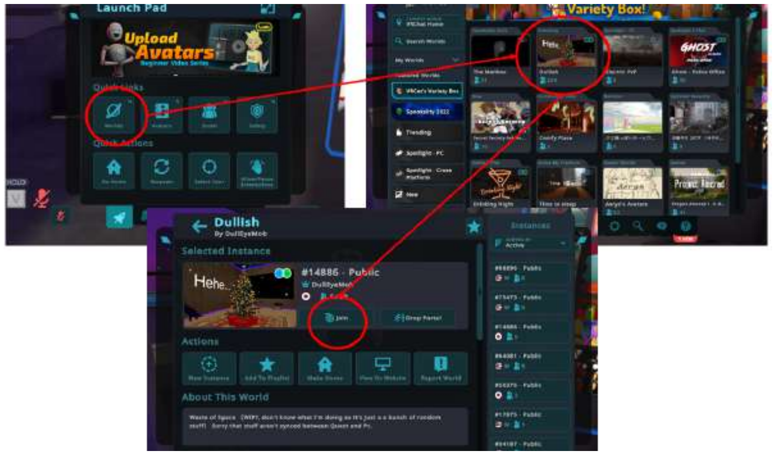

Figure 22. VRChat worlds

VRChat will then download the selected world. Upon the completion of this process users have to press the Go! button in order to visit the world.

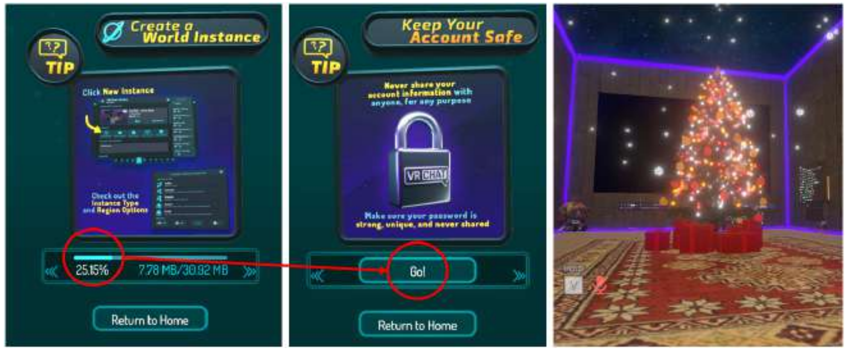

Figure 23. VRChat Worlds

Another option allowing users to visit a world in VRChat is through a *Portal*. Users can follow the same process as described above but instead of selecting the Join option to visit a world, they can select the *Drop a Portal* option to open a gateway to the selected world. The portal will be available for 30 seconds and users can simply go through it to visit the world it provides a gateway to.

Figure 24. VRChat Portals

User can toggle their Launch Pad and select the *Go Home* option to return to the home world of VRChat. Also, users can move from world to world using the tools described above without the requirement to return to the VRChat Home world first.

Figure 25. VRChat home world

Social Aspects of VRChat

The most important aspect of VRChat is socialization with other users. The best way to make friends in VRChat is to visit worlds and interact with other people. Then users can toggle their Launch Pad, select the *Social* option, select the *In Room* option to see the fellow users in the same world, select their icon, and finally use the *Friend Request* to ask other users to become their friends.

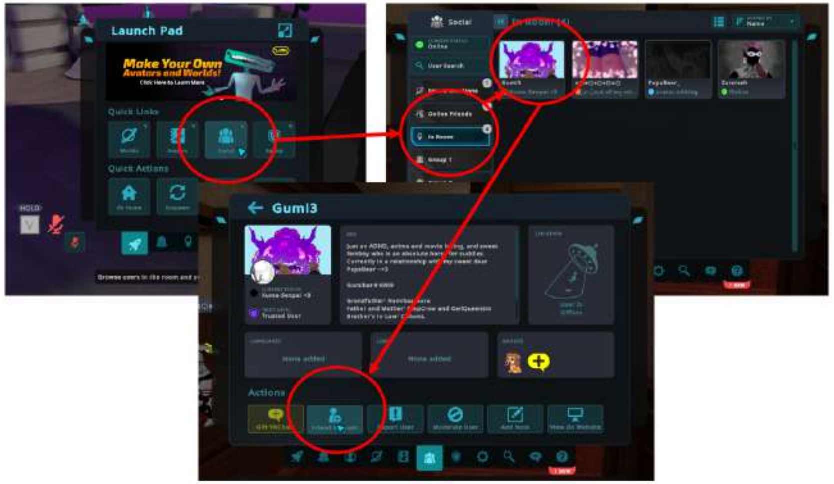

Figure 26. VRChat Friend Request

If required, users can select the *User Search* option from the Social menu of VRChat to search for people by their username.

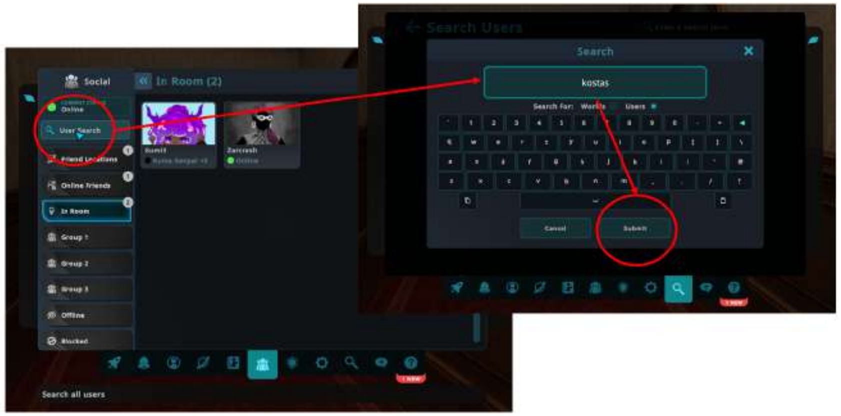

Figure 27. VRChat User Search

From the same menu users can check their friends' locations in order to visit them, along with their online/offline friends list.

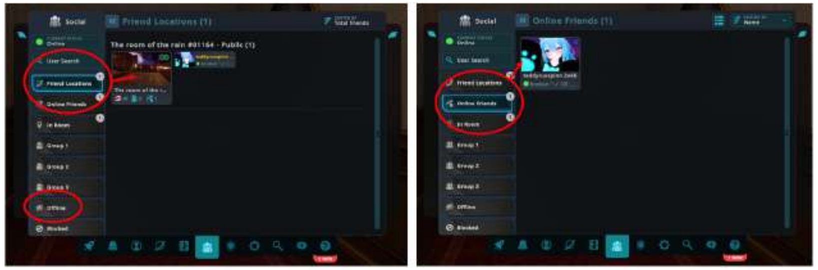

Figure 28. VRChat friends lists

When users receive a friend request a brief message appears at the bottom of their screen. The friend requests can be accessed through the Launch Pad by selecting the *Notifications* panel at its bottom. There users can choose to either accept of decline a friend request.

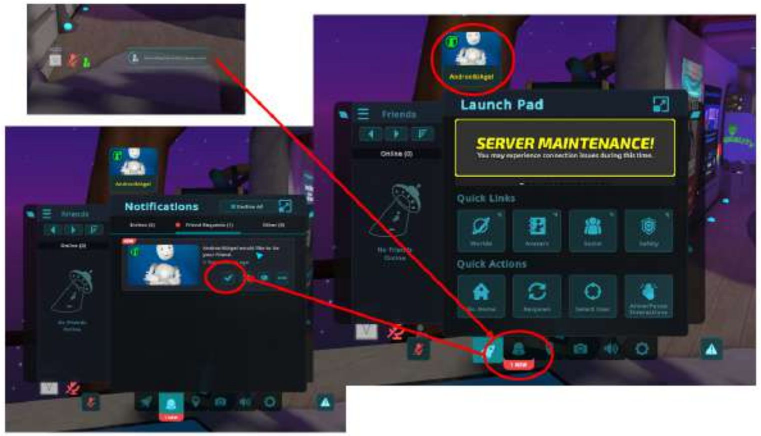

Figure 29. VRChat friend request acceptance

After completing the friend request process a friend can invite users to join them into a world. This invitation will appear as a notification and can be also accessed from the Launch Pad where users can choose to either accept or decline the invitation.

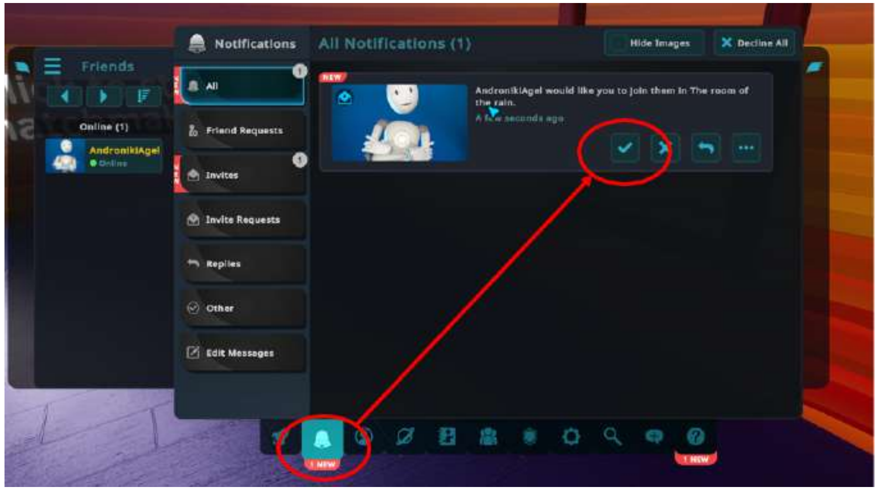

Figure 30. Invitation to join a world

Upon acceptance users will be transferred to the world their friend is and therefore they can speak and to and interact with each other.

Users can invite friends to join them to VRChat worlds to. To do so users have to open the Launch Pad and select a world. Then users have to select the *New Instance* option. This will allow users to create an instance of any public VRChat world, upon which they will have control over the access levels as explained below. Instances are an invaluable tool allowing users to increase the privacy of the world they interact with by allowing certain users to join.

Figure 31. VRChat friend in the same world

Figure 32. VRChat world instance creation

This will lead to the instance options menu where users can select the access levels of the world they are about to create. This includes *Public instances*, where any user can join at any time, *Friends+* instances, were any friend, or friend of friend can join, *Friends instances*, where only friends can join, *Invite+* instances were only invited users can join and accept join requests from other users, and finally *Invite* instances were only invited users can join and only the instance creator can accept join requests. For novice users it is recommended to create *Invite* instances in order to be able to fully control which users can access them.

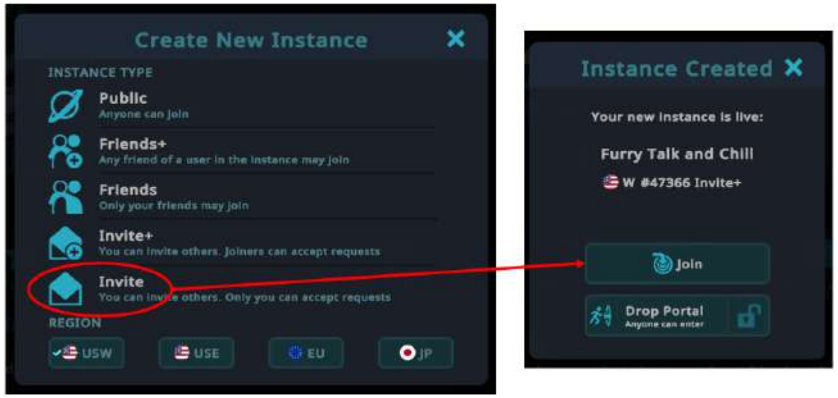

Figure 33. VRChat world instance access level

After creating an instance, users can toggle their Launch Pad, select the Social option, find an online friend and sent them an invite (containing a message or not) to join their world.

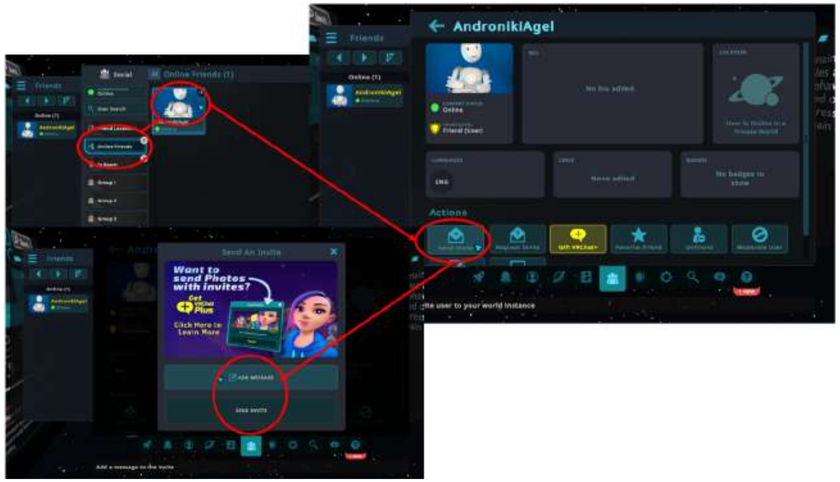

Figure 34. VRChat invitation to join word

Invited users will receive their invitations as notifications (as described in Figure 30) and will be able to join the world they are invited into by accepted them.

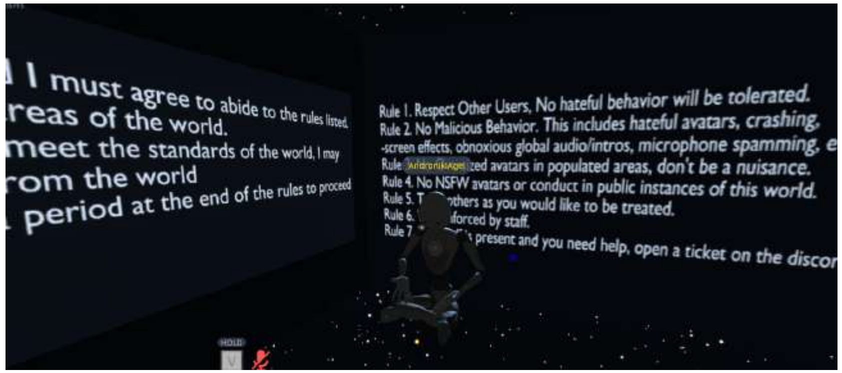

Figure 35. VRChat user appearing a world instance after accepting an invitation

Finally, it must be mentioned that users can follow the same invitation process to invite any friend in any public instance of any world. However, same public worlds feature limitations on that ability.

Desktop users can perform a variety of expressions through their avatars by pressing the R button and selecting an expression or an emoji to be communicated to other nearby users.

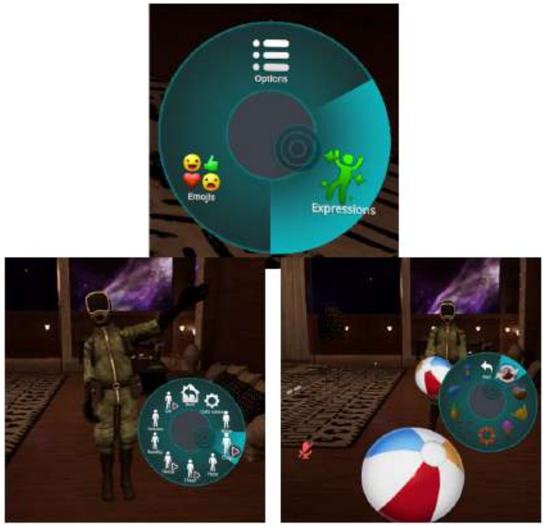

Figure 38. VRChat expressions/emojis

Interaction

Interaction with items is different for each game world. VRChat offers a crosshair in the middle of the screen which is used as an indicator to aim to certain items in VRChat worlds in order to interact with them.

Figure 36. VRChat crosshair

The most common interaction modalities involve clicking or holding a mouse button down.

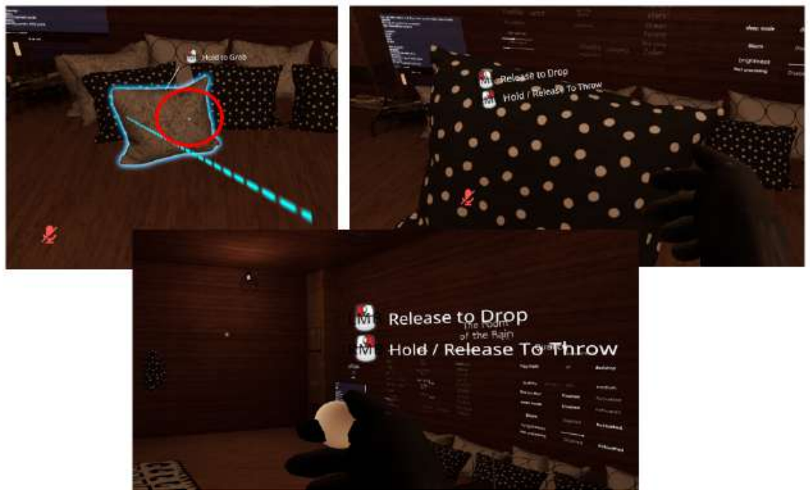

Figure 37. VRChat interactions

3. Immersive VR Version

Connecting Oculus Quest 2 to a mobile phone

In order to use an Oculus Quest 2 HMD, users have to download the Oculus app from either the App Store or Google Play, enable the Bluetooth and Location services of their mobile device, and log into the Oculus app using their Facebook or Instagram accounts. Also, if preferred, users can create their own oculus account using their E-Mail address. Then users have to power up their Oculus Quest 2 device, connect it to a power source using its USB cable, select the menu button at the top right of the Oculus app, select the devices menu, and select the Oculus Quest 2 pairing option for the device list.

The mobile device will communicate with the Oculus Quest 2 device and pair with it. Users have to follow the detailed pairing instructions (e.g., select the preferred language, connect to the WiFi etc.). Finally, when the process is over the users will be prompted to create a guardian. This will allow the Oculus Quest 2 to set the floor level and available play space ensuring users safety. The process is very easy to follow, and the Oculus Quest 2 HMD will provide detailed instructions.

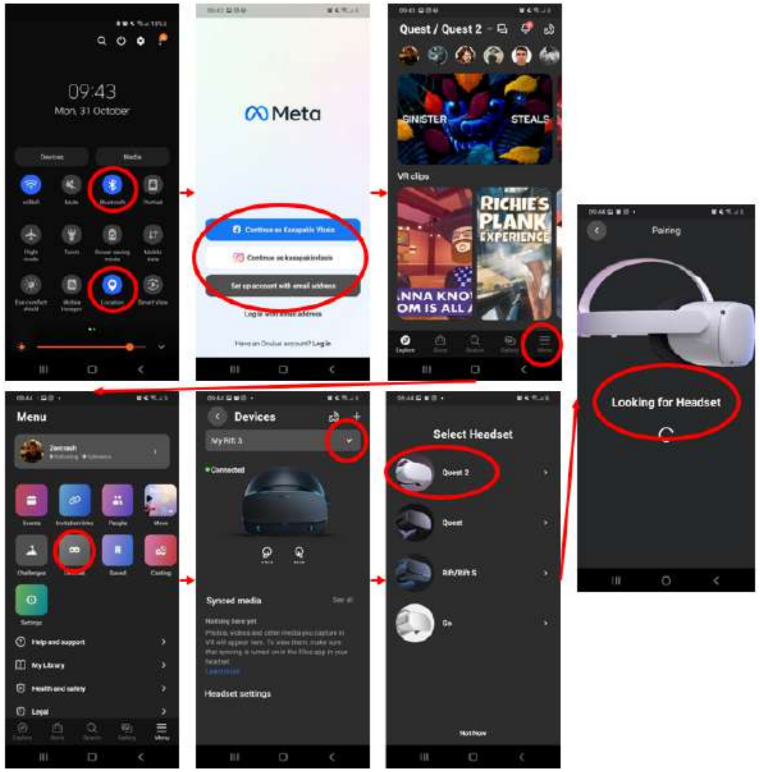

Figure 39. Connect Quest 2 to a mobile phone

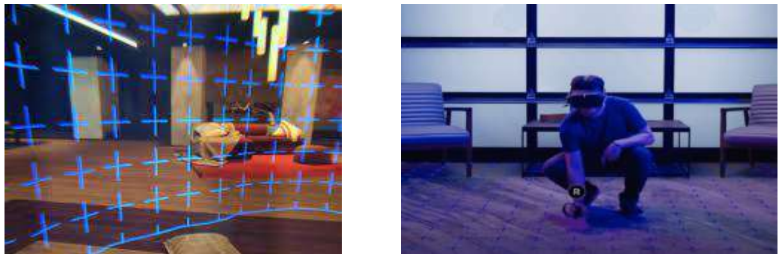

Figure 40. Oculus Quest 2 Guardian

VRChat Installation

After setting up the Oculus Quest 2 devices, users have to select the right controller menu button, navigate to the App Library of Oculus, and search for VRChat using the virtual keyboard and the trigger button of the left controller.

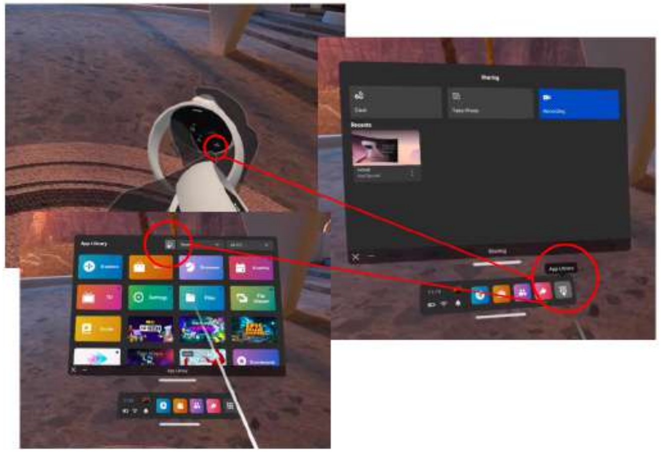

Figure 41. VRChat Installation

Figure 42. Virtual Keyboard

Users can select the VRChat icon to install it on their Oculus Quest 2 device.

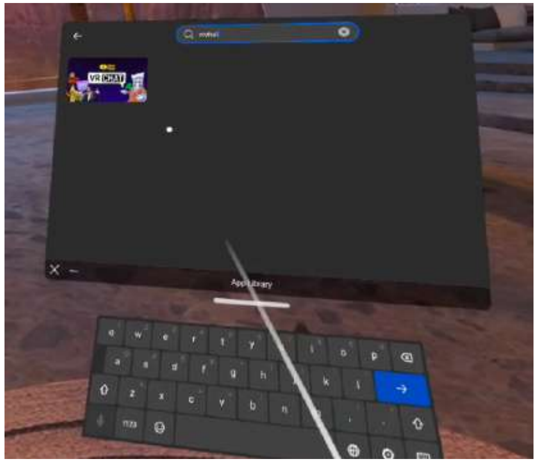

Figure 43. VRChat installation

Finally, users can return to the App Library and select VRChat to launch it.

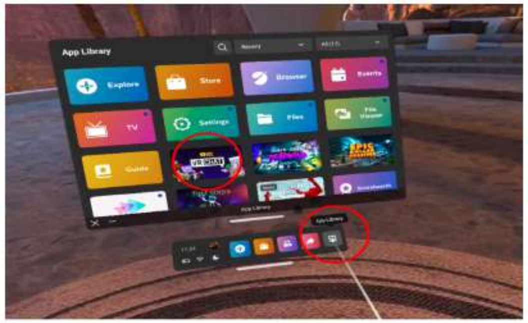

Figure 44. VRChat launch from App Library

Launching VRChat

Launching VRChat in Oculus Quest 2 will ask users to log into it using their VRChat account. Here it must be noted that users can be log into VRChat using their Oculus account too, but this is not recommended as losing the Oculus account will subsequently prevent users from accessing their VRChat account too.

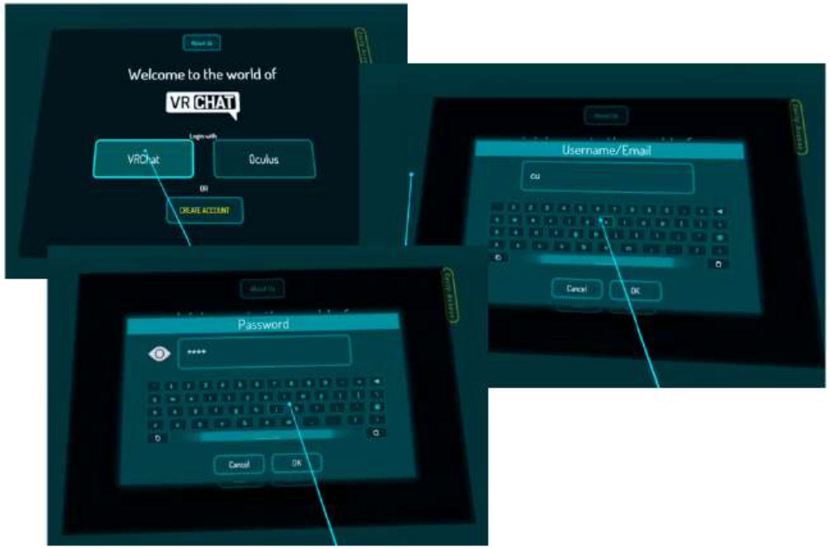

Figure 45. Logging into VRChat using VRChat account

The first world users visit when logging into VRChat using Oculus Quest 2 is the VRChat Tutorial. Nevertheless, for this manual, users are advised to skip the tutorial as the next steps will thoroughly guide them through the VRChat basic functionalities.

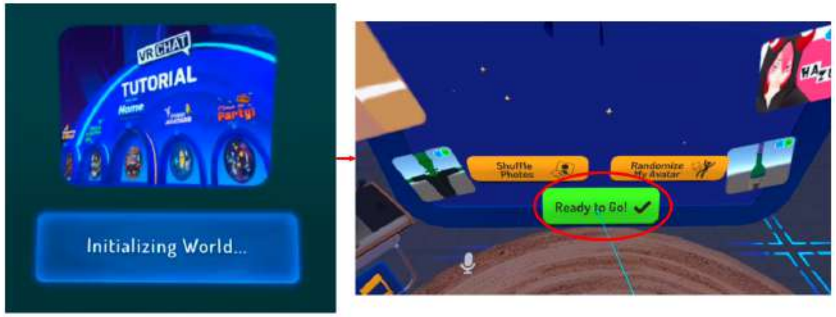

Figure 46. VRChat tutorial

Users will be then prompted to select their locomotion technique. VRChat supports *Holoport* and *First Person*. Users are advised to use Holoport as they can point and teleport around the VRChat worlds. First-Person locomotion technique refers to the usage of the joystick to move around the VRChat worlds. Nevertheless, being in same place in the real world and moving around in the virtual world while simulating walking causes cybersickness to many users. Therefore, users are advised to use Holoport.

Figure 47. VRChat locomotion settings

Users can move the left controller joystick up, point the location they wish to move, and release it to do so. During the first world of VRChat users have to move to an arrow located at the end of the world in order to be able to continue using VRChat.

Figure 48. VRChat locomotion

Finally, users will be prompted to visit a VRChat world using a portal. Users are advised to use Home world during using VRChat for the first time.

Figure 49. VRChat worlds

VRChat Avatars & Worlds

From this point on the functionality of VRChat is exactly the same as the Desktop version presented above. First users can use their Holoport function to visit the mirror of the Home world and check their avatar. They can also change avatars using the avatar menu of the Home world using their right controller trigger to select them.

Figure 50. VRChat locomotion

Users can also change avatars using the Launch Pad. To access the Launch Pad users, have to press the menu button of their left controller and then use the trigger button of their right controller to select the menu items. Users are recommended to set their security levels as described in Safety & Settings).

Figure 51. VRChat Launch Pad

Users can select the Avatars menu and then select the avatar they prefer from the VRChat avatars repository as done in the desktop version (see Navigation, Avatar Selection & Launch Pad).

Figure 52. VRChat Avatars

To join a world, users have to simply toggle the Launch Pad, select the Worlds menu, select a World and then select Join to visit it.

Figure 53. Visiting VRChat worlds

To return to the Home world users have to toggle their Launch Pad and select the Go Home option.

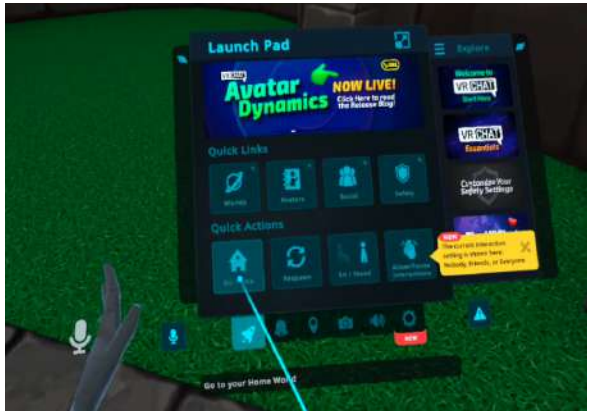

Figure 54. Returning to Home world

Moreover, users can select the Worlds menu, select a World, and drop a portal in order for them and other users to visit it.

Figure 55. Dropping portals

Moreover, users can select to create instances of Worlds featuring restrictions on who of the users can visit it (see Social Aspects of VRChat).

VRChat Interactions

The simplest form of interaction in VRChat is through the trigger button of the right controller. This can be used to select items into the virtual world of change settings.

Figure 56. Interacting with the VR world using the trigger button

Another common interaction method in VRChat is the usage of the side button on the right controller. Users can hold this button to pick up items and release it to drop them.

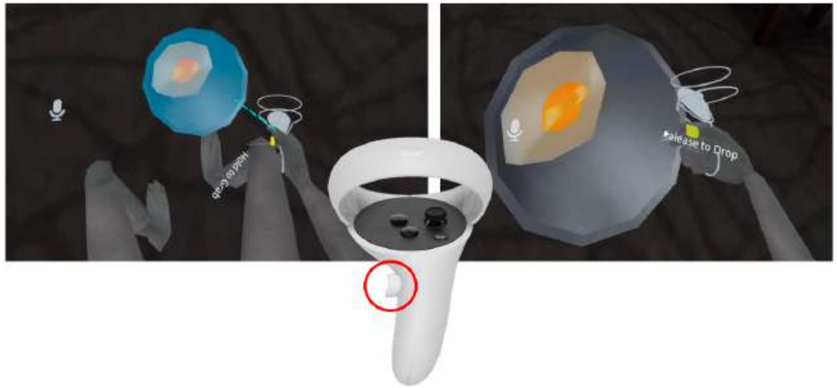

Figure 57. Picking-up items

Social Aspects of VRChat

As in the desktop version, users can use emojis and expressions. To do so users will have to press and hold the Menu button of the left controller and then use the joystick button to navigate through the emojis and expressions menu.

Figure 58. Using Emojis and Expressions

Users can also use the Social menu of the Launch Pad in order to find friends and sent friend requests as done in the desktop version (see Social Aspects of VRChat).

Figure 58. Utilizing the Social menu of VRchat

MODULE 8
Advantages of using VR in teaching/education

With advances in new technologies, education is rapidly taking off in new directions that substantially change the way learners learn but also the way teachers teach.

Virtual reality (VR) can be traced back to the 1960s when the first head-mounted displays were created. The technology was primarily used in military and industrial settings for training and simulation purposes. In the late 1980s and early 1990s, VR technology became more accessible to the general public, and entertainment companies began to explore its potential as a medium for gaming and other interactive experiences. However, it wasn't until the 2010s that VR technology truly began to take off with the introduction of devices such as the Oculus Rift, HTC Vive, and PlayStation VR.

The origins of VR in education can be traced back to the early 1990s, when the first VR systems were developed for educational purposes. These systems were primarily used for scientific visualization and simulations, such as exploring complex data sets or modeling natural phenomena. One of the earliest examples of VR in education was the Virtual Reality Medical Center (VRMC), founded in 1994 by Dr. Brenda Wiederhold. The VRMC used VR technology to treat patients with phobias and anxiety disorders, such as fear of flying or public speaking. In the early 2000s, VR technology began to be used in classrooms to enhance learning experiences. For example, the Virtual Field Trips project, launched in 2004 by the University of North

Carolina, allowed students to explore historical and cultural sites around the world using VR technology. Some of scenarios developed within this project go along these lines.

Today, VR is being used in a wide range of educational settings. For example, VR simulations are used to teach medical students anatomy and surgical procedures, while VR field trips are used to introduce students to new cultures and environments. VR technology is also being used to teach subjects such as science, engineering, and history in immersive and interactive ways. Donally (Donally 2018) underlines that virtual reality in education is transforming how we learn and teach, providing students with immersive and interactive experiences that engage and inspire.

The use of VR in education is still in its early stages, but its potential to transform the way we learn and teach is immense. Researchers underline not only the interactive aspect of applying VR but provide evidence for cognitive advantages: Virtual reality has the power to create authentic learning experiences that engage and inspire students, leading to better retention and deeper understanding, see (Johnson & Nagel 2016). Some of critics on applying VR in the classroom concerns the danger of societal disengagement of learners.

However, Bailenson (Bailenson 2017) points out that VR is an effective tool for creating empathy, increasing engagement, and enhancing learning outcomes in a wide range of educational settings. Soft skills are highlighted also in (Freeman et al. 2014): Virtual reality can provide students with opportunities to develop key 21st century skills, such as collaboration, creativity, and critical thinking, leading to greater success in the workforce. It can be also a powerful tool for addressing issues of accessibility and inclusion in education, particularly for students with disabilities (Edwards & Edwards 2020), (Mekacher 2019). As VR technology continues to evolve and become more accessible, it is likely that we will see even more innovative applications of this powerful tool in the years to come.

1. Learning through experience

Virtual reality has the potential to revolutionize education by providing students with immersive and interactive experiences that can enhance learning outcomes. One of the key benefits of VR in education is its ability to facilitate learning through experience. By simulating real-world situations and scenarios, students can engage in active learning and develop their skills and knowledge in a safe and controlled environment. This experiential learning approach has several advantages in the educational context.

Active and immersive learning. VR immerses students in a three-dimensional virtual environment, creating a sense of presence and allowing them to interact with objects and information in a natural and intuitive way. This active engagement enhances the learning experience by stimulating multiple senses and promoting a deeper level of understanding.

Practical application and skill development. Through VR simulations, students can practice and apply their knowledge and skills in realistic scenarios. For example, in medical education, VR can provide students with simulated surgeries or patient interactions, allowing them to hone their clinical skills in a controlled setting before working with real patients. Similarly, VR can be used in engineering education to provide hands-on experience with complex machinery or architectural design.

Safe and controlled environment. VR eliminates the risks associated with real-world training or experimentation. Students can make mistakes, experiment with different approaches, and learn from failures without any adverse consequences. This freedom to explore and learn from trial and error fosters a growth mindset and encourages students to take risks in their learning journey.

Multi-sensory and multi-modal learning. VR can engage multiple senses simultaneously, offering a rich and multi-modal learning experience. Students can see, hear, and even touch virtual objects or environments, enhancing their cognitive processing and information retention. This multi-sensory approach caters to different learning styles and preferences, making learning more accessible and inclusive.

Complex and abstract concepts visualization. VR can help students visualize and understand complex or abstract concepts that are difficult to grasp through traditional methods. For example, in physics education, students can explore and manipulate virtual models of atomic structures or celestial movements, allowing them to better comprehend these abstract concepts through interactive and visual experiences.

Emotional and empathetic learning. VR can evoke emotional responses and foster empathy by placing students in the shoes of others. For instance, history students can virtually experience significant historical events, enabling them to develop a deeper emotional connection and a better understanding of the context. This emotional engagement enhances the learning experience and promotes empathy and perspective-taking.

By leveraging the power of VR to facilitate learning through experience, educators can create dynamic and interactive learning environments that go beyond traditional textbooks and lectures. The ability to simulate real-world situations, provide practical application opportunities, and engage multiple senses makes VR a valuable tool for enhancing learning outcomes in various disciplines.

Through VR experiences, students can explore historical events, practice problem-solving and decision-making, and engage in scientific simulations, among other things. By engaging in these experiences, students can develop a deeper understanding of the subject matter and improve their critical thinking, creativity, and problem-solving skills.

Moreover, learning through experience in VR can be particularly beneficial for students who learn better through hands-on experiences rather than traditional classroom lectures. VR can provide these students with an opportunity to engage with the subject matter in a more tangible way and help them develop a better understanding of complex concepts.

Learning through experience is a crucial aspect of education, and VR has the potential to enhance this aspect by providing students with immersive and interactive experiences. By engaging in VR simulations, students can develop their skills and knowledge in a safe and controlled environment, and ultimately improve their learning outcomes.

2. Enhanced engagement and motivation

Virtual reality (VR) has the potential to enhance students' engagement and motivation in the learning process. By providing immersive and interactive experiences, VR captivates students' attention and sparks their curiosity.

Immersive and captivating experiences. VR transports students to virtual environments that feel real and compelling. This immersive nature of VR captivates students' attention and creates a sense of presence, making them more invested in the learning process. As a result, students are more likely to stay engaged and focused on the educational content. The article (Bower, Sturman & Kennedy 2019) explores the potential of virtual reality (VR) in higher education and its impact on student engagement and learning outcomes. It discusses how immersive experiences provided by VR can captivate students' attention and create a sense of presence, leading to increased engagement with educational content. The authors highlight the importance of designing meaningful and interactive VR experiences that align with learning objectives to maximize the benefits for higher education students.

Active participation and interactivity. VR allows students to actively participate and interact with the virtual environment. They can manipulate objects, explore surroundings, and make decisions that have consequences within the simulated world. This active engagement promotes a sense of agency and empowerment, leading to increased motivation and a deeper connection to the learning material. A study by Fabris and his coauthors (Fabris, Ch. et al. 2019) examines the effect of active learning through virtual reality on student engagement and academic achievement in higher education. It specifically investigates the role of interactivity and active participation within the VR environment. The research findings highlight that active engagement, including the ability to manipulate objects, explore virtual spaces, and make decisions, positively influences student engagement and learning outcomes. The study underscores the potential of VR to enhance students' sense of agency and connection to the learning material, leading to improved academic achievement.

Personalized and learner-centered approach. VR can provide personalized learning experiences tailored to individual students' needs and preferences. Educators can design VR scenarios that adapt to the student's progress, presenting challenges and content at an appropriate level. This learner-centered approach fosters a sense of ownership and relevance, enhancing motivation and self-directed learning.

A nice literature review that discusses the state of the art and perspectives on immersive VR in education, including higher education is provided by (Freina & Ott 2015). The review emphasizes the potential of VR to provide personalized learning experiences and adaptivity based on individual students' needs and preferences. It discusses how VR environments can be designed to accommodate different learning styles and present content at appropriate levels, fostering a learner-centered approach. This learner-centric approach in VR enhances motivation, engagement, and self-directed learning. This review encompasses a broad range of research and perspectives related to VR in education and can serve as a valuable source for exploring personalized and learner-centered approaches in VR within higher education.

Novelty and excitement. The novelty factor of VR creates excitement and curiosity among students. The opportunity to explore new virtual worlds, interact with 3D objects, and experience situations that are otherwise inaccessible generates enthusiasm and a sense of adventure. This heightened interest can translate into increased motivation and a willingness to invest more effort in the learning process.

Emotional engagement. VR has the ability to evoke emotions and elicit emotional responses from students. By simulating real-world scenarios or placing students in different perspectives, VR can create emotionally impactful experiences. This emotional engagement enhances learning by making the content more memorable and facilitating the formation of strong cognitive and emotional connections. In (Dubovi 2022), the author explores the impact of emotional engagement in VR role-play on learning gains in higher education. The research findings demonstrate that VR has the ability to create emotionally impactful experiences by placing students in different perspectives and simulating real-world scenarios. The emotional engagement elicited by VR enhances the learning process by making the content more memorable and facilitating the formation of strong cognitive and emotional connections. The study highlights the importance of emotional engagement in VR as a means of enhancing learning outcomes in higher education settings.

Gamification elements. VR experiences can incorporate gamification elements such as challenges, rewards, and progress tracking. By introducing game-like elements, VR can tap into students' intrinsic motivation and desire for achievement. Features like leaderboards, badges, or leveling up can provide a sense of accomplishment and encourage students to actively pursue their learning goals.

The following article coauthored by the creator of the Khan Academy (Ahmad, A. et al. 2020) investigates the effect of gamification elements, including those found in VR, on student motivation, engagement, and learning outcomes in higher education. The research explores how features such as challenges, rewards, and progress tracking tap into students' intrinsic motivation and desire for achievement. The study highlights the positive impact of gamification elements in VR, such as leaderboards, badges, and leveling up, on enhancing students' sense of accomplishment and motivation, leading to increased engagement and improved learning outcomes.

By leveraging the immersive and interactive nature of VR, educators can create learning environments that inspire and motivate students. The combination of captivating experiences, active participation, personalized approaches, novelty, emotional engagement, and gamification elements makes VR a powerful tool for enhancing student engagement and motivation in education.

Research literature has consistently highlighted the importance of learning through experience in education, and virtual reality has emerged as a promising tool to facilitate this type of learning. Studies have shown that experiential learning can enhance students' engagement, motivation, and retention of knowledge, as well as improve their problem-solving and critical thinking skills (Kolb, 2014; Carbone et al., 2017).

VR can provide students with a safe and controlled environment to engage in experiential learning. By simulating real-world situations and scenarios, students can practice and apply their knowledge and skills in a more tangible way. For example, VR simulations can provide students with opportunities to explore historical events, scientific phenomena, and engineering challenges, among other things (Sawyer et al., 2018).

Moreover, VR can provide students with experiences that would otherwise be too costly, dangerous, or impractical to conduct in real life. For example, VR can be used to simulate space exploration, medical procedures, and military training, among other things. By providing these experiences in a virtual environment, students can engage in hands-on learning without putting themselves or others at risk (Yan et al., 2019).

Furthermore, research has shown that learning through experience in VR can be particularly beneficial for students who struggle with traditional classroom lectures. For example, students with attention deficit hyperactivity disorder (ADHD) may benefit from engaging in VR experiences that provide them with a more dynamic and interactive learning environment (Zhang et al., 2021).

3. Statistics and perspectives on the usage of VR in HE

Virtual reality usage in higher education has experienced significant growth in recent years. According to a 2020 survey by the EDUCAUSE Center for Analysis and Research, 23% of higher education institutions in the United States reported using VR or augmented reality (AR) technologies, with an additional 15% planning to implement them within the next two years (EDUCAUSE, 2020).

VR is being utilized across diverse disciplines in higher education, offering various educational benefits. For instance, in medical education, VR simulations are used to train medical students in surgical procedures and anatomy (Mergen et al., 2023). Similarly, in engineering and architecture programs, VR allows students to interact with virtual prototypes and simulations, enhancing their design skills and spatial understanding (Han 2023). Moreover, VR is being employed for historical and cultural explorations, enabling students to virtually visit significant sites and engage with immersive learning experiences (Hu et al., 2019).

An important advantage of VR in higher education is its ability to create immersive and experiential learning environments. Through VR, students can engage with realistic scenarios and environments, gaining hands-on experiences that might be otherwise challenging or costly to access in real life. This active participation and experiential learning promote deeper understanding and knowledge retention (Makransky et al., 2017). For example, VR has been used to simulate complex scientific phenomena, allowing students to observe and interact with concepts that are difficult to visualize in traditional learning settings (Huang et al., 2010).

Furthermore, VR plays a significant role in developing students' skills and preparing them for their future careers. By incorporating gamification elements such as challenges, rewards, and progress tracking, VR taps into students' intrinsic motivation and desire for achievement (Rivera & Garden 2021). Features like leaderboards, badges, and leveling up provide a sense of accomplishment and encourage students to actively pursue their learning goals. These gamification elements enhance motivation, engagement, and skill development within the VR learning environment.

In terms of accessibility and inclusion, VR has the potential to address various challenges in higher education. It can provide equal learning opportunities for students with physical disabilities or those facing geographical or financial limitations. By simulating real-world experiences, VR allows students to access educational content and experiences that might be otherwise inaccessible, promoting inclusivity and diversity.

These recent developments highlight the increasing integration of VR in higher education, offering innovative and engaging learning opportunities. However, it is important for institutions to consider pedagogical frameworks, ethical considerations, and the evolving technological landscape to maximize the benefits of VR in educational settings.

4. Students with disabilities

Virtual reality in education can be particularly beneficial for students with disabilities, as it can provide them with more inclusive and accessible learning opportunities. By using VR, students with physical disabilities can participate in educational activities that would otherwise be challenging or impossible due to physical limitations. For example, students with mobility impairments can explore a virtual environment without having to worry about accessibility barriers, see e.g. (Kelleher et al. 2018) and (Kim et al. 2019).

VR can also be beneficial for students with cognitive or sensory disabilities. For example, students with autism spectrum disorder can benefit from VR simulations that help them develop social skills and improve their ability to navigate social situations. Similarly, VR can be used to simulate sensory environments to help students with sensory processing disorder develop coping strategies.

Moreover, VR can help reduce the stigma associated with certain disabilities by creating an inclusive and accessible learning environment. By using VR to engage students with disabilities in the same activities as their peers, educators can promote greater social and emotional learning outcomes and foster a more inclusive classroom culture.

Virtual reality in education can be a powerful tool for providing students with disabilities with more inclusive and accessible learning opportunities. By using VR to simulate real-world experiences and reduce accessibility barriers, educators can help promote greater equity in education and improve learning outcomes for all students.

A study (Mavridis et al., 2017) focused on the use of VR technology to provide effective training for individuals with autism spectrum disorders (ASD). The study used a virtual environment to simulate social scenarios and teach social skills to individuals with ASD. The virtual environment was designed to create realistic social interactions that mimic real-life situations, which can be challenging for individuals with ASD. The participants in the study were able to interact with virtual characters, practice social skills, and receive immediate feedback. The study found that the VR training was effective in improving social skills, as well as increasing participants' motivation and engagement in the learning process.

Another study (Tsiotsios et al., 2017) focused on the use of VR technology to support students with learning disabilities (LD). The study used a VR game to teach reading comprehension to students with LD. The game was designed to provide an interactive and engaging learning experience that motivates students to read and comprehend texts. The study found that the VR game was effective in improving reading comprehension skills, as well as increasing students' motivation and engagement in the learning process.

Both studies demonstrate the potential of VR technology in providing effective learning experiences for students with disabilities. The use of VR can provide a safe and controlled environment for students to engage in experiential learning and develop their skills and knowledge. Additionally, the interactive and immersive nature of VR can enhance students' motivation and engagement in the learning process, ultimately leading to better learning outcomes.

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MODULE 9
Learning in the future, visions for evolution of methods and learning spaces

Introduction

The European Higher Education and Research Area is going through a transformation process that will push Europe to a leading position on the way to a green digitalization of societies. The environment of learning, including methods and spaces is expected to change drastically. With knowledge of today’s technologies we can only imagine the future but the way forward is almost clear. In this paper we will attempt to describe the learning in the future in both school and higher education as their evolution needs to develop in parallel. The paper will utilize results from several EU funded projects, including, STEAME, STEAME-Hybrid, ONLIFE, STEAME-Students, BYOD, FACILIATET-AI, STEAME Teacher Facilitators Academy, and more.

1. The vision base

The project "STEAME: Guidelines for Developing and Implementing STEAME Schools" that endinged on 31 December 2021 provides the ground for building the learning of the future as a kick-off of a paradigm shift to Education 4.0. It provides what steps Education Systems all around the world could follow in order to escape from

Education 2.0 and change to Education 3.0 and eventually to Education 4.0 with learning based on inquiry and project based learning. Literature and research has been showing for years now that this should be the way forward in order to help school students develop the needed competences and skills that appear to lack when they enter HE studies or enter the world of work. With today's development of digital learning most of the learning needed by school students can be easily accessible or retrieved at any time and place.

STEAME (Science - Technology – Engineering - Arts - Mathematics - Entrepreneurship) has been developed to support European teachers' knowledge and understanding of creating successful STEAME learning and creativity project activities. It offers approaches to teaching, teaching materials, entrepreneurship aspects, organizational suggestions for STEAME-oriented teaching, propositions and analysis of STEAME-oriented curriculum. All the OERs of the project are available through the STEAME Observatory at www.steame.eu . As an observatory, it is designed to be adaptive and dynamic, able to support a dynamic and adaptive STEAME Curriculum in any school that needs to implement STEAME activities in the learning process.

The process of adding and updating the content is a continuous one, providing the opportunity to all teachers across the EU and beyond to be up to date and to share and publish their own work if they wish to.

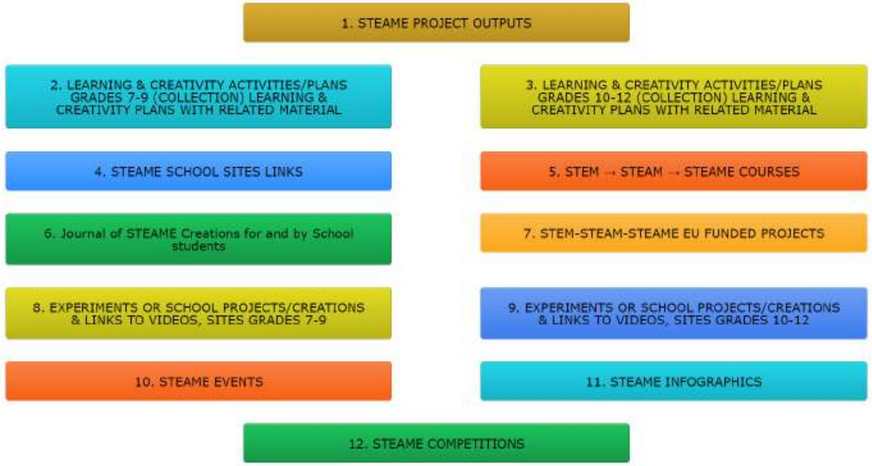

Figure 1. The structure of the STEAME Observatory

The STEAME Framework consists of the following elements:

1. Learning and Creative Methodologies (PBL-IBL-PSL);
2. Guide to Science Communication as a skill for students;
3. Guide to Learning and Creative(L&C) Plan Development, including a L&C Plan Template in different languages;
4. Evaluation Rubric for implementing a project;
5. Observatory (Guide to dynamic and adaptive STEAME material).

The following four methodologies are adopted by the STEAME framework (PBL, IBL, PSL):

- Project-Based Learning Methodology (PBL);
- Inquiry-Based Learning Methodology (IBL);
- Problem Solving Learning Methodology (PSL);
- A guided method to L&C Plans development with an 18 steps prototype procedure in supporting project based work of student groups, moderated and supported by at least two teachers of different disciplines.

The STEAME project, based on an International investigation, a European wide survey and based on focus groups with teachers and experts, associate partners and through its consortium creative work, has developed guidelines for STEAME school organization structures covering actions for existing schools and actions for future schools. Below we present indicative photos of the design of the STEAME School of the future. In the project website www.steame.eu , one can find a full detailed content and designs of the STEAME School of the future.

Figure 2. A top view of the design of the school fully energy self-sustainable with photovoltaics

Figure 3. A side view of the school one basement, ground floor, first floor and roof

The basement main content is a full set of STEAME Laboratories, VR rooms and entrances to the main amphitheatre and sports centre.

The ground floor contains mainly satellite laboratories, open work space, learning stations and base entries into the small amphitheatres, reception entrance and main dual reception of the sports centre, one entrance for the school students during the day and another entrance for the community during the night, the access to the internal yard and cafeteria and more.

The first floor contains open work space, learning stations, learning centres, learning rooms, a slow moving train with space for group student work, entry into amphitheatres and more.

The roof contains, photovoltaics providing green sustainable energy to the school, pool recreation area, circular sport field, sports courts, roof cafeteria and restaurant and more.

The school provides the option to change colours every day with an app so students decide what will be the colour of their school every day.

Figure 4. The logo of the project STEAME

2. The evolution

The evolution of Lesson Plans from what is happening today in most education systems located as EDUCATION 2.0 is evolving into Learning Plans and eventually into Learning & Creativity Plans. The STEAME project has adapted and developed the Learning & Creativity Plans as a new name of Lesson Plans.

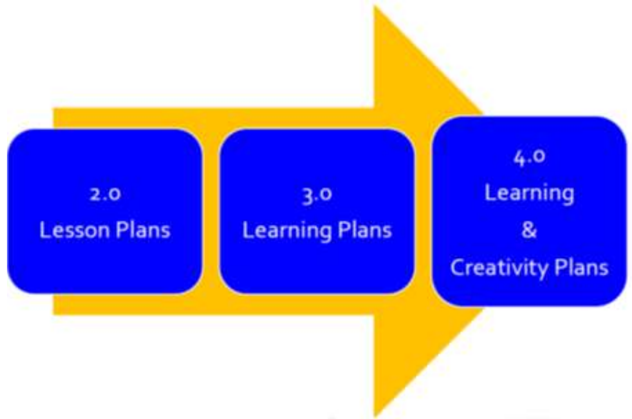

Figure 5. The Evolution of Lesson Plans

The evolution of Pedagogy and Andragogy into Peeragogy & Heautagogy, the latter adapted by the STEAME projects.

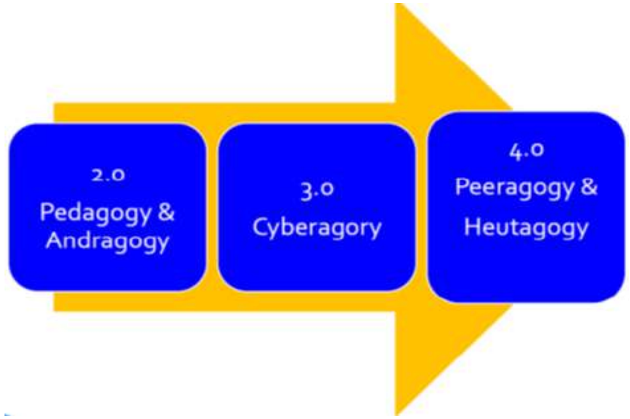

Figure 6. The Evolution of Pedagogy and Andragogy

A second step development was the project STEAME-Goes-Hybrid where the PBL activity could be done remotely and online so students and teachers at distance (flip classroom or need due to lock-downs or need due to illness) can work on project work collaboratively and co-creatively. The platform access and guidelines of this solution can be found in www.steame-hybrid.eu

Figure 7. The logo of the project STEAME-Goes-Hybrid

A third step development was the BYOD-Learning (www.BYOD-Learning.eu) where it is believed that all classroom learning can be transformed into video learning where each teacher can produce his/her teaching or facilitation of learning in to learning videos. These learning videos were originally planned to be of 45 min duration (usual classroom lesson duration) but also made available into more accelerated learning, that is 30 min and 15 min duration, supporting talented students in learning who could learn faster. Eventually and after reactions of students, the project adapted to the needs of students by supporting shorter videos , like 5 min each as smaller parts of a complete lesson plan duration. This will facilitate the learning at any place and anytime through an approach of Bring-Your-Own-Device (BYOD). The videos can also support the retrieving of knowledge and can save a lot of time from classroom learning so students can spend more time on applying knowledge through project work , thus developing competences and skills.

Figure 8. The logo of the project BYOD – learning

The fourth step was to the need to support teachers in becoming adaptable to change and the project ONLIFE (onlife.up.krakow.pl) has developed a special programme and module supporting teachers to develop competence in self-improvement and adapting to change without having to go through special trainings.

Figure 9. The logo of the project ONLIFE

The fifth step was the need for teachers and students to understand the new tech environments governed by Artificial Intelligence (AI). The project Facilitate-AI (www.facilitate-ai.eu) that started in February 2022 and will be completed in January 2023 aims to accomplish this in two main steps. In the first year the AI experts have trained teachers about AI and in the second year trained teachers are designing Learning & Creativity plans in support of facilitating the learning of AI by school students. During 2023 a training by teachers to teachers is planned for preparing teachers for a pilot learning activity.

Figure 10. The logo of the project Facilitate-AI

3. The students

Following collaboration work with experts, teachers, academics and students a critical need became evident to generate on one hand a bottom-up approach in bringing changes in Education Systems in the future as policy recommendations made do not seem to thickening movements for change and on the other hand to support the wider preparation of teachers for such a change.

Changing from traditional classroom learning into an open space PBL environment is not something that could happen from one day to another or even from one year to another. This change has high cost and requires big efforts by service teachers, by student teachers , by HE institutions and by authorities.

The sixth step came in to play with the need to organize the European School students and to give them a voice. By supporting school students to get a voice it is an opportunity to put force into change as nowadays young students adapt to technology changes and grow much differently than the way their parents and teachers grew. The project STEAME-Students developed a platform of communication for school students and supported the kick-off of the first European STEAME School Students Network, with acronym E3SN. The first committee developed its first working statute and a Manifesto , which was presented publically on 14 March 2023 in Krakow, Poland, during the EUROMATH & EUROSCIENCE conference for school students. The project ended on 31 May 2023 and the results can be found in https://thalescyprus.com/?page_id=3386. A new project proposal named STEAME-Students 2.0 has been submitted in 2023 proposing the further and wider expansion of the E3SN with more student participation.

Figure 11. The logo of the project STEAME-Students

4. The teachers

The seventh step and may be the most important is the project STEAME Teacher Facilitators Academy, which started on 1st June 2023, coordinated by the University of the National Education Commission in Krakow, Poland with 14 partners and 19 associate partners.

The main innovations to be delivered by this project are:

1. STEAME Teacher Facilitators Competence Framework for student and serving teachers;
2. STEAME Teacher Facilitators Learning Modules/Workshops;
3. International Sharing Observatory for STEAME Learning Facilitators;
4. Development of the STEAME Facilitators Community of Practice/Mentoring and Certification Programme;
5. Policy Recommendations – European Federation of STEAME Teacher Facilitators Academies.

The website of the project is already published at www.steame-academy.eu and has created its logo shown here

Figure 12. The logo of the project STEAME Teacher Academy

Schools, Universities, Researchers can become associate partners through the website. In addition, regions in Europe and beyond may express interest in becoming regional STEAME-Teacher Academies supported by the special observatory to be created by this project.

Several parallel proposed projects building on the learning of the future are in the pipeline to complement the missing dynamic puzzle for the evolution of education that is expected to be created by Higher Education support through research and innovations. Some examples of these new proposals either running or submitted in 2023 include the REVEALING (VR Classrooms), STEAME-Hybrid Labs, STEAME-Parents and more.

All projects mentioned in this paper are co-funded by the European Union.

Co-funded by the European Union

Figure 13. The logo of the funding authority

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MODULE 10
Testing for the pilots

1. Access to Revealing Virtual Reality Learning Environments

Access to Community Labs Worlds

The first thing users have to do to access the Revealing VRLEs is to follow the registration process described in Module 7 for VRChat and visit the Home World of VRChat, either using a desktop computer or a Head Mounted Display.

Figure 1. Home world

After accessing VRChat, users should open the VRChat menu and then select 'Worlds' from the Quick Links.

Figure 2. World menu

Figure 3. Enabling Community Labs Worlds

Currently, Revealing VRLEs are located within VRChat Community Labs. Community Labs hosts VRChat worlds that are in a trial period before becoming public based on their user base. To access the Community Labs worlds, users should select the menu item and then choose the "View Community Labs Worlds" option.

By doing so, Community Labs worlds should be visible to users.

Figure 4. Community Labs Worlds are now visible

Search for Revealing VRLEs

In order to search for the Revaling VRLEs, users should select the "Select Worlds" option from the Worlds menu of VRChat, and search for Revealing VRLEs by name.

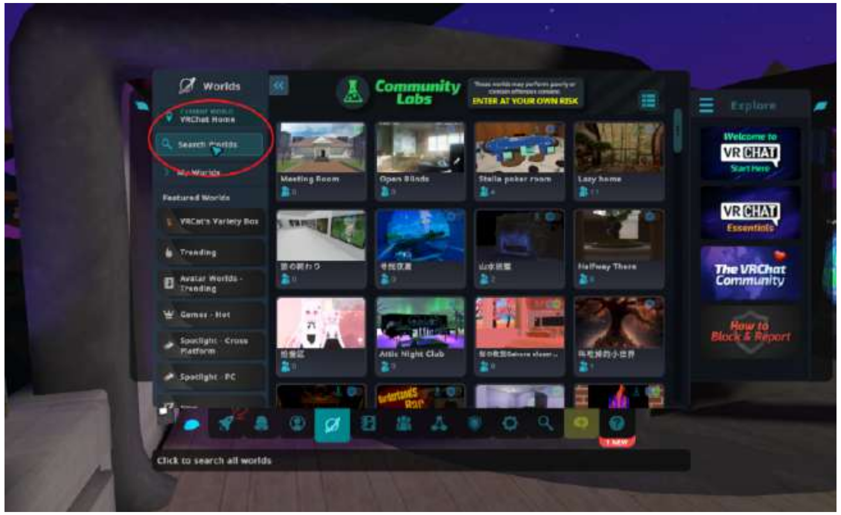


Figure 5. Search Worlds menu

The Revealing VRLEs are named as follows:

- Ancient Greek Technology
- Chimborazo expedition
- Sea Urchins Measurements
- Linear Algebra
- Teriade Museum

Figure 6: Revealing VRLEs

Users can search for Revealing VRLEs using the search option of VRChat.

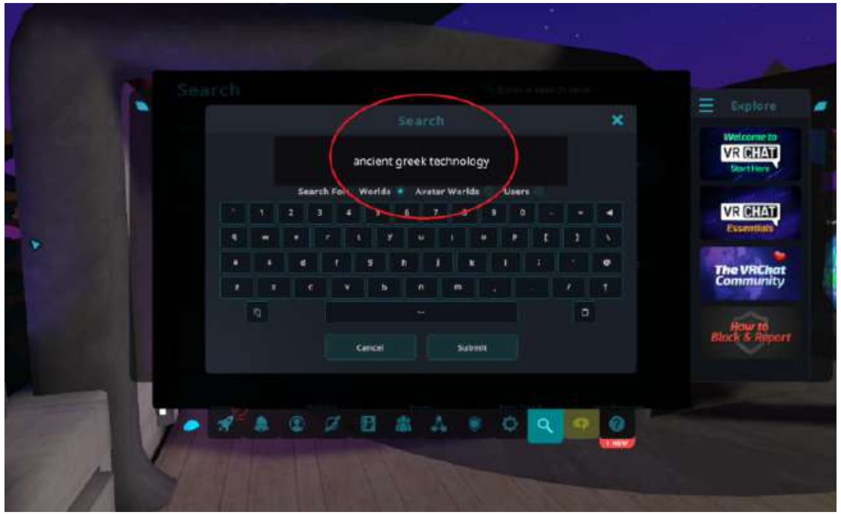


Figure 7. Search for Revealing VRLE

After searching for a Revealing VRLE by name, users should see it inside the search results.

By selecting the Revealing VRLE users will be able to create a new instance of it in order to be able to invite friends into it.

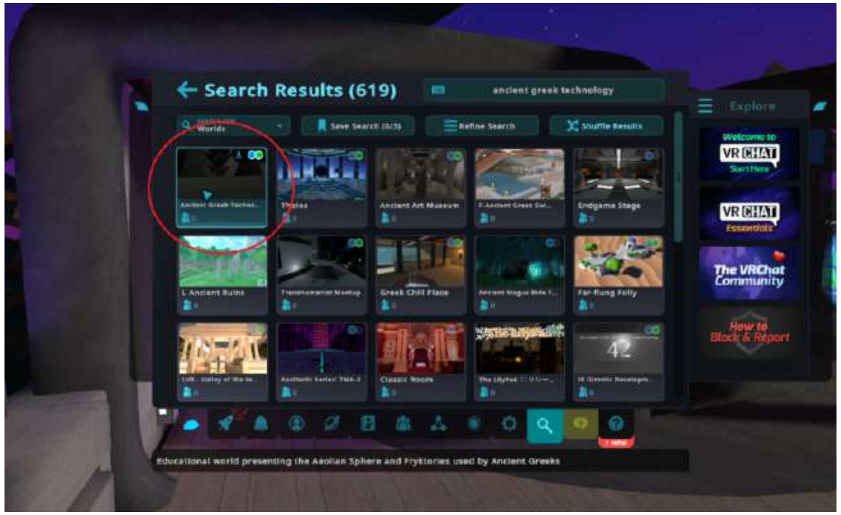


Figure 8. Ancient Greek Technology VRLE world selection

Figure 9. Creating a new VRLE instance

VRChat supports multiple world instance options. For the realization of the revealing VRLEs, it is recommended to use the Friends + option which allows only for friends to be invited inside the world instance.

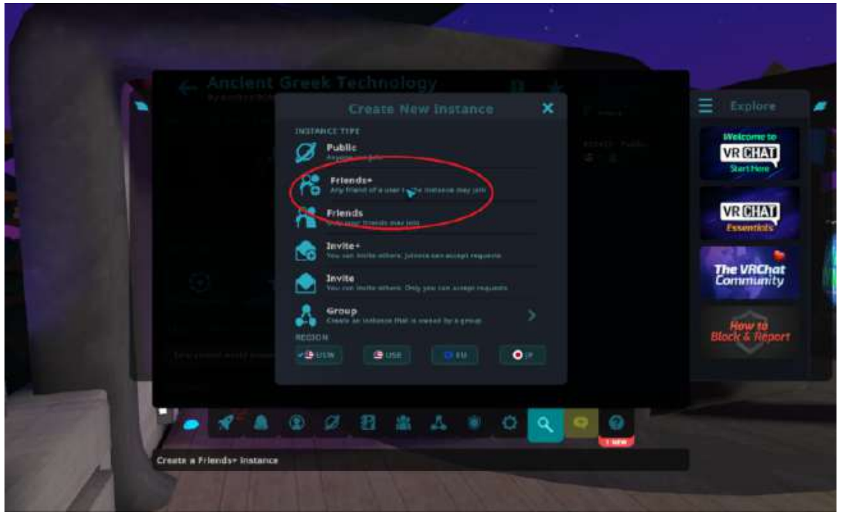


Figure 10. Friends+ Instance can allow friends to join your instance

Finally, users should select the Join option for the instance to be created.

Figure 11. Create VRLE Instance

To travel to the VRLE, users should select the 'GO!' option after the download is finished. The process of visiting Revealing VRLEs instances is the same for all available Revealing VRLEs.

Figure 12. Press GO! To travel to VRLE Instance

2. Reading VRLEs

Ancient Greek Technology

Ancient Greek Technology VRLE of Revealing allows students to learn about ancient Greek technological advancements. The first one refers to a primitive steam engine called the Aeolian Sphere. Initially, students, under the guidance of a teacher, can pick up a torch and ignite the wood placed under the sphere.

Figure 13. Aeolian Sphere torch

By doing so, the water at the base of the sphere will heat up and cause it to rotate based on the steam exhaust placed on it.

Figure 14. Aeolian Sphere

Inside the same VRLE, students can also observe the parts of the Aeolian Sphere placed on a table near it, while the teacher explains their functionality.

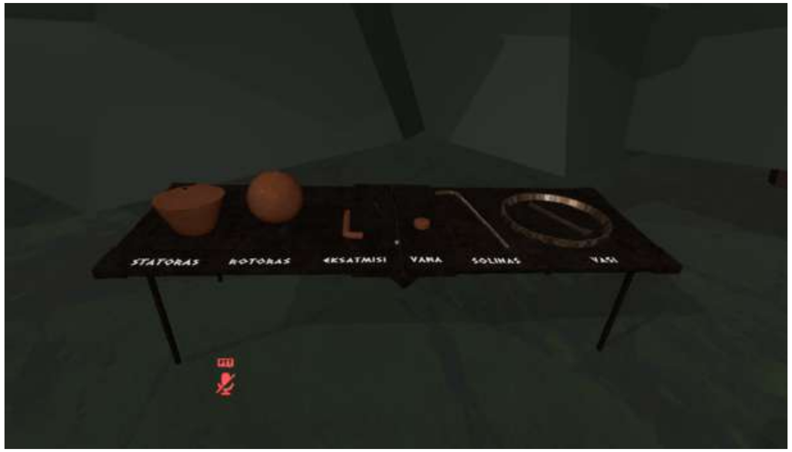


Figure 15. Aeolian Sphere parts

Continuing, teachers can utilize a simple PowerPoint presentation controller to deliver presentations to students about Phryctories. Phryctories refer to a communication system used by ancient Greeks. The system consists of torches placed in specific positions on a tower or wall. Their arrangement could be deciphered to represent a certain letter based on a pre-defined letter table, thus enabling remote individuals to communicate with each other.

Figure 16. PowerPoint presentation controller

Students can observe the presentation through a large display placed near the PowerPoint presentation controller.

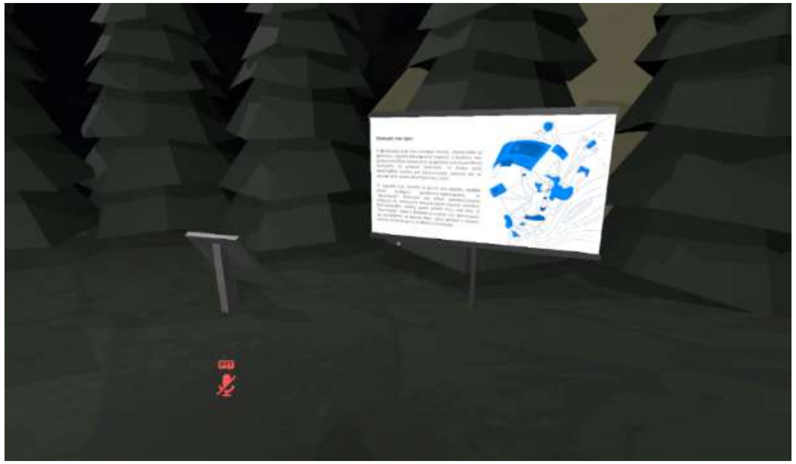


Figure 17. PowerPoint presentation about Phryctories

Then, students approach a virtual Phryctoria system. There, they can study the pre-defined letter table and create their own letters by placing torches in certain spaces of a wall.

Figure 18. Phryctories board and wall

Finally, the VRLE includes two Phryctories systems placed at a distance for students to try to communicate with each other.

Figure 19. Communicating using Fryktories

Sea Urchins Measurement

The next Revealing VRLE refers to a sea urchin measurement expedition. Students are immersed in an underwater environment and can utilize rulers, pens, and erasers to measure sea urchins during two different time periods, 2023 and 2100. Then, the professor records the students' measurements by taking a picture of them inside the virtual world using VRChat virtual camera. Finally, students visit a virtual classroom where the professor explains the statistical analysis process to be followed for analyzing the expedition results, while they perform that statistical analysis in the real world based on the sea urchins size measurements collected in the virtual world.

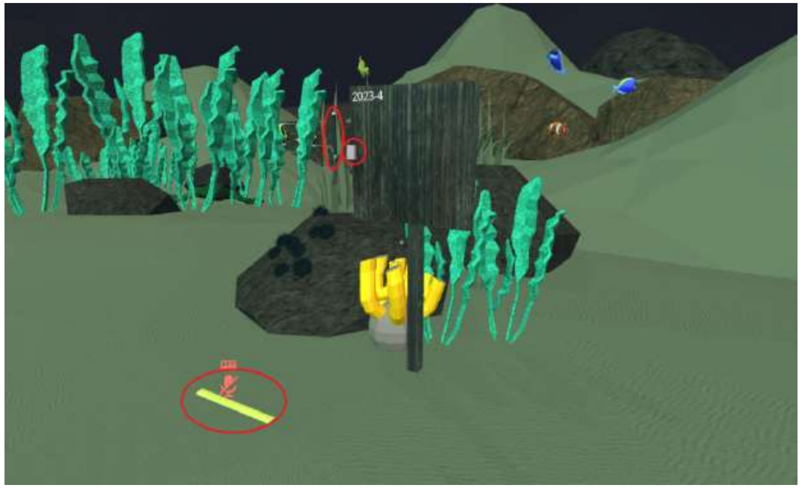


Figure 20. Sea Urchins size measurement tools

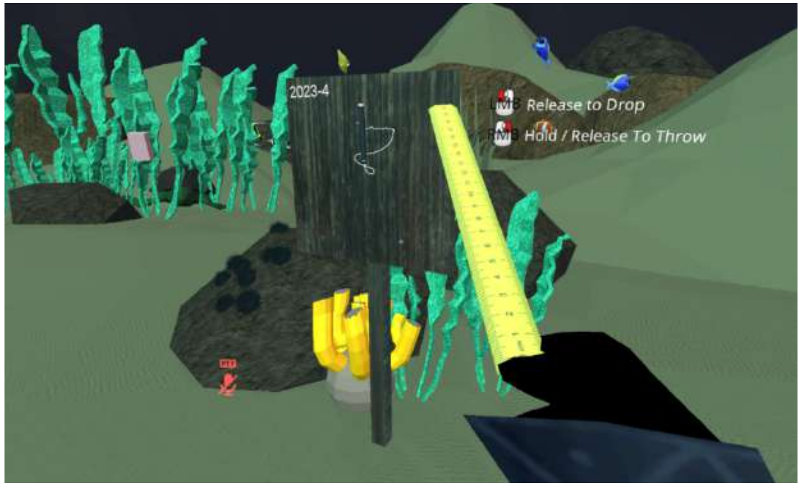


Figure 21. Sea Urchins measurement ruler

At first, students are invited to measure the size of sea urchins and record the results on wooden tables placed throughout the virtual world.

Then, they are asked to travel to the year 2100, by interacting with a portal placed inside the virtual world and follow the same procedure.

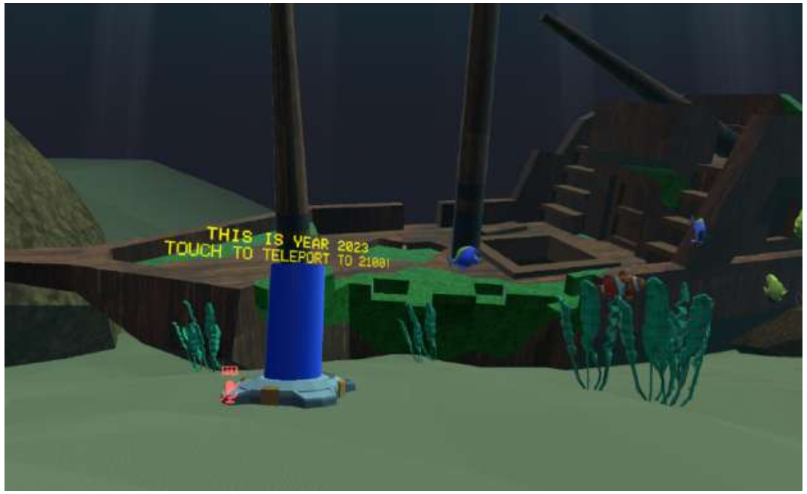


Figure 22. Portals between time periods

Meanwhile, the teacher has to select the VRChat camera from the VRChat menu.

Figure 23. VRChat camera

Then, she has to select the Photo Camera option.

Figure 24. VRChat photo camera

Finally, the teacher can take photos of the sea urchins measurements written on the wooden planks.

Figure 25. Taking a picture inside VRChat

Figure 26. Portal to classroom

Continuing, students are advised to visit a virtual classroom using a portal.

Inside that classroom, the teacher explains the statistical analysis process to the students. Finally, both students and the teacher leave the virtual world. The teacher disseminates the measurements to the students using the photos taken inside the virtual world. This enables them to perform statistical analysis in the real world using sophisticated software.

Figure 27. Classroom environment

Linear Algebra

Linear Algebra VRLE of Revealing refers to the utilization of virtual light build platforms which allow students to familiarize themselves with its concepts.

Figure 28. Linear Algebra VRLE environment

Students are instructed by the teacher to interact with the buttons in front of the light bulbs. Each button affects the state of the light bulb placed in front of it, as well as the state of the light bulbs placed to its right and left. Therefore, students have to apply Linear Algebra to create combinations of light bulbs based on the teacher's instructions.

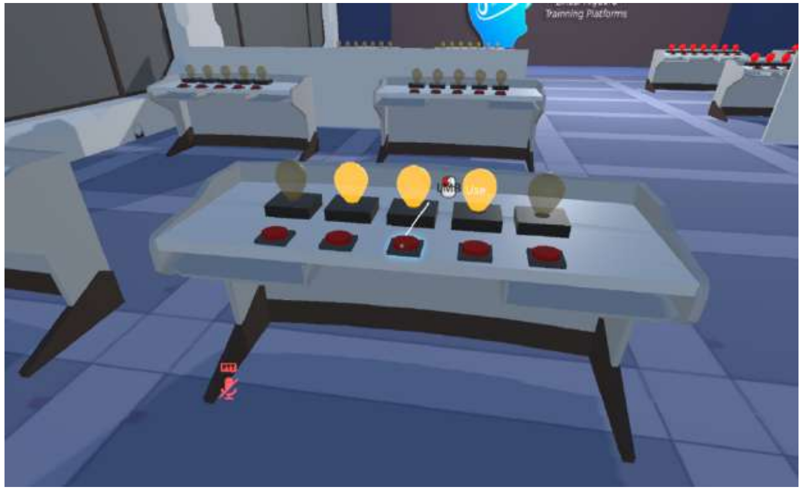


Figure 29. Linear Algebra VRLE - two states bulbs platforms

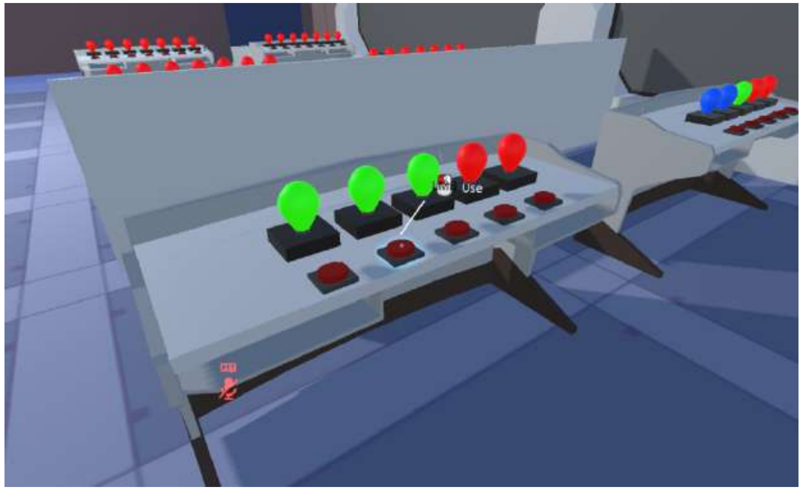


Figure 30. Linear Algebra VRLE - three states bulbs platforms

Linear Algebra VLRE contains two different types of platforms. The first one includes light bulbs with two states (on and off), and the second one includes light bulbs with three states (red, green, and blue), increasing the difficulty for students.

German Explorers

German Explorers Revealing VRLE educates students on the expedition process of Alexander von Humboldt to Chimborazo Mountain. The VRLE is situated inside a wooden cabin at the bottom of the Chimborazo Mountain. First the VRLE allows students to observe the tools utilized during the expedition, in the form of signs, and discuss their functionality with the teacher.

Figure 31. German Explorers VRLE cabin and signs

Students can interact with the signs inside the virtual world.

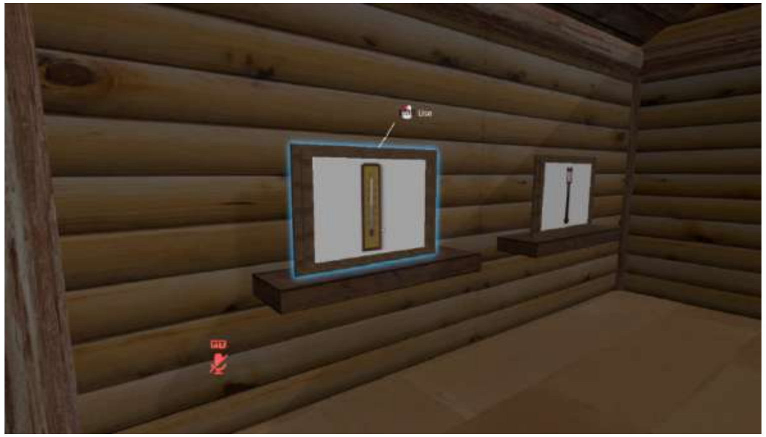


Figure 32. Using a sign

Interacting with the signs results in their rotation, revealing the true functionality of each expedition tool in the back.

Figure 33. Sign back area

Students can also read about the rest of the expedition equipment and interact with its parts by picking them up and observing them in real time.

Figure 34. German explorers' equipment

After discussing the equipment, students have to visit a virtual globe placed in a room of the cabin. Students have to discuss about the location of Ecuador and find a hidden button on the globe.

Interacting with the button will cause the map of Ecuador to appear, allowing students to further discuss the Chimborazo Mountain location with the teacher.

Figure 35. Globe hidden button

Figure 36. Map of Ecuador

Next, students will have to leave the cabin by interacting with the main entrance of the cabin.

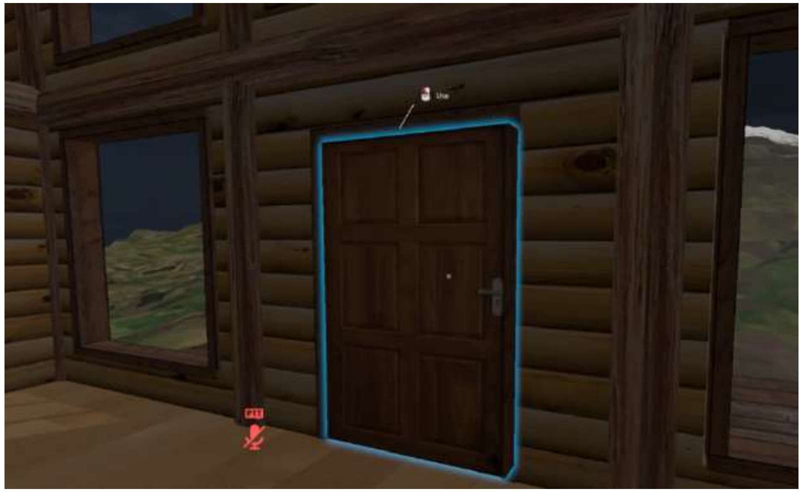


Figure 37. Using the door to travel to the mountain

This action will teleport them to the bottom of the mountain where students can discuss its plantation. Students are asked to pick up certain species of plantation and place them on incrementally higher platforms resembling the different plantation zones of the mountain. Finally, students can use the portal next to the platforms to teleport to the top of the mountain.

Figure 38. Using 3D objects to adjust plantation levels and portal to travel to the top

At the top of the mountain students will find one final sign describing additional expedition equipment.

Figure 39. Final sign

Finally, students can use a portal to travel back to the cabin if required.

Figure 40. Portal to the cabin

Gallery Visit

The last Revealing VRLE refers to a gallery visit. The gallery is an exact replica of the Teriade museum located in Mytilene Lesvos, featuring paintings created by world-famous artists.

Figure 41. Teriade museum

During this VRLE, the teacher starts presenting paintings created by Pablo Picasso.

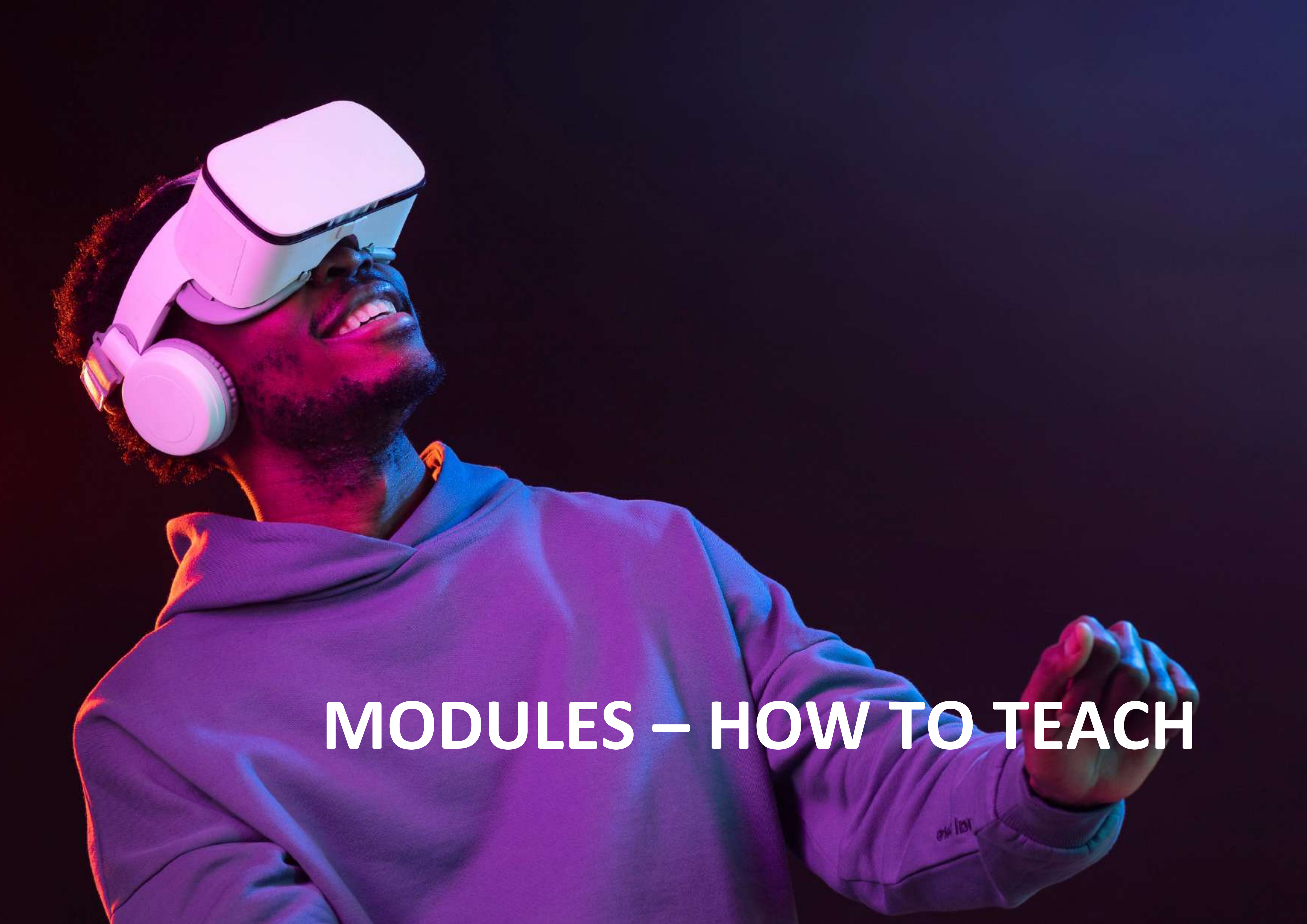
Figure 42. Picasso room

Next students are invited to observe and discuss the paintings of Marc Chagall.

Figure 43. Marc Chagall room

Finally, the gallery visit is completed by visiting another room where paintings by the famous painter Miro are displayed.

Figure 44. Miro room



MODULES – HOW TO TEACH

MODULE 1 description

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 1

Module Title: Introduction to VRLEs

Module Description

This module introduces participants to Virtual Reality Learning Environments and their basic functionalities. In detail, it presents an overview of the VRLEs field along with the available VRLE design and development platforms comparing their functionalities and capabilities.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Understand the concept of VRLEs.
- Understand the differences between different VRLEs platforms.
- Understand the differences in the development process from a technological standpoint.

Instruments/ Tools/ Supporting Material/ Resources to be used.

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Links
- Videos

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The trainer will provide a thorough presentation of the VRLEs field.
- The trainer will present the available VRLE design and development platforms.
- The trainer will present the development differences and capabilities of the VRLE design and development platforms.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	What are VRLES?
How	PPT Slides
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect
Estimated Time	15 minutes
2. Development activity A	
What	Which are the most widespread platforms for VRLEs design and development?
How	PPT Slides
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect
Estimated Time	15 minutes
3. Development activity B	
What	Which are the technological/development differences among the VRLEs platforms?
How	PPT Slides
Where	Physical in training room

Who	Trainer presentation and questions to trainees to reflect
Estimated Time	15 minutes
4. Assessment activity	
What	Trainees are invited to select a VRLE platform based on VRLEs scenarios presented by the trainer.
How	PPT Slides
Where	Physical in training room
Who	Teacher is making questions and inviting trainees to make questions
Estimated Time	5 minutes
5. Reflection activity	
What	Reflection through discussion
How	PPT Slides
Where	Physical in training room
Who	Trainer will guide the discussion and help trainees discuss with each other about VRLEs platforms
Estimated Time	10 minutes

MODULE 2 description

UNIVERSITY OF THE AEGEAN

Co-funded by the Erasmus+ Programme of the European Union

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

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Reference number: KA220-HED-ED73663C

Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers

Training Module Lesson Plan

Module Number: 2

Module Title: Introduction to the VRLEs in VRChat

Module Description

This module introduces participants to Virtual Reality Learning Environments designed and developed in VRChat platform. The module presents the registration process for VRChat platform and its basic functionalities using both a desktop computer and a head mounted display. Finally, it presents VRChat VRLEs invited participants to test them in real time.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Understand the concept of VRLEs in VRChat.
- Understand the registration process of VRChat.
- Understand the basic functionalities of VRChat.
- Navigate and use VRChat VRLEs.

Instruments/ Tools/ Supporting Material/ Resources to be used.

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Links
- Videos
- Live demonstration

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The trainer will provide a thorough presentation of VRChat platform.
- The trainer will present the VRChat registration process for both desktop computers and head mounted displays.
- The trainer will present VRLEs developed in VRChat and guide trainees on accessing and using them.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	What is VRChat?
How	PPT Slides
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect
Estimated Time	15 minutes
2. Development activity A	
What	Which is the registration process and basic functionalities of VRChat?
How	Live demonstration
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect
Estimated Time	15 minutes
3. Development activity B	
What	What VRLEs are developed in VRChat?
How	PPT Slides and Live demonstration
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect

Estimated Time	15 minutes
4. Assessment activity	
What	How to use VRChat and its VRLEs
How	Live demonstration
Where	Physical in training room
Who	Trainer will guide trainees on using VRChat and its VRLEs
Estimated Time	45 minutes
5. Reflection activity	
What	Reflection through discussion
How	Live demonstration
Where	Physical in training room
Who	Trainer will guide the discussion and help trainees discuss with each other on the aspects and issues of VRChat VRLEs.
Estimated Time	30 minutes

MODULE 3 description

Co-funded by the Erasmus+ Programme of the European Union

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

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Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 3

Module Title: How to prepare a VRLE learning scenario (UAb)

Module Description

The "Learning Scenarios" is a module of Instructional Design that consists of several planning phases, including: (1) defining learning objectives;(2) establishing the learning scenario, designing the environment, and selecting agents or actors. The session planning matrix includes various elements such as phase/time, learning objectives, content/key principles, methodology, resources, student activities, and assessment. This Instructional Design model is based on various theoretical models and frameworks that assist in defining these components. The definition of learning objectives is guided by Bloom's taxonomy (Anderson & Krathwohl, 2021); the methodology is based on various pedagogical methods to support the learning process, including expository, demonstrative, active, and collaborative methods (Ghirardini, 2011; Gouveia et al., 2007; Morgado et al., 2022). Merrill's instructional principles (Merrill, 2002) are used to support instructional design. In the assessment component, models such as Boud's (Boud & Falchikov, 2005) "sustainable assessment" or the PRACT model (Tinoca et al., 2014) from the Portuguese Open University (UAb) are followed, proposing models and tasks that take into account students' attitudes, knowledge, and skills/competencies.

Learning Outcomes

With the completion of this module the trainees will be able to:

- Understand the importance of defining clear and measurable learning objectives in the instructional design process.
- Apply Bloom's taxonomy to effectively develop learning objectives that align with desired learning outcomes.
- Analyze and evaluate different learning scenarios to design appropriate environments and select suitable agents or actors.
- Demonstrate an understanding of key principles in designing the learning environment to enhance the learning experience.
- Apply various pedagogical methods (expository, demonstrative, active, and collaborative) to support the learning process within a given scenario.
- Apply Merrill's instructional principles to support effective instructional design in learning scenarios.
- Design and implement appropriate assessment strategies, such as Boud's "sustainable assessment" or the PRACT model, to evaluate students' attitudes, knowledge, and skills/competencies within a learning scenario.

Instruments/ Tools/ Supporting Material/ Resources to be used

Slides/Presentation: A set of slides or a presentation to introduce and explain the concepts, phases, and components of the learning scenarios module. These will include visual elements, diagrams, and relevant content.

Case Studies: Real-world examples or case studies that demonstrate the application of learning scenarios in instructional design. They can be presented as written case studies, videos, or interactive multimedia presentations.

Templates and Worksheets: Templates or worksheets that guide participants in practicing the process of defining learning objectives, designing learning scenarios, and selecting appropriate methodologies. These templates will be provided as downloadable files or interactive digital forms.

Assessment Examples: Examples of assessments that align with the learning scenarios module. This may include sample rubrics, self-assessment tools, or scenario-based assessment tasks that allow participants to practice evaluating students' attitudes, knowledge, and skills/competencies.

Methodology

- **Introduction and Overview:** Introduction and overview of the module. Discuss the importance of learning scenarios in instructional design and how they contribute to effective learning experiences.

- **Presentation of Concepts and Components:** Use slides or a presentation to introduce and explain the key concepts, phases, and components of learning scenarios. Include visual elements, diagrams, and relevant content to enhance understanding and dialogue/discussion.
- **Case Studies:** Share real-world examples or case studies that demonstrate the application of learning scenarios in instructional design. These can be presented as written case studies, videos, or interactive multimedia presentations. Discuss and analyze the case studies with the participants, encouraging them to identify the effective use of learning scenarios.
- **Interactive Discussions:** Facilitate interactive discussions with the participants to encourage active engagement and collaboration. Ask questions, encourage participants to share their experiences and insights, and facilitate peer-to-peer learning.
- **Practice Activities:** Provide templates that guide participants in practicing the process of defining learning objectives, designing learning scenarios, and selecting appropriate methodologies. These activities can be completed individually or in small groups, allowing participants to apply the concepts and principles learned.
- **Assessment Practice:** Offer examples of assessments aligned with learning scenarios. Provide sample rubrics, self-assessment tools, or scenario-based assessment tasks that allow participants to practice evaluating students' attitudes, knowledge, and skills/competencies within a learning scenario.
- **Question and Answer and Reflection:** Allocate time for questions and answers to clarify any doubts or concerns. Encourage participants to reflect on what they have learned during the session and discuss the practical application of learning scenarios in their own instructional design practices.
- **Summary and Conclusion:** Summarize the main points covered during the training session, highlighting the key takeaways related to learning scenarios in instructional design. Provide additional resources for participants to further explore the topic independently.

Learning Activities Plan

1. Introduction Activity	
What	Engage participants in a group discussion to share their prior knowledge and experiences related to instructional design and learning scenarios.
How	Facilitate the discussion using open-ended questions and encourage participants to actively participate and share their insights.
Where	In a physical environment conducive to group discussions and interactions.
Who	The facilitator leads the discussion, and all participants actively contribute with their ideas and experiences.
Estimated Time	15 minutes

2. Development activity	
What	Present the key concepts, phases, and components of learning scenarios through a slide presentation.
How	Use visual aids, diagrams, and relevant content to explain the information effectively.
Where	In a physical environment where the presentation can be displayed and viewed by all participants.
Who	The facilitator delivers the presentation, and participants actively listen and take notes.
Estimated Time	20 minutes
3. Hands on activity	
What	Divide participants into small groups and provide them with templates and worksheets to practice defining learning objectives, designing learning scenarios, and selecting appropriate methodologies.
How	Participants work collaboratively in their groups, applying the concepts learned during the presentation and using the provided tools.
Where	In a physical environment where participants can work in their respective groups.
Who	Participants work in groups, with the facilitator available for guidance and support.
Estimated Time	30 minutes
4. Assessment activity	
What	Distribute sample assessments aligned with learning scenarios, such as scenario-based tasks or rubrics.
How	In groups participants analyze the assessments and discuss how they align with the learning scenarios module.
Where	In a physical environment where participants can access the assessment materials and engage in discussions.
Who	Participants review and discuss the assessments, sharing their insights and evaluations.
Estimated Time	15 minutes
5. Reflection activity	
What	Allocate time for individual reflection on the session's content and ask participants to share their reflections in pairs or small groups.

How	Participants reflect on their learning, identify key takeaways, and discuss their thoughts and insights with their peers.
Where	In a physical environment conducive to individual reflection and group discussions.
Who	Participants engage in reflective activities and share their reflections with their peers.
Estimated Time	10 minutes

References

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MODULE 4 description

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 4

Module Title: How to use the VRLE Resource Directory

Module Description

The " How to use the VRLE Resource Directory " module is designed to familiarize participants with the VRLE Repository (VRChat) and its resources and demonstrate how these resources can be effectively integrated into lessons. The module aims to support educators in incorporating virtual reality learning environments (VRLEs) into their teaching practices by providing access to a centralized repository of educational tools, 3D models, interactive materials, worlds, and other resources.

Learning Outcomes

With the completion of this module the trainees will be able to:

- Understand the purpose and significance of the VRLE Repository in enhancing Virtual Reality learning.
- Navigate and explore the categories and resources available in the VRLE Repository.
- Identify and select relevant resources from the VRLE Repository that can enhance lessons.
- Apply the selected resources to create engaging and immersive learning experiences in the field.
- Reflect on the potential benefits and challenges of integrating VRLE resources into teaching practices.
- Independently search and locate resources within the VRLE Repository based on their scientific area of interest.
- Analyze and evaluate the suitability of VRLE resources for specific learning objectives.
- Collaborate with peers in discussing and sharing findings from the VRLE Repository exploration.
- Critically reflect on the implications and potential impact of integrating VRLE resources in education.
- Demonstrate basic proficiency in using the VRLE Repository platform (VRChat) to access and utilize resources.

Instruments/ Tools/ Supporting Material/ Resources to be used.

VRLE Repository (VRChat): VRChat will serve as the primary platform for accessing and exploring the resources in the VRLE Repository. Trainees will use VRChat to browse through various categories, conduct specific resource searches, and engage with immersive learning environments.

Exercise Sheet: Trainees will receive an exercise sheet that provides guidance on finding valuable elements within the VRLE Repository for teaching. The sheet will contain instructions, prompts, and guiding questions to facilitate the exploration and selection of relevant resources.

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- **Presentation and Demonstration:** The module will begin with a presentation that introduces the concept of VRLEs and their potential applications in teaching. Demonstrations will be provided to showcase the capabilities of VRChat and the VRLE Repository platform.
- **Exploration and Navigation:** Trainees will actively explore the VRLE Repository. They will navigate through different categories, search for resources, and interact with immersive learning environments to gain familiarity with the available materials.
- **Guided Exercises:** Trainees will be provided with exercise sheets that guide them in searching for useful elements within the VRLE Repository for teaching. These exercises will include specific tasks, prompts, and guiding questions to facilitate the discovery and selection of relevant resources.
- **Collaborative Discussions:** Trainees will participate in collaborative discussions to share their findings, insights, and

experiences with the VRLE resources. This will encourage peer learning and allow trainees to exchange ideas and best practices for incorporating VRLEs in education.

- **Reflection and Application:** Trainees will engage in reflection activities, prompted to critically evaluate the effectiveness and potential applications of VRLE resources in teaching. They will discuss their reflections and brainstorm ways to integrate VRLEs into their own instructional practices.
- **Assessment and Feedback:** Trainees will have opportunities to assess their understanding and progress through assessment activities related to the use of VRLEs in teaching. Feedback will be provided to help trainees improve their skills and knowledge in utilizing VRLE resources effectively.
- **Ongoing Support:** Trainees will have access to ongoing support and resources, including online tutorials, guides, and additional materials, to further enhance their understanding and proficiency in utilizing VRLEs for teaching.

Learning Activities Plan

1. Introduction Activity	
What	Introduce the VRLE Repository and its objectives, explaining how it facilitates the adoption and implementation of VRLEs in higher education teaching practices.
How	Provide an overview of the repository's functioning, highlighting its structure and available resources.
Where	In a physical environment where educators can access information about the VRLE Repository
Who	The facilitator responsible for providing information about the repository.
Estimated Time	10 minutes
2. Presentation of VRLE Repository Resources	
What	Demonstrate the available resources in the VRLE Repository, such as 3D models, interactive materials, educational worlds, and VR-related tools.
How	Live demonstration to showcase examples of resources and explain how educators can utilize them in their teaching practices.
Where	In a physical where educators can view the presentation or demonstration.
Who	The facilitator responsible for presenting the VRLE Repository resources.
Estimated Time	15 minutes
3. Hands on activity	
What	Guide educators in the practical exploration of the VRLE Repository, encouraging them to conduct searches and look for specific resources in their areas of interest. Propose

	practical exercises for educators to apply VRLE Repository resources in creating a vocational teaching session.
How	Provide step-by-step guidance on how to use the functionalities of the VRLE Repository, such as conducting searches, filtering results, and downloading desired resources. Provide an exercise sheet that guides educators in searching for and selecting useful elements within the VRLE Repository to enhance a vocational teaching session. The sheet may include specific instructions on the types of elements to look for, such as 3D models related to work equipment or tools, virtual environments simulating professional situations, or other relevant resources.
Where	In a physical environment where educators can access the VRLE Repository and perform practical activities.
Who	Participating educators who are applying VRLE Repository resources in creating a vocational teaching session, with the facilitator's support.
Estimated Time	35 minutes

4. Assessment activity	
What	Facilitate a group discussion about educators' experiences and findings during the exploration and application of VRLE Repository resources.
How	Encouraging educators to share their insights, challenges encountered, and potential applications of the repository's resources in their teaching practices.
Where	In a physical or virtual environment where educators can interact and share their experiences.
Who	All participating educators and the session facilitator.
Estimated Time	15 minutes
5. Reflection activity	
What	Engage trainees in a reflection activity to encourage them to critically analyze their learning experience with the VRLE Repository.
How	Provide prompts or guiding questions that prompt trainees to reflect on the benefits, challenges, and potential applications of the repository in their vocational teaching practices.

Where	In a physical environment where trainees can engage in individual or group reflection.
Who	Trainees who have participated in the training session on the VRLE Repository and the facilitator or instructor guiding the reflection activity.
Estimated Time	15 minutes

MODULE 5 description

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 5

Module Title: Didactics of the VR model (material perspective)

Module Description

Virtual learning environments need a special kind of their design, because it is a three-dimensional space. The most important principles for the design of such spaces as well as the corresponding research results are presented. This should enable teachers to design pedagogically appropriate virtual learning environments.

Learning Outcomes

With the completion of this module the trainees will be able to:

- Know the key design elements for a pedagogically oriented virtual learning environment.

- Know how to use these elements
- Be able to justify why these elements in particular are conducive to learning

Instruments/ Tools/ Supporting Material/ Resources to be used

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Video

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- Presentation with discussion
- Group discussion
- Tasks to solve in teams

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	At the beginning, the trainer introduces himself and describes his experience with the topic. He gives an overview of the course of the training and the most important topics. He explains the goals and what the participants should know and be able to do at the end. Participants will discuss their experiences with pedagogical design of learning environments.
How	The introduction will be given by an oral presentation supported by a presentation.
Where	physical environment/seminar room
Who	Teacher as presenter and moderator and trainee as discussants
Estimated Time	20 minutes
Development activity	
What	The trainer will present key research findings on the design of virtual learning environments. Examples from existing applications will be included.
How	This part is mainly done by the trainer with the help of a presentation, but examples are also given to the participants for discussion.
Where	physical environment
Who	Teacher as presenter and moderator and trainee as discussants
Estimated Time	30 minutes

Hands on activity	
What	Participants are activated to evaluate and discuss various examples presented by the trainer. The main objective is to understand the key design principles of virtual learning environments and how to use them in a pedagogically appropriate way.
How	The groups look at the examples presented and discuss the design principles.
Where	physical environment
Who	Teacher as presenter and moderator and trainee as discussants
Estimated Time	20 minutes
2. Assessment activity	
What	Participants are given tasks on a padlet that they have to answer. The topics are related to the content taught.
How	Working with a Padlet on a browser
Where	virtual environment
Who	Teacher as presenter and moderator and trainee as discussants
Estimated Time	5 minutes

3. Reflection activity	
What	Participants reflect on their learning experiences and compare them to the goals set for the training.
How	Participants write down their experiences in a paddlet, which is then discussed together.
Where	physical and Browser
Who	Teacher as presenter and moderator and trainee as discussants
Estimated Time	10 minutes

MODULE 6 description

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 6

Module Title: Methodology of the VR environment (teacher perspective)

Module Description

Please explain the scope and aims of this module, the rationale of this training module according to the project’s deliverables, provide information on the various constituents/ dimensions of the topic under consideration, and briefly describe (if any) theories under consideration.

This module offers practical advice, as well as do’s and dont’s, when it comes to the real life interactions between a teacher and his/her students inside an academic class that is delivered through the use of VR.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Know how to deliver a VR centered lesson while maximising its potential for students
- Effectively and smoothly coordinate such a lesson
- Help students that face difficulties while using VR
- Know what not to do during a VR lesson
- Have in mind practical activities that can take place in such a lesson

Instruments/ Tools/ Supporting Material/ Resources to be used

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Mentimeter
- YouTube (10 Best Examples AR & VR in Education)
- Cartons

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The learning method is using a PPT with interactive links to tools engaging the trainees and links to videos based on which there will be a discussion. The PPT contains text and photos with links to videos in order to make the presentation attractive to the trainees. If time allows the trainees will be asked to develop a Learning & Creativity plan working in groups.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	A short presentation on what the Module is about, along with its main points and goals
How	PPT presentation
Where	Physical in training room
Who	Teacher presents the module
Estimated Time	10 minutes
2. Development activity A	
What	Brainstorming regarding good and bad practices when teaching through VR
How	Mentimeter
Where	Physical in training room
Who	Teacher coordinates the voting
Estimated Time	10 minutes
3. Development activity B	
What	Video on best practices in VR & AR
How	Projection of a video along with commentary from the teacher and the trainees
Where	Physical in training room

Who	Teacher shows the video and ask participants on their reflection from it
Estimated Time	10 minutes
4. Development activity C	
What	Round table discussion
How	Open discussion about previous experiences that participants had with teaching through VR or other similar methods
Where	Physical in training room
Who	Teacher coordinates the discussion
Estimated Time	10 minutes
5. Development activity D	
What	Presentation of VR & AR related educational tools that participants could use in their classes
How	Teacher presents the tools through a PPT, along with hands-on trials of a number of them
Where	Physical in training room
Who	Teacher presents the tools through a PPT, along with hands-on trials of a number of them
Estimated Time	15 minutes

6. Hands on activity	
What	Trainees are split into groups and are asked to create the schedule of an 1 day training that uses VR for delivery
How	Teams will each write down their schedules on large pieces of carton
Where	Physical in training room
Who	Teacher supervises the activity
Estimated Time	15 minutes
7. Assessment activity	
What	Trainees are invited to present their group work
How	Cartons are put next to each other and teams give their feedback for the other teams' schedules
Where	Physical in training room
Who	Teacher supervises the presentations
Estimated Time	10 minutes

8. **Reflection activity**	
What	Live quiz, that partners can participants can play through their phones, regarding scenarios where they face challenges during the delivery of a class through the use of VR
How	Quizizz
Where	Physical in training room
Who	Teacher controls the Quizizz and participants move to the next question through the trainer’s pace
Estimated Time	10 minutes

MODULE 7 description

REVEALING Project

REalisation of **V**irtual r**EA**lity Learn**ING** Environments (VRLEs) for Higher Education

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Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 7

Module Title: How to implement a learning scenario in the VRLE model

Module Description

This module presents the evaluation process of the Virtual Reality Learning Environments designed and developed for this process. In detail, the trainer guides the trainees through best practices of involving real students to the VRLEs.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Understand the process of creating different accounts for VRChat.

- Understand the process of inviting real students into the VRLEs.
- Understand the process of assisting real students into VRLEs completion.

Instruments/ Tools/ Supporting Material/ Resources to be used.

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Links
- Videos
- Live demonstration

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The trainer will ask trainees to create VRChat accounts.
- The trainer will ask trainees to immerse themselves in the VRLEs.
- The trainer will ask trainees to invite users inside the VRLEs.
- The trainer will ask trainees to guides users through VRLEs completion.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	What are the specifications for using different VRChat accounts.
How	PPT Slides
Where	Physical in training room
Who	Trainer presentation and questions to trainees to reflect
Estimated Time	20 minutes
2. Development activity A	
What	What process do trainees have to follow to access the VRLES
How	Live demonstration
Where	Physical in training room
Who	Trainer will assist trainees on accessing the VRLEs
Estimated Time	20 minutes
3. Development activity B	
What	What process do trainees have to follow to invite other users in the VRLEs?
How	Live demonstration
Where	Physical in training room

Who	Trainer will assist trainees on inviting other users inside the VRLEs
Estimated Time	20 minutes
4. Assessment activity	
What	Trainees are asked to complete the VRLE scenario.
How	Live demonstration
Where	Physical in training room
Who	The trainer will assist trainees in completing the scenarios when required.
Estimated Time	20 minutes
5. Reflection activity	
What	Reflection through discussion
How	Recording of difficulties on using the VRLEs using Word.
Where	Physical in training room
Who	Trainer will guide the discussion and help trainees discuss with each other about VRLEs completion process.
Estimated Time	10 minutes

MODULE 8 description

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Co-funded by the Erasmus+ Programme of the European Union

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C

Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers

Training Module Lesson Plan

Module Number: 8

Module Title: Advantages of using VR in teaching/education

Module Description

The scope of this module is to explore the advantages of using virtual reality (VR) in teaching and education. The module aims to provide an understanding of how VR can revolutionize the learning process, enhance student engagement and motivation, and create inclusive and accessible learning opportunities.

The rationale for this training module aligns with the project's deliverables, which include promoting innovative and effective educational practices. By incorporating VR into teaching and education, educators can leverage immersive and interactive experiences to enhance learning outcomes. This module seeks to provide educators with insights into the potential of VR and equip them with knowledge to integrate VR technology into their teaching practices.

The module covers various constituents and dimensions of the topic. It begins by tracing the history of VR in education, from its origins in the 1990s to the recent advancements in VR technology. It highlights the diverse applications of VR in educational settings, such as medical education, engineering, history, and cultural explorations. The module also explores the advantages of learning through experience in VR, including active and immersive learning, practical application and skill development, safe and controlled environments, multi-sensory and multi-modal learning, visualization of complex concepts, and emotional and empathetic learning.

In terms of theories, the module references several research studies and literature reviews that support the effectiveness and benefits of VR in education. These include theories of experiential learning, cognitive engagement, emotional engagement, and gamification. The module cites studies that demonstrate how VR can enhance student engagement, motivation, knowledge retention, problem-solving skills, critical thinking, and social-emotional learning.

Learning Outcomes

With the completion of this module the trainees will be able to:

- Understand the advantages of using virtual reality (VR) in teaching and education.
- Identify the potential applications of VR in different educational disciplines.
- Explain how VR can facilitate learning through experience and enhance student engagement.
- Recognize the benefits of active participation and interactivity in VR environments.
- Describe the personalized and learner-centered approach enabled by VR technology.
- Discuss the role of emotional engagement in VR and its impact on learning outcomes.
- Recognize the gamification elements incorporated in VR experiences and their influence on student motivation.
- Understand the importance of accessibility and inclusion in VR-based education.
- Evaluate the impact of VR on students with disabilities and their learning experiences.
- Consider the ethical considerations and pedagogical frameworks related to the integration of VR in education.
- Discuss the current trends and perspectives on the usage of VR in higher education.
- Recognize the potential challenges and limitations of using VR in education.

Instruments/ Tools/ Supporting Material/ Resources to be used

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- Presentation Slides: The trainees will have access to a Beamer presentation that provides an overview of the advantages of using virtual reality (VR) in teaching and education. The presentation will cover the key concepts, research findings, and case studies related to VR in education. File name: Module8_PresentationSlides.pdf

- Research Articles: The trainees will have access to relevant research articles that support the content covered in the module. These articles will provide in-depth insights, empirical evidence, and recent advancements in the field of VR in education. File names: Module8_ResearchArticle_x.pdf, where x=1,2,3…
- A dedicated online discussion forum (moodle or google group) will be set up for the trainees to engage in discussions, ask questions, and share their insights and experiences related to VR in education. The discussion forum will provide a platform for collaborative learning and knowledge sharing among the trainees.

Methodology

The presentation and learning activities during the training will be organized in the following way.

- The session will commence with a concise presentation that offers an overview of the module topic, highlighting key points and essential concepts that will be discussed.
- Trainees will actively engage in interactive discussions, encouraged to ask questions, share their thoughts, and participate in discussions related to the module topic. This can be facilitated through a live chat or a dedicated online discussion forum.
- A relevant case study or scenario will be presented to demonstrate the practical application of the module content. Trainees will analyze and discuss possible solutions or approaches within small groups or as a whole, promoting active participation and learning.
- Trainees will be divided into small groups and assigned specific tasks related to the module topic. These tasks may involve problem-solving, brainstorming ideas, or creating a short presentation or summary. Clear instructions and guidance will be provided to facilitate group work.
- Each group will have the opportunity to present their findings or solutions to the rest of the trainees. Brief discussions will follow each presentation, fostering peer-to-peer learning and the exchange of ideas. Facilitators will ask follow-up questions to encourage further discussion and provide feedback.
- The module will conclude with a summary of the key points discussed during the session. Trainees will have the opportunity to ask questions and seek clarification on any remaining doubts or concerns. Facilitators will address these questions, ensuring a comprehensive understanding of the module content.

By implementing this methodology, the session will prioritize interactive discussions, case studies, group activities, and presentations. This approach fosters active engagement, collaboration, critical thinking, and practical application of the module content within the given time frame.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	The introductory activity aims to provide an overview of the module topic and set the stage for the subsequent discussions and activities. It will involve a concise presentation that highlights key points and essential concepts related to the topic.
How	The presentation will be delivered using presentation slides.
Where	The activity will take place in a physical environment conducive to presentations.
Who	The facilitator(s) will lead the presentation, delivering the content in an engaging and interactive manner. Trainees will assume an active role by listening attentively, taking notes, and preparing to participate in subsequent discussions.
Estimated Time	The introductory activity is expected to take approximately 10 minutes, allowing for a concise yet comprehensive overview of the module topic.

2. Development activity	
What	In this activity, the trainer will deliver an interactive presentation to engage the participants and facilitate knowledge transfer. The presentation will cover key concepts, examples, and case studies relevant to the module's content. Additionally, interactive tools such as a live dashboard or mentimeter will be utilized to collect opinions and feedback from the trainees.
How	The trainer will use visual aids, slides, and multimedia elements to enhance the presentation and maintain the participants' interest. The content will be organized in a logical sequence, emphasizing important points and providing relevant examples. Throughout the presentation, the trainer will encourage active participation by asking questions, initiating discussions, or conducting polls using interactive tools like mentimeter. Trainees can use their smartphones or other devices to provide instant feedback, answer questions, or express their opinions.
Where	This activity can take place in a physical classroom equipped with audiovisual

	equipment, or in a virtual setting using video conferencing tools or webinar platforms. The interactive tools like mentimeter can be accessed online, allowing participants to engage and provide feedback using their own devices.
Who	The trainer will lead the presentation, delivering the content and facilitating discussions. The participants will actively listen, ask questions, and interact with the trainer and other participants during the session. They will also use the interactive tools to provide feedback, respond to polls, and share their opinions on specific topics.
Estimated Time	The duration of the interactive presentation and feedback collection will depend on the complexity of the content and the level of engagement from the participants. Typically, this activity can range from 20 to 40 minutes, allowing sufficient time for the presentation and interactive discussions. The time can be adjusted based on the specific needs and objectives of the module.
3. Hands on activity	
What	The hands-on activity aims to provide practical experience and application of the concepts covered in the module. Participants will engage in a series of exercises or simulations related to the module's topic, allowing them to apply their knowledge and skills in a hands-on manner
How	Participants will work individually or in small groups to complete the hands-on exercises or simulations. The trainer will provide clear instructions and guidelines for the activity, ensuring that participants understand the objectives and tasks at hand. Participants may use specific tools, software, or resources provided by the trainer to complete the activity effectively.
Where	This hands-on activity can take place in a physical classroom equipped with the necessary resources, such as computers or other devices. Alternatively, participants can engage in the hands-on activity in a virtual environment using online collaboration platforms or simulation software.
Who	The trainer will oversee the activity, providing guidance and support as needed. Participants will actively participate, applying their knowledge and skills to complete the hands-on exercises or simulations. Collaboration and teamwork may be encouraged depending on the nature of the activity.

Estimated Time	The hands-on activity is expected to take approximately 30 minutes. This timeframe allows participants enough time to engage in the practical exercises or simulations while maintaining a reasonable pace. The duration can be adjusted based on the complexity of the tasks and the specific learning objectives of the module.
4. Assessment activity	
What	The assessment activity aims to evaluate participants' understanding of the module's content and their ability to apply the knowledge gained. It can take the form of a quiz, a case study analysis, a group discussion, or any other suitable assessment method.
How	Participants will be presented with questions or tasks that require them to demonstrate their comprehension of the module's concepts. The assessment can be conducted through an online platform, written exercises, or in a group setting facilitated by the trainer.
Where	The assessment activity can be conducted in a physical or virtual environment, depending on the training setup. In a physical classroom, participants can complete written assessments individually or in groups. In a virtual setting, online assessment tools or collaboration platforms can be utilized.
Who	The trainer will administer the assessment activity and provide clear instructions to participants. Participants will individually or collectively engage in the assessment, showcasing their understanding and application of the module's content.
Estimated Time	The estimated time for the assessment activity is approximately 15 minutes. This time includes distributing the quiz, allowing participants to read and answer the questions, and collecting their responses.
5. Reflection activity	
What	The reflection activity will provide an opportunity for participants to reflect on the advantages of virtual reality in higher education discussed throughout the module. They will engage in a guided reflection exercise to consolidate their learning and personal insights.
How	Participants will be given a set of reflection questions or prompts related to the advantages of virtual reality in higher education. They will have some time to individually reflect on these questions and write down their thoughts.

Where	The reflection activity can take place in a physical classroom or a virtual environment. Participants can use pen and paper or digital tools to record their reflections.
Who	The trainer will facilitate the reflection activity by providing the reflection questions or prompts and creating a supportive and inclusive environment for participants to share their thoughts. Participants will engage in the reflection exercise individually, and they may have the opportunity to share their reflections with others in small groups or through online discussion forums.
Estimated Time	The estimated time for the reflection activity is approximately 10-15 minutes. This time allows participants to reflect on the advantages of virtual reality in higher education, contemplate their own insights, and jot down their reflections.

MODULE 9 description

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 9

Module Title: Learning in the future, visions for evolution of methods and learning spaces

Module Description

Please explain the scope and aims of this module, the rationale of this training module according to the project's deliverables, provide information on the various constituents/ dimensions of the topic under consideration, and briefly describe (if any) theories under consideration.

This module discusses the past and the future of learning in an evolution approach from Education 1.0 to Education 4.0. This is on the basis of digital developments and the contemporary evolution of learning in youth.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Understand the concepts of learning evolution from Education 1.0 to 4.0
- Understand the differences between knowledge, competence and skill
- Understand the IPL and PBL methods in relation to STEAME activities and learn how to support students working in groups both physically or hybrid
- Learn how to develop Learning and Creativity Plans (L&C Plans) and cooperate with other colleagues in creating multi-science project descriptions

Instruments/ Tools/ Supporting Material/ Resources to be used

Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- PPT
- Links
- Videos
- All of the above are saved in the same digital folder named: Learning in the future

www.steame.eu, www.steame-hybrid.eu , www.byod-learning.eu , www.facilitate-ai.eu , https://onlife.up.krakow.pl/ , https://ecovem.eu/ , https://www.metis4skills.eu/ , www.steame-academy.eu

Methodology

Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The learning method is using a PPT with interactive links to tools engaging the trainees and links to videos based on which there will be a discussion. The PPT contains text and photos with links to videos in order to make the presentation attractive to the trainees. If time allows the trainees will be asked to develop a Learning & Creativity plan working in groups.

Learning Activities Plan

Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	The trainees are asked to reply to the following question through Mentimeter: **What do you want to see in a future school or university that you do not see today?**
How	Link to ***www.menti.com*** **use WORDCOUNT in mentimeter**
Where	Mixed physical and virtual environment
Who	Teacher sets the question and trainees reply using their smartphone or laptop.
Estimated Time	5 minutes

2. Development activity A	
What	Present and discuss Education 1.0 to 4.0
How	Slides with characteristics of each level
Where	Physical in training room
Who	Teacher presents statements and asks trainees to reflect
Estimated Time	10 minutes

3. Development activity B	
What	STEAME learning through Project Based Learning explored
How	Slides and links to examples
Where	Physical with trainees and virtual for material
Who	Teacher presents and trainees reflect
Estimated Time	10 minutes

4. Development activity C	
What	Learning Spaces of the future
How	Slides and links to designs, photos and videos
Where	Physical with trainees and virtual for material
Who	Teacher presents and trainees reflect
Estimated Time	10 minutes …

5. Development activity D	
What	More elements in the evolution of learning: STEAME-Hybrid, BYOD-Learning, Facilitate-AI, Mircoelectronics, STEAME-Academy etc
How	Slides and links to websites, photos and videos Trainees are asked to do an online ONLIFE self-assessment for adaptable competencies
Where	Physical with trainees and virtual for material
Who	Teacher presents and trainees reflect
Estimated Time	15 minutes

6. Hands on activity	
What	Trainees are asked to construct a Learning & Creativity plan working in pairs or more.
How	Use of an empty template of L&C Plan
Where	Physical between trainees and virtual for tools or other collaborators
Who	Teacher is monitoring and discussing with the different developing groups of trainees
Estimated Time	15 minutes

7. Assessment activity	
What	Trainees are invited to present their group work
How	Presentation using the digital L&C Plan, 5-7 min per group
Where	Physical between trainees
Who	Teacher is making questions and inviting other trainees to make questions
Estimated Time	15 minutes …
8. Reflection activity	
What	Reflection through discussion or use of menti-meter with new question set by trainees
How	PPT and menti-meter tool
Where	Physical between the trainees and virtual for tools
Who	Teacher set challenges for the future and supports discussion between the trainees
Estimated Time	10 minutes

MODULE 10 description

Co-funded by the Erasmus+ Programme of the European Union

REVEALING Project

REalisation of **V**irtual r**EA**lity **L**earn**ING** Environments (VRLEs) for Higher Education

Reference number: KA220-HED-ED73663C
Implementation period: Nov 2021 – April 2024

C1 Training Activity of HEI Teachers
Training Module Lesson Plan

Module Number: 10a, 10b, 10c, 10d

Module Title: Testing for the pilots (Part A, B, C, & D)

Module Description

This module allows participants to test the pilot VRLEs developed for this project. In detail, this module with train participants on how to access and operate the VRLEs in order to be able to guide students through their operation in the future.

Learning Outcomes

With the completion of this module, the trainees will be able to:

- Access the VRLEs developed during this project.
- Understand their functionalities.
- Complete each VRLE scenario.

Instruments/ Tools/ Supporting Material/ Resources to be used.
Please explain what type of resources, materials and tools will be utilized by the trainees (list of files, web links, videos, PPT – name the corresponding files using file names by the Module's number).

- Live demonstration

Methodology
Please explain briefly how you will organize/approach the presentation and learning activities during the training.

- The trainer will invite trainees in the VRLEs developed for this project.
- The trainer will introduce trainees to the basic functionalities of the VRLEs.
- The trainer will complete the VRLEs scenarios to demonstrate the process to trainees.
- The trainer will ask the trainees to complete the VRLEs scenarios themselves.

Learning Activities Plan
Please explain the activities during the training, using the following template.

1. Introduction Activity	
What	What is the process for accessing the VRLEs?
How	Live demonstration
Where	Physical in training room
Who	Trainer will guide trainees on connecting to the VRLEs.
Estimated Time	20 minutes
2. Development activity A	
What	What are the basic functionalities of each VRLE?
How	Live demonstration
Where	Physical in training room
Who	Trainer will present the basic VRLEs functionalities.
Estimated Time	20 minutes
3. Development activity B	
What	What is the process for completing each VRLE?
How	Live demonstration
Where	Physical in training room
Who	Trainer will demonstrate each VRLE completion process.
Estimated Time	20 minutes
4. Assessment activity	
What	What are the difficulties of using the VRLEs?
How	Live demonstration

Where	Physical in training room
Who	Trainer will encourage participants to provide feedback on VRLEs usage difficulties.
Estimated Time	15 minutes
5. Reflection activity	
What	Reflection through discussion
How	Recording of VRLEs usability issues using Word.
Where	Physical in training room
Who	Trainer will guide the discussion and help trainees discuss VRLEs usability issues.
Estimated Time	15 minutes

Revealing: Realisation of Virtual Reality learning environments for higher education

Reference number: 2021-1-DE01-KA220-HED000032098

https://revealing-project.eu