

VR4 EMPATHY

Catalogue of good practices

About the use of VR-based resources in school education

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CHAPTER 1

Introduction

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1. INTRODUCTION

Virtual Reality (VR) in education offers immersive and engaging learning experiences by transporting students to different worlds, dissecting complex subjects, and allowing them to practise skills in safe environments[1]. As VR becomes an increasingly mainstream technology, studies support the theory that immersion can improve learning outcomes. For example, 40% of VR learners report greater confidence in using their new skills after practicing them in VR[2]. Additionally, VR learners are up to four times more focused and 3.75 times more emotionally connected to educational content[3]. However, research gaps remain in understanding the long-term impact of VR on student engagement and information retention. Further investigation is also needed to identify which subjects and learning objectives are most effectively taught through VR. Therefore, VR should still be viewed as complementary to traditional teaching methods, providing immersive, experience-based learning opportunities that are not feasible in a conventional classroom setting. Alongside important teacher-student interactions, social learning dynamics, and the development of interpersonal skills, VR can enrich the educational landscape as a supplementary tool rather than a standalone solution[4].

This benchmarking analysis of ten VR-based educational resources highlights international use cases and educational resources in VR, emphasising critical features for improving engagement in the classroom and impact learning. The report is produced by VR4EMPATHY, an EU-Commission co-funded project driven by a consortium of education providers, educational ministries, and EdTech providers. The examples and analysis are prepared by Khora, a leading immersive production studio and lead partner for co-design, quality assurance, and development of VR-based educational resources in VR4EMPATHY.

1.1. The landscape of VR and learning

Developers, educators, and innovators constantly produce new VR education solutions, experiences, and platforms for hosting virtual and digital resources. Estimating the total

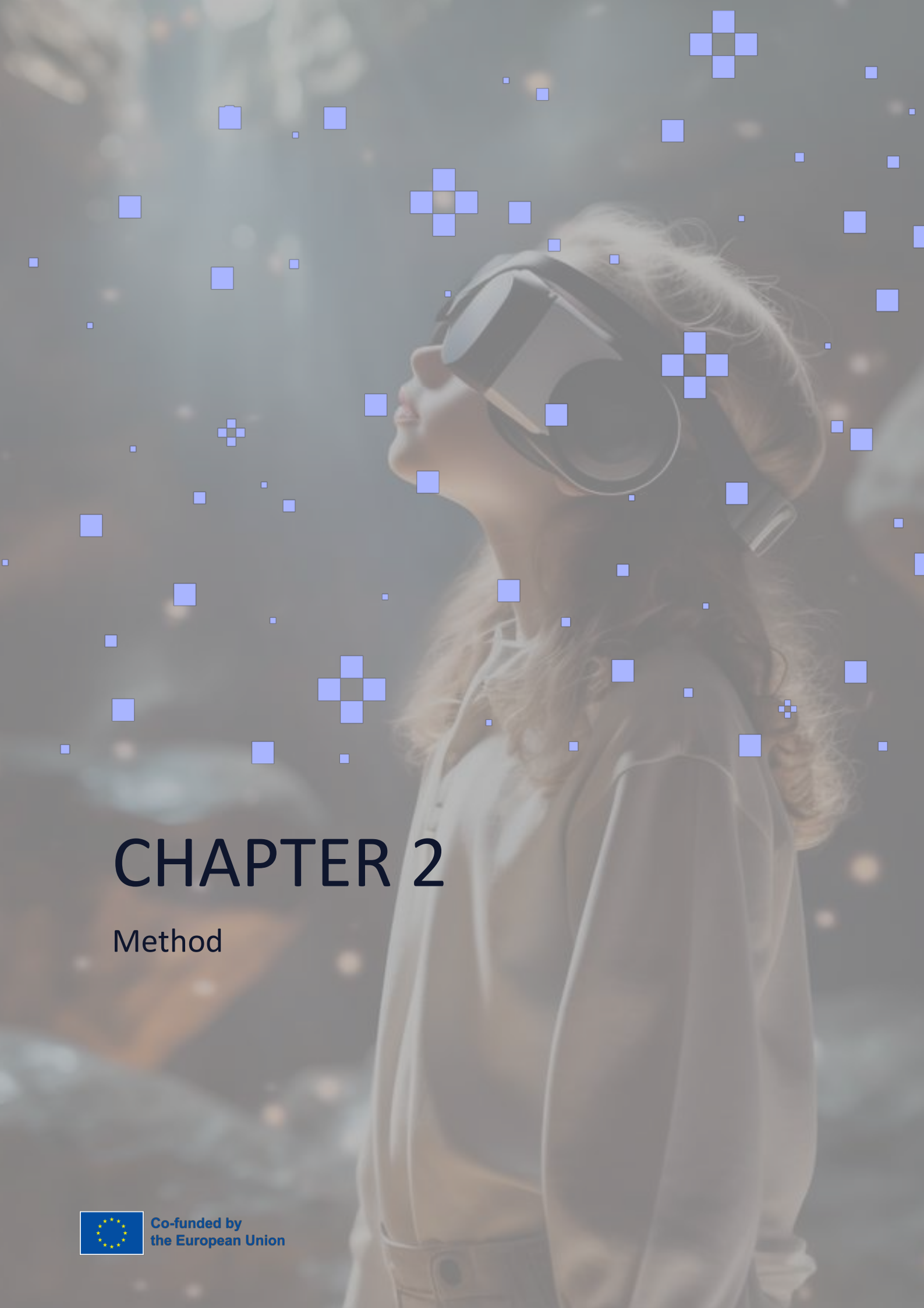
[1] Chen et al (2024), Effectiveness of Virtual Reality on Learning Engagement, International Journal of Web-Based Learning and Teaching Technologies 19(1):1-14
[2] PwC's Study Into the Effectiveness of VR for soft skills training, retrieved Feb 16 2024
[3] XRToday - Top 7 VR Education Applications to Explore in 2023, retrieved March 25 2024
[4] Learning Empathy Through Virtual Reality: Multiple Strategies for Training Empathy-Related Abilities Using Body Ownership Illusions in Embodied Virtual Reality (2018), Frontiers in Psychology

number of VR resources available for educational purposes is challenging due to the rapidly evolving nature of the technology and the continuous development of new content. However, insights from educational platforms provide a glimpse into the scale and diversity of VR applications in education.

Platforms such as YouTube VR, ClassVR, and Unimersiv provide thousands of educational VR and AR resources and offer pedagogically sound and engaging VR and AR content pieces. The content includes pre-made VR activities, lesson plans, and the ability to upload custom 360-degree images and videos. The platforms cover a wide range of subjects, from art and biology to geography, science, math, and history, showcasing the extensive application of VR in educational settings. Other web-based platforms, like Prisms of Reality and Eduverse, offer e-learning with integrated VR to facilitate experience-based learning. The former provides a solution that enables content to work via VR headsets and on tablets, phones, laptops, and computers to provide a full-scale web-based solution. The system is free for educators and supports fully remote and hybrid learning solutions, which has sparked curiosity in Eduverse Expeditions and taking students on virtual excursions[5].

Furthermore, the VR market, encompassing both hardware and software, has seen significant growth, indicating an expanding ecosystem that supports educational applications, among other uses. While specific numbers on educational resources are not readily available, the growth of the VR market suggests an increasing number of resources over time. For instance, the VR hardware and software markets have been projected to grow substantially, with billions in revenue being generated annually[6]. Given these indicators, it is reasonable to infer that VR educational resources will likely continue to grow as the technology becomes more accessible and applications in education become more widely recognised and implemented.

[5] XRToday - Top 7 VR Education Applications to Explore in 2023, retrieved March 25 2024
[6] Virtual Reality - Statistics and Facts, retrieved 16 Feb 2024



CHAPTER 2

Method

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2. METHOD

This report relies on desk research, interviews, and empirical testing to establish best practices and highlight examples of VR resources in education. During the desk research phase, the team scanned and searched technology media and newspapers, reviewed scientific articles, and explored distributor platforms of VR content, such as Google, Steam, Meta, YouTube, and AppStore. To triangulate insights, the team interviewed other professionals in VR and producers of digital educational resources and validated assumptions in surveys with 300+ European teachers and students co-executed by partners in VR4EMPATHY. Finally, the team conducted tests of the chosen VR examples and assessed outcomes. The analysis and list of experiences focus on all educational subjects, as our interest is to focus on immersive functionalities and how these are mechanisms for improving learning among secondary school students.

2.1. Interviews

All interviewees have consented to publicly reveal their name, title, and participation in the study. Special thanks for the invaluable insights:

- **Ane Skak**, Founder and Film Director at Immersive Stories, Copenhagen, Denmark.
- **Christopher Schnoor**, VR director and 360 film producer, Khora Virtual Reality, Copenhagen, Denmark.
- **Talitha Rachmani Umar**, Researcher in VR, psychology, and learning, University of Indonesia, Jakarta, Indonesia.
- **Taelo Mathuloe**, researcher in XR for sustainability and global citizenship, Trinity College Dublin, Dublin, Ireland.
- **Thomas Therkildsen**, Director Facial Action Coding System and Photogrammetry, Rockstar Games and Lead Developer and co-founder of LGBTQ+ VR Museum, Copenhagen, Denmark.

2.2. Key Take-Aways: Interviews

- **Less is More**. Many learners report that they get bored or feel tired after watching VR for long time periods. Poor quality of content negatively affects an immersive experience and the learning impact. It is preferable to shorten the duration of an experience and create high-quality content, or to mindfully include forms of interactivity, to hold the attention of the viewer.

- **Interactions should facilitate learning, not distract users**. Overall, students give positive feedback on interactive content since the ability to manipulate a virtual environment is stimulating and empowers the user with agency. However, interactivity should be used with intention in those subjects where it makes sense, such as procedural subjects, simulated learning of machines, instructions, and pre-defined manuals. For more "human" and story-driven experiences, a linear storytelling is often more accessible, as it limits the users from being distracted when navigating interactions and complex, virtual functionalities.

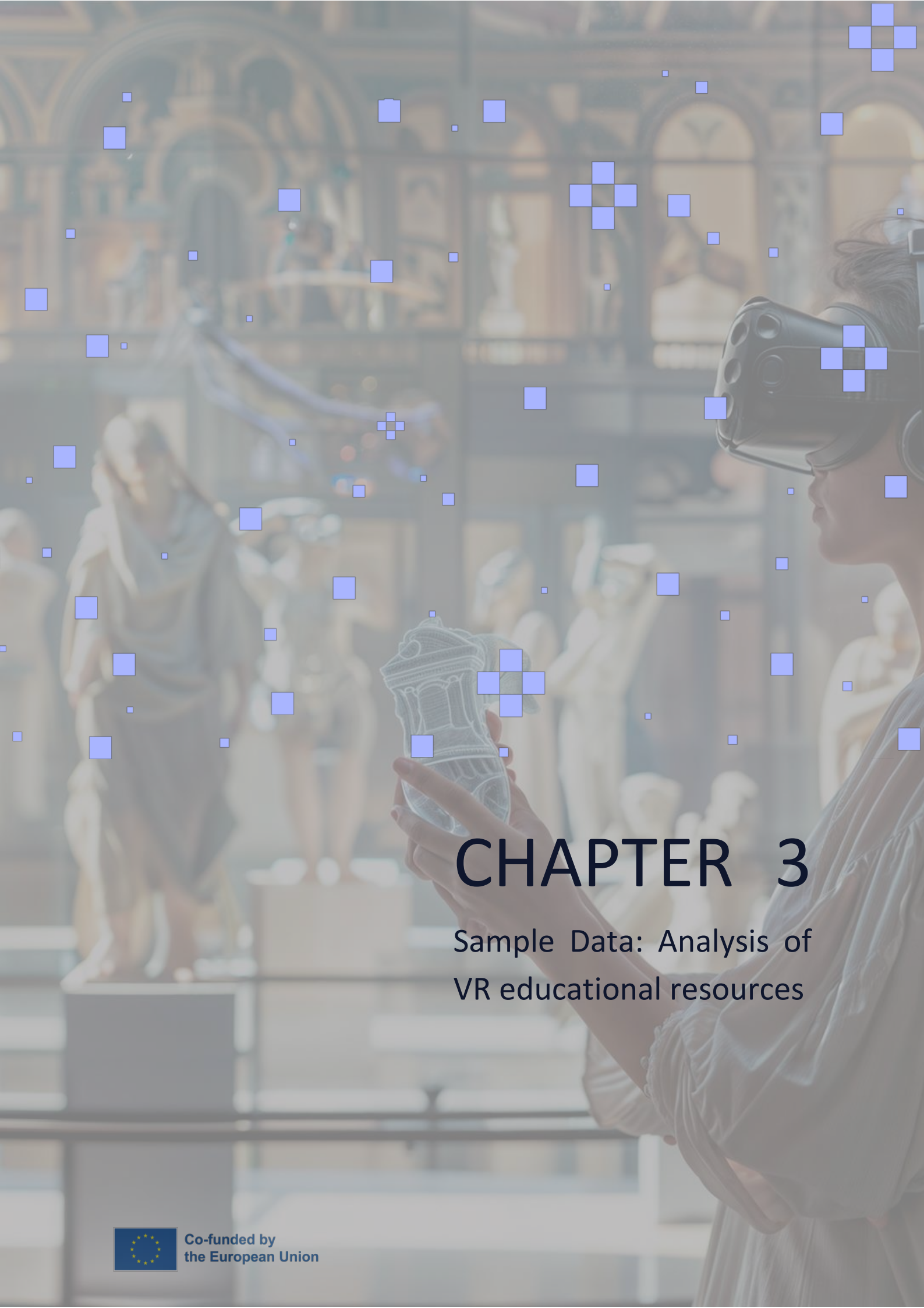
- **Humanise the content through sound, eyes, voice and guided storytelling.** Storytelling and the quality of the storyteller are key to driving a story. When the main characters, for instance, make eye contact with the user or address them directly, it helps to create a sense of self-presence and embodiment. It is important to bring in cultural aspects, stories and artefacts that the audiences can relate to, and using the technology to enhance these aspects.

- **Location is king, but content is king kong:** Documentary-style content, a strong location and archive materials work well to create a feeling of "time travel." Inaccessibility is interesting because VR can take you to place which may otherwise be practically impossible to reach (e.g., space or under water).

- **Length vs. depth:** An inductive approach, moving from small observations to large conclusions, is suitable to enable depth in an experience. For example, in sciences, VR can help visualise what happens at an atomic level to help students extrapolate to their wider surroundings and as such, understand what happens at microscopic levels and how everything is connected.

- **Experimental anonymity:** VR enables access. In VR, you can be anyone and anywhere. VR is suitable for exploring subjects users unknowingly want to know about but are uncomfortable with. VR can help people explore topics, subjects, and places they might not physically dare to visit.

- **Facts vs. reflection:** VR is not necessarily better than classical educational mediums for fostering remembrance of historical facts; however, practitioners find that it is a better medium for igniting reflection and critical thinking. VR helps students reflect on a deeper level because of the sense of embodied experience it provides.



CHAPTER 3

Sample Data: Analysis of VR educational resources

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3. SAMPLE DATA: ANALYSIS OF VR EDUCATIONAL RESOURCES

Functionalities that leverage VR's immersive nature to create engaging, emotionally resonant experiences conducive to deep learning are particularly effective in enhancing learning outcomes and fostering student empathy. This report highlights ten VR experiences for education that have been selected based on a representative sample (N: 35) of VR educational resources analysed across several school subjects with a focus on functionality and the content type that is most suitable to foster empathy and impact learning outcomes for secondary school students. The experiences are chosen for their international recognition and suitability to complement traditional teaching.

The educational VR resources and subsequent functionality of interest highlighted in this report are:

1. Perspective shifting - Anne Frank House
2. First-person POV: Chauvet: The Dawn of Art
3. Experiential Simulations: Sharecare VR
4. Emotional Storytelling: Traveling While Black
5. Virtual Field Trips: Space Explorers
6. Collaborative Environments: MultiBrush
7. Feedback and Assessment: Keep Talking and Nobody Explodes
8. Emotional Engagement through Sensory Immersion: Notes on Blindness
9. Personalised Learning Paths: Mondly
10. Visualisation of Complex Concepts: GeoGebra

3.1 Perspective shifting - Anne Frank House

Key feature: Perspective Shifting

VR's capacity to tell stories in an immersive environment can significantly impact empathy generation and a deeper understanding of topics, situations, and subjects. One of the most significant features of VR is its capacity for perspective shifting. This immersive storytelling method can generate empathy and foster a deeper understanding of an issue or context. By placing students in diverse perspective frames, they experience different views and opinions, which is particularly powerful in subjects such as history, literature, and social studies. For

instance, in history classes, students can be virtually transported to historical events, allowing them to witness and understand the complexities of those times firsthand. In literature, they can step into the shoes of different characters, gaining insight into their motivations and emotions. Social studies benefit immensely from this feature as it helps students comprehend social issues, understand historical contexts and conflicts, and explore cultural differences where multiple perspectives are crucial for a holistic understanding.



Figure 1 – From Anne Frank House VR

About the experience

The Anne Frank House VR experience, produced by Force Field, serves as a poignant example of perspective shifting in VR. This immersive journey allows users to explore the story of Anne Frank during World War II, offering a unique opportunity to engage with historical events on a personal level. In this VR experience, users are transported back in time to the "Secret Annex" in Amsterdam where Anne Frank and her family hid from the Nazis for over two years. The virtual tour of the Annex is meticulously designed, allowing users to navigate each room and delve into Anne's thoughts and experiences as if they were alongside her. This deep engagement with Anne's personal narrative not only highlights the historical significance of her story but also humanises the broader context of the Holocaust.

The Anne Frank House VR provides an intimate look at the lives of the eight Jewish inhabitants of the Annex, fostering a profound sense of empathy and understanding. By experiencing Anne's environment and hearing her reflections, users gain a powerful perspective on the human impact of historical events beyond the facts and figures often presented in textbooks.

Potential impact on learning

Integrating VR experiences like the Anne Frank House into educational settings alongside traditional teaching methods can impact learning outcomes for secondary school students in various ways outlined below:

- **Enhanced Engagement:** The explorative elements that Anne Frank House introduces can capture students' attention effectively because they are given agency to take ownership of their experience. By engaging multiple senses, VR can make historical events more memorable, in this case leading to a deeper understanding of what the Jewish population went through during The Second World War. As noted by Thomas Therkildsen, one of the interviewees in the project, teaching history through immersive methods like escape rooms has been shown to improve learning outcomes significantly. VR takes this a step further by providing a fully immersive experience.
- **Empathy and Emotional Connection:** VR's ability to place students in the shoes of historical figures like Anne Frank fosters empathy and emotional connection. This emotional engagement is crucial for developing a deeper understanding of historical events and their human impact. Students will likely remember and reflect on these experiences more deeply, enhancing their overall grasp of the subject matter.
- **Contextual Understanding:** VR allows students to explore historical contexts in a detailed and nuanced manner. The Anne Frank House VR, for example, not only provides information about Anne's life but also contextualises it within the broader framework of World War II and the Holocaust. This comprehensive understanding helps students connect the dots between different historical events and their significance.
- **Critical Thinking and Analysis:** By immersing students in different perspectives and inviting them to reflect on different viewpoints the experience encourages critical thinking and analysis. In Anne Frank House students are prompted to consider multiple viewpoints, understand different motivations, and analyse the consequences of historical events. This analytical approach is essential for developing higher-order thinking skills.

- **Room for improvement:** While the experience invites students to explore, think critically, and witness first-class storytelling, the technical interactions that are integrated in the experience are sometimes more confusing than facilitating.

In conclusion, the Anne Frank House offers an immersive, empathetic, and context-rich learning environment. When used alongside traditional teaching methods and teacher-student interactions, VR can provide a comprehensive and engaging approach to learning that prepares students for a deeper understanding of complex historical and social issues.

3.2 First-person POV: Chauvet: The Dawn of Art

Key feature: First Person Point of View (POV)

In VR, first-person Point of View (POV) perspectives provide an immersive experience that can enhance empathy and perspective-taking. This feature allows learners to navigate and interact with three-dimensional spaces as if they were physically present, offering a unique and engaging way to explore various subjects. By simulating the perspective of historical figures, people from different cultures, animals and organisms, VR helps develop spatial understanding and reasoning skills. This approach is particularly effective in subjects such as social science, engineering, arts, culture, and geography.

For instance, in social sciences, students can experience life from the perspective of people from different historical periods or cultural backgrounds, deepening their understanding of social dynamics and historical contexts. In engineering, VR can simulate complex machinery and architectural structures, allowing students to interact with these elements hands-on. The arts benefit from the ability to explore artistic techniques and cultural artefacts up close, while geography students can virtually visit different parts of the world to understand physical and cultural landscapes better.

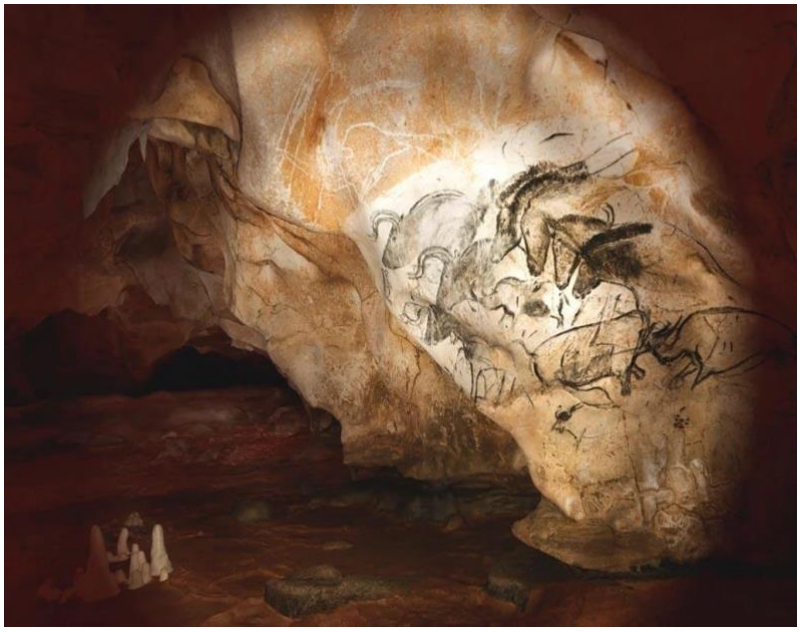


Figure 2 – From Chauvet: The Dawn of Art

About the experience

Chauvet: The Dawn of Art is a ten-minute VR experience narrated by Cécile de France (French) or Daisy Ridley (English). It guides visitors through the UNESCO World Heritage Site, the Chauvet Cave in France. Users can explore 12 stations within the cave with expert commentary from Chauvet's scientific team, discover the cave's surroundings, and see the Horses Fresco up close. The experience includes interactive elements like touching the cave walls and exploring by torchlight, transporting users back 36,000 years to witness humanity's first masterpieces in the Ardèche gorges.

The immersive environment offers students a unique opportunity to explore history as if they were physically present, witnessing ancient drawings and the first humans who ventured into this subterranean world. The experience is interactive, allowing students to light torches and touch the walls, supported by a voice-over guiding them through one of the greatest scientific breakthroughs of the 20th century. "The Dawn of Art" is more than a tour; it's a storytelling experience that sparks emotions and immerses students in the past, just as the first humans were in their painted caves.

Potential Impact on learning

Integrating VR experiences like Chauvet: The Dawn of Art into educational settings alongside traditional teaching methods can impact learning outcomes for secondary school students in various ways as outlined below:

- **Enhanced Engagement:** Students perceive a historical setting from their own point of view and the immersion of the self in a historical context is likely to capture students' attention effectively. By engaging multiple senses, VR can make historical events more memorable, potentially leading to better retention of information. Students who experience the details of the Chauvet Cave are likely to retain detailed knowledge about the culture, architecture, and stories associated with prehistoric times.
- **Empathy and Emotional Connection:** VR's ability to immerse students in historical settings fosters empathy and emotional connection. This emotional engagement is crucial for developing a deeper understanding of historical events and their human impact.
- **Contextual Understanding:** VR allows students to explore historical contexts in a detailed and nuanced manner. Chauvet: Dawn of Art provides an immersive look at prehistoric times, helping students connect historical facts with the lived experiences of people from that era. This comprehensive understanding helps students connect different historical events and reflect on their significance.
- **Critical Thinking and Analysis:** By immersing students in different perspectives, VR encourages critical thinking and analysis. Students are prompted to consider multiple viewpoints, understand different motivations, and analyze the consequences of historical events. This analytical approach is essential for developing higher-order thinking skills.
- **Spatial Understanding and Reasoning:** The first-person POV in VR helps students develop spatial understanding and reasoning skills. By navigating three-dimensional spaces, students can better grasp the layout and architecture of prehistoric sites, enhancing their spatial awareness and ability to visualise historical environments.

In conclusion, the Chauvet: Dawn of Art experience exemplifies the potential of VR in education by offering an immersive, empathetic, and context-rich learning environment.

3.3 Experiential Simulations: Sharecare VR

Key feature: Experiential Simulations

Experiential VR simulations offer an innovative approach to education by providing students with hands-on learning activities and experiences that would be impossible, dangerous, or impractical in the real world. These simulations allow students to engage deeply with the subject matter by conducting scientific experiments, exploring hazardous environments, or practising medical procedures in a risk-free, controlled virtual setting. The immersive nature of these experiences can significantly enhance engagement and retention of information, making complex concepts more accessible and understandable.

For instance, in the sciences, VR can simulate laboratory experiments that might be too costly, time-consuming, or dangerous to perform in a traditional classroom. In geography, students can explore the inside of a volcano or the ocean's depths without any physical risk. In medical education, students can practise surgical procedures or explore the human body in detail, gaining a level of hands-on experience that would be difficult to achieve otherwise.

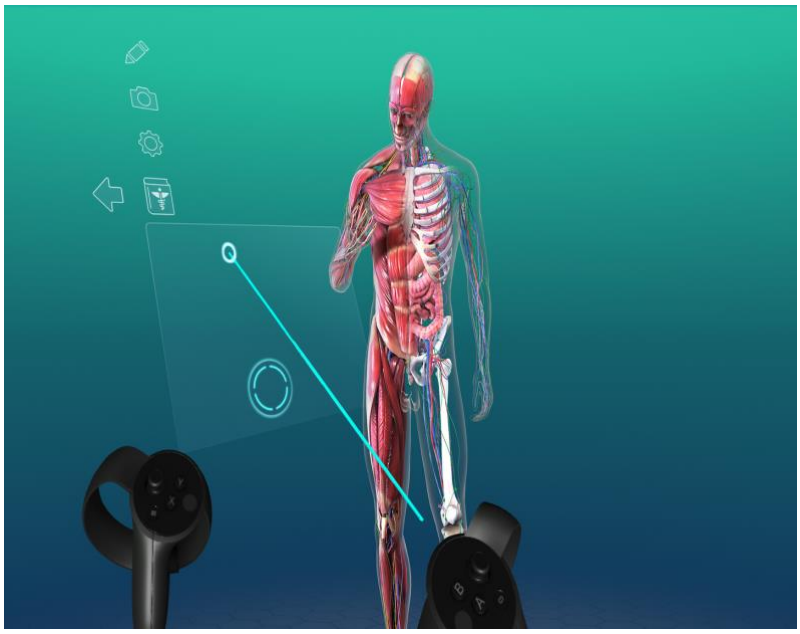


Figure 3 – From Sharecare VR

About the experience

Sharecare VR, produced by Sharecare Inc., is an educational virtual reality experience designed to take users on a journey inside the human body. This immersive experience allows students to explore the complexities of cellular structures and functions as if they were physically present within a cell.

In Sharecare VR, students can jump into different body parts and organs and see how the human body looks both healthy and with different diseases. This VR experience is not only visually stunning but also interactive. Students can manipulate different elements within the human body, conduct virtual experiments, and see the immediate effects of various biological processes. This level of interactivity helps reinforce learning by allowing students to apply their knowledge practically and engagingly.

Potential impact on learning

Integrating experiential VR simulations like Sharecare VR into traditional educational settings can have a substantial impact on learning outcomes for secondary school students, as outlined below:

- **Enhanced Engagement:** The interactive elements of VR capture students' attention more effectively than traditional teaching methods. By engaging multiple senses, VR makes scientific concepts more memorable, leading to better retention of information. Students who explore the human body in VR are likely to retain detailed knowledge about cellular structures and functions.
- **Deeper Understanding of Complex Concepts:** VR allows students to visualize and interact with complex biological processes that are often difficult to grasp through textbooks alone. Sharecare VR provides an inside look at cellular functions, helping students understand how various processes contribute to the overall functioning of the human body. This deeper understanding is crucial for mastering advanced topics in biology.
- **Risk-Free Exploration:** VR simulations provide a safe environment for students to explore and experiment without the risks associated with real-world settings. In Sharecare VR, students can conduct virtual experiments and observe the effects of different variables on cellular processes without any physical danger. This risk-free exploration encourages curiosity and experimentation, which are essential for scientific learning.

- **Critical Thinking and Problem-Solving:** By immersing students in a virtual environment where they can manipulate variables and observe outcomes, VR encourages critical thinking and problem-solving. Students are prompted to apply their knowledge, analyze results, and draw conclusions based on virtual experiments. This analytical approach is essential for developing higher-order thinking skills.
- **Real-World Applications:** Experiential simulations in VR can bridge the gap between theoretical knowledge and real-world applications. By understanding cellular functions in a virtual environment, students can better appreciate the practical implications of biological research and medical advancements. This connection between theory and practice enhances the relevance of their studies.
- **Room for improvement:** To master the interactions in the application students need a bit of introduction as they require the user to be an experienced VR user. The interactions are not explained in an easy way by the application, the user has to learn themselves.

In conclusion, Sharecare VR exemplifies an immersive, interactive, and context-rich learning environment. When used alongside traditional teaching methods and teacher-student interactions, it can provide a comprehensive and engaging approach to learning that prepares students for a deeper understanding of complex scientific concepts and real-world applications.

3.4 Emotional Storytelling: Traveling While Black

Key feature: Emotional Storytelling

Emotional storytelling in VR harnesses the power of personal narratives and emotional experiences to create a profound connection between the learner and the subject matter. This immersive approach goes beyond mere information delivery, allowing users to experience and feel the emotions of others. By incorporating real-life situations and challenges individuals face—such as living with a disability, experiencing homelessness, or confronting discrimination—VR storytelling can foster empathy and a deeper understanding of complex social issues.

Emotional storytelling is particularly effective in developing empathy as it places users in scenarios where they can witness firsthand the struggles and triumphs of others. This method

is invaluable in subjects such as social studies, literature, and history, where understanding diverse perspectives and human experiences is crucial. By emotionally engaging with the content, students are more likely to retain information and develop a nuanced understanding of the studied topics.

About the experience

Traveling While Black, produced by Felix & Paul Studios, is a compelling VR experience that explores the history of restricted movement for Black Americans and the creation of safe spaces in their communities. Through powerful narratives, it challenges our understanding of race in America.

Users embark on a journey highlighting the struggles and resilience of Black Americans facing racial prejudice. The experience starts with the Green Book, a guide for safe travel during segregation, and moves to contemporary accounts of navigating racial biases.

This interactive and emotional VR simulation provides a visceral understanding of past and present challenges for minority travelers, sparking critical dialogue about race, memory, and the ongoing fight for equality and justice.



Figure 4 – From Traveling While Black VR

Potential Impact on Learning

Integrating VR experiences like Traveling While Black into traditional educational settings can enhance learning outcomes for secondary school students in the following ways:

- **Enhanced Empathy and Emotional Engagement:** Emotional storytelling in VR captures students' attention and engages them deeply. Experiencing personal stories and challenges helps students develop empathy and understand diverse perspectives. Traveling While Black enhances this by letting users sit across from storytellers, making eye contact. This emotional engagement fosters a compassionate and inclusive mindset.
- **Deeper Understanding of Social Issues:** VR allows students to explore complex social issues in a nuanced and detailed manner. Traveling While Black provides an immersive look at the historical and contemporary challenges faced by Black Americans, helping students connect these experiences with broader social and historical contexts. This comprehensive understanding is essential for grasping the intricacies of race relations and social justice.
- **Critical Thinking and Reflection:** VR encourages critical thinking and reflection by immersing students in real-life scenarios. Students are prompted to consider multiple viewpoints, understand different motivations, and analyse the social and historical factors contributing to discrimination and inequality. This analytical approach helps develop higher-order thinking skills and promotes thoughtful discussions.
- **Enhanced Emotional Recall:** VR's immersive nature and storytelling's emotional impact make information more memorable. Students who engage with VR experiences like Traveling While Black are likely to retain the lessons learned and recall the emotional narratives long after the experience. This improved retention supports deeper learning and long-term knowledge retention.
- **Encouraging Dialogue and Discussion:** VR experiences incorporating emotional storytelling encourage students to engage in meaningful dialogues about sensitive topics. Traveling While Black provides a safe space for students to discuss issues of race, discrimination, and social justice based on the experience they all collectively just had, promoting a classroom environment where difficult conversations can be had with empathy and respect.

- **Room for improvement:** Traveling While Black takes 20 minutes, which is lengthy for a non-interactive VR experience that seldomly benefits from being more than 6-8 minutes in length. With a lengthy VR experience, you run the risk of nausea and disengagement.

In conclusion, Traveling While Black exemplifies the potential of emotional storytelling in VR for education. By offering an immersive, empathetic, and context-rich learning environment, VR can significantly enhance the educational experience for secondary school students. When used alongside traditional teaching methods and teacher-student interactions, VR can provide a comprehensive and engaging approach to learning that prepares students for a deeper understanding of complex social issues and fosters a more empathetic and inclusive worldview.

3.5 Virtual Field Trips: Space Explorers

Key feature: Virtual Field Trips

Virtual field trips enable students to visit remote or inaccessible locations, ranging from ancient historical sites to distant planets. This immersive technology exposes students to diverse cultures, ecosystems, and realities, thereby deepening their understanding of the subject matter and generating empathy. VR field trips make education more tangible and engaging by providing a virtual presence in places they might never physically visit. This feature is particularly valuable in subjects like geography, history, and science, where firsthand experience of locations can greatly enhance comprehension and interest.

For example, in geography, students can virtually explore different landscapes and understand geographical features up close. In history, they can visit ancient ruins or historical battlefields, gaining insights into historical events and cultures. In science, students can travel to distant planets or the depths of the ocean, experiencing phenomena that are otherwise beyond reach.

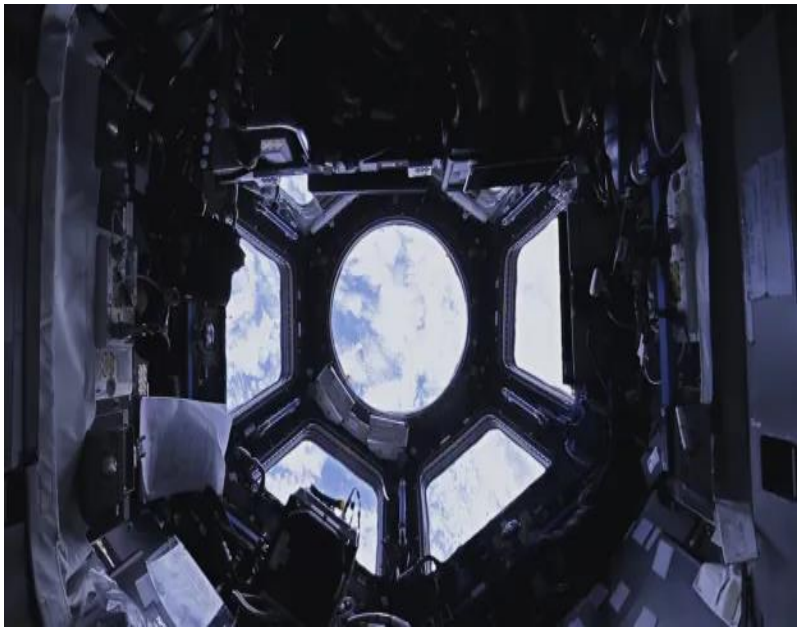


Figure 5 – From Space Explorers VR

About the experiences

Space Explorers, produced by Felix & Paul Studios, is a virtual reality experience that brings the wonders of space travel to the classroom. This VR experience allows users to visit the International Space Station (ISS) and embark on a transformative journey filmed in outer space using specialized made-for-space 3D 360° VR cameras.

In Space Explorers, students are transported to the ISS, where they can observe astronauts conducting experiments, performing spacewalks, and living in microgravity. The experience offers stunning visuals of Earth from space and provides insights into the daily life and challenges faced by astronauts. This immersive experience highlights the technological marvels of space travel and emphasises the collaborative efforts of international space missions.

Potential Impact on Learning

Integrating virtual field trips like Space Explorers into traditional educational settings can significantly enhance learning outcomes for secondary school students in the following areas:

- **Enhanced Engagement:** Virtual field trips capture students' attention by providing a vivid and engaging way to explore new locations. By experiencing these places firsthand, students are more likely to retain information and develop a deeper understanding of the subject matter.
- **Broadened Perspectives and Empathy:** Virtual field trips expose students to diverse cultures, environments, and perspectives. This exposure helps students develop empathy and a broader understanding of the world. For instance, seeing the living conditions on the ISS can foster a sense of global citizenship and interconnectedness.
- **Contextual Understanding:** VR allows students to explore contexts that are difficult to convey through traditional methods. Space Explorers provides a unique insight into space travel and the life of astronauts, which helps students connect theoretical knowledge with real-world applications.
- **Critical Thinking and Analysis:** By immersing students in different environments, VR encourages critical thinking and analysis. Students can compare and contrast different locations, analyse environmental changes, and consider the impact of human activities on the planet. This analytical approach helps develop higher-order thinking skills.
- **Real-World Applications:** Virtual field trips bridge the gap between theoretical knowledge and real-world applications. For example, Space Explorers can inspire interest in STEM fields by showcasing the real-life applications of science and technology in space exploration.

In conclusion, Space Explorers exemplifies context-rich and interactive learning environments that can enhance the educational experience for secondary school students. When used alongside traditional teaching methods and teacher-student interactions, site-specific VR and time travels can provide comprehensive and engaging approaches to learning that prepare students for a deeper understanding of diverse cultures, environments, and scientific phenomena.

3.6 Collaborative Environments: MultiBrush

Key feature: Collaborative Environments

VR platforms that support multi-user environments provide an innovative way for students to collaborate on projects and explore learning materials together, even when they are physically distant. This fosters a sense of community and enhances student collaboration, communication skills, and empathy. Collaborative VR environments allow for real-time interaction, idea sharing, and collective problem-solving, making learning a more dynamic and engaging experience. These platforms are particularly effective in subjects that benefit from teamwork, such as art, design, science, and social studies.

In collaborative environments, students can collaborate on complex projects, share insights and feedback, and learn from each other's perspectives. This type of interaction enhances their understanding of the subject matter and develops important soft skills like teamwork, leadership, and effective communication.



Figure 6 – From Google TiltBrush

About the experiences

MultiBrush is building on the foundation of TiltBrush produced by Google, and is a globally-renowned VR application that functions as a 3D makerspace, allowing users to paint and create art in a virtual or mixed reality room. Users can choose from a multitude of creative tools and paint with light, color, and texture, creating immersive and intricate artworks. TiltBrush transforms the traditional canvas into a three-dimensional space, offering artists

and students a new dimension of creative expression. Multibrush adds a multiplayer dimension to the art application, fostering collaboration and co-creation among users. In MultiBrush, multiple users can join the same virtual space, share the canvas, and collaborate on artistic projects in real-time. This multiplayer functionality enhances the social aspect of VR, allowing users to interact, share ideas, and work together regardless of their physical locations.

Potential Impact on Learning

Integrating collaborative VR environments like MultiBrush into traditional educational settings can impact learning outcomes for secondary school students in the following ways:

- **Enhanced Engagement and Creativity:** Collaborative VR environments capture students' attention by providing a platform for creative expression and teamwork. By working together in a virtual space, students can experiment with ideas, create complex projects, and learn from each other's creative processes. This enhances their engagement and fosters a greater interest for learning.
- **Improved Communication and Social Skills:** Collaborative VR platforms encourage students to communicate effectively, share ideas, and provide constructive feedback. These interactions help develop important social skills, such as active listening, empathy, and teamwork. Students learn to work collaboratively, respect different perspectives, and build a sense of community.
- **Deeper Understanding of Subject Matter:** By collaborating on projects and sharing insights, students gain a deeper understanding of the subject matter. In art classes, for example, they can explore different artistic techniques and styles, learn about color theory and composition, and create intricate artworks together. In science, they can work on virtual experiments and simulations, enhancing their comprehension of complex concepts.
- **Diverse Learning Styles:** Visual learners benefit from the immersive visualisations, auditory learners from the interactive discussions, and kinesthetic learners from the hands-on activities. This inclusivity ensures that a broader range of students can benefit from the educational content.
- **Development of Soft Skills:** Collaborative VR environments help students develop essential soft skills such as teamwork, leadership, problem-solving, and time management. By working together on projects, students learn to delegate tasks,

manage their time effectively, and solve problems collaboratively. These skills are crucial for their future academic and professional success.

- **Enhanced Empathy and Cultural Awareness:** Collaborative VR platforms allow students from various backgrounds to interact and work together. The online environment facilitates a place to collaborate with peers from different regions, and students gain a broader perspective on the world and learn to appreciate diverse viewpoints.
- **Real-World Applications:** Collaborative VR environments bridge the gap between theoretical knowledge and real-world applications. For instance, in design and engineering classes, students can collaborate on virtual prototypes and simulations, gaining practical experience that is directly applicable to real-world scenarios. This hands-on experience enhances their understanding and prepares them for future careers.

In conclusion, TiltBrush and MultiBrush offer an immersive, interactive, and socially engaging learning environment that prepares students for a deeper understanding of the subject matter, fosters creativity and collaboration, and develops essential soft skills.

3.7 Feedback and Assessment: Keep Talking and Nobody Explodes

Key feature: Feedback and Assessment

VR applications that provide immediate feedback on actions or decisions enable students to learn from their mistakes in a safe environment. This feature is particularly effective in areas such as vocational training, language learning, and any subject where practical skills are being developed. Immediate feedback helps students understand the consequences of their actions, correct errors, and reinforce learning through practise. This continuous loop of action and feedback accelerates skill acquisition and enhances learning outcomes.

For instance, in vocational training, VR can simulate real-world scenarios where students can practice their skills and receive instant feedback on their performance. VR applications can provide immediate corrections and suggestions in language learning, helping students improve their pronunciation, grammar, and conversational skills. This interactive and responsive approach to learning ensures that students remain engaged and motivated.



Figure 7 – From Keep Talking and Nobody Explodes

About the experience

Produced by Steel Crate Games, Keep Talking and Nobody Explodes is a collaborative VR game that, although not originally designed for educational purposes, can be effectively adapted for language learning. In this game, a group of players outside the headset provides instructions on defusing a bomb, while a single player wearing the headset must carry out these instructions. The game's success relies heavily on clear and precise communication between the players.

By switching the language used in the game, Keep Talking and Nobody Explodes becomes an excellent tool for practicing communication in foreign languages. Players must convey complex instructions, listen carefully, and respond accurately, making it an ideal environment for developing language skills. The game's immediate feedback mechanism allows players to see the consequences of their communication efforts in real-time, reinforcing learning through practical application.

Potential Impact on Learning

Integrating VR experiences like Keep Talking and Nobody Explodes into traditional educational settings can significantly enhance learning outcomes for secondary school students in the following ways:

- **Enhanced Engagement and Motivation:** By participating in a collaborative, communicati ve, and dynamic game, students are more likely to stay motivated and interested in the subject matter.
- **Immediate Feedback and Skill Improvement:** VR applications that provide immediate feedback help students quickly identify and correct their mistakes. In Keep Talking and Nobody Explodes, students receive real-time feedback on their communication skills, allowing them to make adjustments and improve their language proficiency effectively. This continuous feedback loop accelerates learning and skill acquisition.
- **Practical Application of Language Skills:** The game's format requires students to use their language skills in a practical and meaningful context. By communicating instructions and following directions, students practise their speaking, listening, and comprehension skills in a real-world scenario. This practical application reinforces learning and helps students develop confidence in their language abilities.
- **Development of Critical Thinking and Problem-Solving Skills:** The collaborative nature of the game encourages students to think critically and solve problems together. Players must analyze the instructions, communicate effectively, and make quick decisions to defuse the bomb. This process helps develop higher-order thinking skills and promotes teamwork and collaboration.
- **Diverse Learning Styles:** VR caters to various learning styles, making it an inclusive tool for education. Visual learners benefit from the immersive visual elements, auditory learners from the communication and listening tasks, and kinesthetic learners from the interactive nature of the game. This inclusivity ensures that a broader range of students can benefit from the educational content.
- **Real-World Applications:** The skills developed in VR games like Keep Talking and Nobody Explodes have real-world applications. Effective communication, critical thinking, and problem-solving are essential skills in any language and can be applied in various professional and personal contexts. By practicing these skills in a safe and controlled environment, students are better prepared for real-world challenges.
- **Room for improvement:** As this experience is not originally created as a learning application there are several aspects that could be improved. The timing of different interactions can be adjusted as well of integration of different languages in the actual experience.

In conclusion, Keep Talking and Nobody Explodes exemplifies the potential of feedback and assessment in VR for education. By offering an immersive, interactive, and feedback-rich learning environment, VR can enhance understanding of practical skills, foster effective communication, and develop critical thinking abilities when used alongside traditional teaching methods and teacher-student interactions.

3.8 Emotional Engagement through Sensory Immersion: Notes on Blindness

Key feature: Emotional Engagement through Sensory Immersion

VR has the ability to engage multiple senses—sight, sound, and sometimes even touch through haptic feedback. This sensory immersion can create deep emotional connections to the learning material, making experiences more memorable and impactful. By fully engaging the senses, VR can transport students into different environments and perspectives, enhancing their understanding and empathy. This feature is particularly effective in subjects where emotional engagement is crucial, such as literature, social studies, and health education. For instance, in literature, students can immerse themselves in the world of a novel, experiencing the story from the protagonist's point of view. In social studies, they can step into the shoes of individuals from different cultures or historical periods. Health education can benefit from VR by simulating experiences of living with disabilities or chronic illnesses, fostering empathy and understanding.

About the experience

Produced by Novelab and Atlas V, Notes on Blindness is an immersive VR experience that tells the story of John M. Hull, a writer and theologian who became totally blind after decades of steadily deteriorating vision. During his transition to blindness, Hull began documenting his experiences on audio cassettes. These original recordings form the basis of this interactive, cognitive, and emotional experience of blindness.

Notes on Blindness uses movement tracking, spatialized sound, and controller interactions to create a deeply immersive experience. Users are guided through Hull's world, experiencing the transformation of his sensory perceptions as his vision fades. The VR experience replicates the auditory and tactile sensations Hull described, allowing users to understand and feel the emotional and cognitive impact of blindness.



Figure 8 – From Notes on Blindness

Potential Impact on Learning

Integrating VR experiences like Notes on Blindness into traditional educational settings can enhance learning outcomes by enhancing engagement and emotional connection in the following ways:

- **Enhanced Engagement and Retention:** Sensory immersion in VR captures students' attention and makes learning experiences more memorable. By engaging multiple senses, VR helps students retain information more effectively. Experiencing the world as John M. Hull did can leave a lasting impression, helping students understand and remember the challenges of blindness.
- **Deep Emotional Connection and Empathy:** VR's ability to simulate real-life experiences fosters deep emotional connections and empathy. Notes on Blindness allows students to experience the world from the perspective of a person who is blind, helping them develop a profound understanding of the emotional and practical challenges faced by individuals with visual impairments.

- **Contextual Understanding:** VR allows students to explore complex concepts in a detailed and nuanced manner. Notes on Blindness provides an immersive look at the cognitive and emotional aspects of blindness, helping students connect theoretical knowledge with real-world experiences. This contextual understanding is crucial for subjects like psychology, health education, and social studies.
- **Diverse Learning Styles:** VR caters to various learning styles, making it an inclusive tool for education. Visual learners benefit from the visual elements, auditory learners from the spatialized sound, and kinesthetic learners from the interactive aspects. This inclusivity ensures that a broader range of students can benefit from the educational content.
- **Critical Thinking and Reflection:** VR encourages critical thinking and reflection by immersing students in different perspectives. Students are prompted to consider the impact of sensory impairments on daily life and reflect on their own perceptions and biases. This analytical approach helps develop higher-order thinking skills and promotes thoughtful discussions.
- **Real-World Applications:** Sensory immersion in VR can bridge the gap between theoretical knowledge and real-world applications. Experiencing blindness through Notes on Blindness can enhance students' understanding of accessibility and inclusion, preparing them to advocate for and support individuals with disabilities in their communities and future careers.
- **Room for improvement:** The experience takes 26 minutes, which increases the risk of nausea and other discomfort from wearing a VR headset for so long.

In conclusion, Notes on Blindness exemplifies the transformative potential of emotional engagement through immersion. By offering an immersive, empathetic, and context-rich learning environment, it can provide a comprehensive and engaging approach to learning that prepares students for a deeper understanding of complex human experiences and fosters empathy, critical thinking, and real-world application skills.

3.9 Personalised Learning Paths: Mondly

Key feature: Personalised Learning Paths

VR can offer customised learning experiences that adapt to the learner's pace, interests, and learning style. By addressing individual needs and preferences, personalised learning paths in VR can significantly increase student motivation and improve learning outcomes. This tailored approach ensures that each student receives the appropriate level of challenge and support, fostering a more effective and engaging educational experience. Personalised learning paths are particularly beneficial in language learning, vocational training, and any subject where individual progression is crucial. By providing adaptive content and feedback, VR can help students stay motivated and achieve their learning goals more efficiently.



Figure 9 – From Mondly VR

About the experience

Mondly has emerged as a leading platform for language learning in VR. Its captivating and interactive approach transports learners into immersive simulated environments, enabling them to engage in lifelike conversations, refine their pronunciation, and expand their vocabulary. Mondly VR uses cutting-edge speech recognition technology to provide instant

feedback, helping learners improve their language skills in real-time. The platform's gamified lessons and visually appealing virtual scenarios transform the language acquisition journey into an engaging and enjoyable personalised experience. Currently, Mondly VR offers learners a choice of 30 languages to explore, making it a versatile tool for diverse linguistic needs.

Potential Impact on Learning

Integrating personalised VR learning experiences like Mondly VR into traditional educational settings can enhance learning outcomes for secondary school students in the following ways:

- **Increased Motivation and Engagement:** Personalised learning paths capture students' attention by providing content that is relevant to their interests and learning styles. In Mondly VR, the immersive and interactive language lessons keep students motivated and engaged. Engage's customizable lessons and interactive environment make learning more dynamic and enjoyable.
- **Tailored Learning Experiences:** VR can adapt to the learner's pace and level, ensuring that each student receives the appropriate level of challenge and support. Mondly VR's speech recognition technology provides instant feedback, helping learners refine their pronunciation and language skills. Engage allows teachers to create tailored lessons that address specific learning objectives and student needs
- **Enhanced Understanding:** Personalised learning paths in VR enhance retention and understanding by allowing students to interact with content in meaningful ways. In Mondly VR, learners practise language skills in lifelike scenarios, making the learning experience more memorable. Engage's use of custom virtual objects and interactive lessons help reinforce concepts and improve comprehension.
- **Development of Practical Skills:** VR's immersive environments provide a safe space for students to practise and develop practical skills. Mondly VR enables learners to engage in real-life conversations, improving their fluency and confidence in the target language. Engage allows students to participate in interactive lessons and simulations, enhancing their hands-on learning experience.
- **Flexibility and Accessibility:** VR platforms like Mondly offer flexibility and accessibility, allowing students to learn at their own pace and from any location. This flexibility is particularly beneficial for students with different learning needs or those who require additional support outside of traditional classroom hours.

In conclusion, Mondly VR exemplifies tailored, interactive, and context-rich learning environments that provide an engaging approach to learning that fosters motivation and engagement and develops practical skills.

3.10 Visualisation of Complex Concepts: GeoGebra

Key feature: Visualisation of Complex Concepts

Immersion through VR and Augmented Reality (AR) excels at making abstract or complex concepts tangible, providing concrete representations of ideas that are often difficult to grasp through text or lectures alone. This immersive visualisation aids comprehension by allowing students to interact with and manipulate complex concepts in a three-dimensional space. Whether visualising geometric shapes in math, molecular structures in chemistry, or historical events in 3D, these visual tools enhance understanding and make learning more engaging and accessible.

For instance, in mathematics, students can explore geometric shapes and their properties, gaining a deeper understanding of spatial relationships and theorems. In chemistry, they can visualise and manipulate molecular structures, helping them understand how molecules interact and bond. In history, students can explore 3D reconstructions of historical events and locations, providing a more immersive understanding of historical contexts and events.

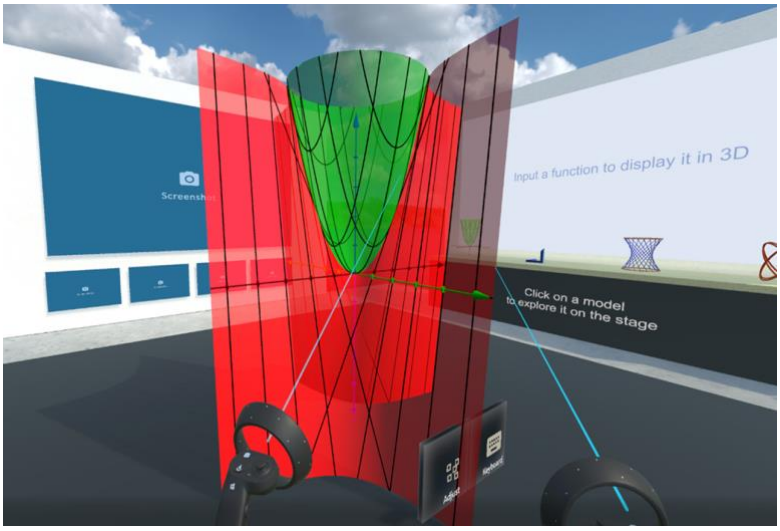


Figure 20 – GeoGebra VR

About the experiences

GeoGebra is a well-known educational technology company that has integrated AR and VR features into its computer program to revolutionise how teachers and students explore and learn about geometry. GeoGebra's platform allows users to visualise geometric shapes, functions, and other mathematical concepts in an immersive 3D environment. This integration of AR and VR features provides an innovative way for students to engage with complex mathematical ideas and enhances the traditional learning experience.

GeoGebra's VR and AR capabilities allow students to:

- Visualise geometric shapes and their properties in three dimensions.
- Manipulate shapes and observe the effects of transformations and rotations.
- Explore functions and graphs interactively, understanding their behaviour and characteristics.
- Engage with simulations that make abstract mathematical concepts more concrete and comprehensible.

Potential Impact on Learning

Integrating VR and AR experiences like GeoGebra into traditional educational settings can enhance learning outcomes for secondary school students by improving their comprehension of complex concepts in the following ways:

- **Enhanced Engagement and Interest**: VR and AR's interactive and immersive elements capture students' attention and make learning more engaging. By exploring geometric shapes and mathematical concepts in a 3D environment, students develop a greater interest in the subject matter and are more likely to stay motivated and curious.
- **Deeper Understanding of Mathematical Concepts:** Visualising complex concepts in three dimensions can help students understand and remember them more effectively. Students gain a deeper understanding of their properties and relationships by manipulating and exploring geometric shapes and functions in a virtual environment. This hands-on approach to learning helps students develop critical thinking and problem-solving skills, essential for mastering advanced mathematical concepts.
- **Diverse Learning Styles:** VR and AR cater to various learning styles, making them inclusive tools for education. Visual learners benefit from the detailed visualisations, kinesthetic learners from the interactive manipulation of shapes and graphs, and auditory learners from the accompanying explanations and feedback. This inclusivity ensures that a broader range of students can benefit from the educational content.
- **Real-World Applications:** The skills developed through immersive visualisation of complex concepts have real-world applications. Understanding geometric shapes and spatial relationships is essential in fields such as engineering, architecture, and computer science.
- **Enhanced Problem-Solving Skills:** Interactive and immersive learning environments encourage students to experiment, explore, and solve problems creatively. GeoGebra's VR and AR features allow students to test hypotheses, observe outcomes, and refine their understanding of mathematical concepts, promoting a deeper and more robust problem-solving ability.
- **Collaboration and Communication:** GeoGebra's platform allows for collaborative learning, where students can collaborate to explore and solve mathematical problems. This collaborative approach enhances communication skills and fosters a sense of teamwork and community among students.
- **Room for improvement:** While there are interactive elements in GeoGebra’s VR features it is currently mostly a visualisation tool. A lot of the spatial understanding of

mathematical concepts could potentially come from students being able to build directly in the 3D space on the same level as they currently can in the desktop version of the software.

In conclusion, GeoGebra offers a 3D, interactive, and context-rich learning environment and provides a comprehensive and engaging approach to learning that prepares students for a deeper understanding of mathematical concepts and their real-world applications.



CHAPTER 4

Concluding Remarks and Recommendations

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4. CONCLUDING REMARKS AND RECOMMENDATIONS

The realm of virtual reality in education unveils a landscape ripe with opportunities for hybrid learning experiences. As we witness the exponential growth of VR technologies, it becomes increasingly evident that the integration of immersive functionalities into educational content holds the potential to support traditional pedagogical approaches. This report's exploration into VR applications underscores how such experiences can impact secondary school students.

By leveraging functionalities like perspective shifting, first-hand POV experiences, and emotional storytelling, educators can foster empathy, deepen understanding, and ignite curiosity in diverse subjects from history to science. Experiential simulations enable students to engage with complex, far-fetched concepts hands-on, while collaborative environments foster teamwork and communication skills essential for the modern world. Moreover, the availability of platforms like YouTube VR, ClassVR, and Engage, among others, signifies a growing ecosystem supporting the availability and distribution of immersive learning experiences. As developers continue to innovate and educators embrace these technologies, there is potential for improving personalised learning paths tailored to individual preferences and learning styles.

Still, it is essential to acknowledge VR's complementary nature in education. While VR enriches the educational landscape by providing unparalleled immersive experiences, it should be viewed as a supplementary tool rather than a replacement for traditional teaching methods. The importance of direct teacher-student interaction, social dynamics, and the development of interpersonal skills cannot be overstated.

In conclusion, as VR4EMPATHY strives to bridge the gap between traditional education and digital tools, incorporating VR functionalities holds promise in enhancing learning outcomes, fostering cognitive empathy, and nurturing a generation of learners equipped to navigate an increasingly complex world. The project will introduce immersive learning resources alongside traditional teaching methods in secondary school education through collaboration, innovation, and a steadfast commitment to educational excellence.

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