VISIEN

Virtual and Immersive Solutions for Integrated Educational Needs

*VISIEN: noun (**vizh-uhn** / **vɪʒən**) ~ Foresight or planning for the future*

Integrating Immersive Technologies into Education: A REEdI Framework

The Rethinking Engineering Education in Ireland (REEdI) Project at Munster Technological University (MTU) is funded by the Higher Education Authority (HEA) Human Capital Initiative (HCI) Pillar 3 Programme.

Foreword

The **Rethinking Engineering Education in Ireland (REEdI)** project at **Munster Technological University (MTU)** advances education in Ireland by integrating Immersive Technologies like Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and Extended Reality (XR). In 2024, educators, leaders, and innovators were united to explore how these tools can transform teaching and learning through the **Virtual Immersive Reality for Transformative University Education (VIRTUE) Network**. Collaborative discussions highlighted the successful use of immersive technologies in a broad range of specialities like engineering, science, technology, architecture, sustainability, multimedia, design, and medical training, to name but a few. This showcases immersive technologies' broad applicability and potential to engage students and meet academic goals.

Recognising the need for a structured integration framework, the VIRTUE Network developed **Virtual and Immersive Solutions for Integrated Educational Needs (VISIEN)**, a strategic framework and guide to adopting and scaling immersive technologies in educational institutions. VISIEN aligns with institutional objectives, enhances student outcomes, and supports educators by addressing challenges like accessibility, scalability, and resource allocation.

Continued collaboration with educators, industry leaders, and policymakers will ensure the framework evolves into actionable strategies, ensuring **Ireland's leadership** in immersive educational innovation. This initiative is a foundation for continued dialogue and development, aiming to unlock the transformative potential of immersive technologies for education nationwide and beyond.

MTU, REEdI and the VIRTUE Network express their gratitude to contributors who made this vision possible.

Hans Moolman

REEdI Research Fellow | VIRTUE Network Community of Practice Lead

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Contents

The Rethinking Engineering Education in Ireland (REEdI) Project at Munster Technological University (MTU) is funded by the Higher Education Authority (HEA) Human Capital Initiative (HCI) Pillar 3 Programme.

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1. Introduction

Integrating immersive technologies like AR, VR, MR, and XR into Higher Education Institutions (HEIs) involves a series of steps and considerations. Each technology has different applications, hardware requirements, and cost implications. Integrating immersive technologies into educational institutions offers significant potential and requires careful planning and investment. Educational institutions must assess their educational goals, select appropriate technologies, budget for both upfront and ongoing costs, and ensure they have the necessary infrastructure and support systems in place for a successful implementation.

As technology improves and barriers to adoption – like price, availability, and internet speed disappear - the use cases for these technologies are rapidly evolving. Far from taking people out of their real-life situations, these technologies are used to give us the real world, but with an enhanced toolset. Immersive technologies have emerged as mediums that provide new ways to implement various educational solutions.

With VR's immersive interfaces, educational institutions can enhance learning experiences and improve the delivery of complex content. These technologies allow for advanced visualisation and simulation, helping students better understand abstract concepts through interactive, hands-on experiences. AR and VR offer significant value in areas such as immersive learning, virtual labs, skill-based training, remote collaboration, and knowledge retention. In education, these tools enable innovative approaches to teaching and assessment, improve student engagement and comprehension, and provide cost-effective alternatives to traditional physical resources. By simulating real-world environments and scenarios, immersive technologies prepare students for future careers while fostering creativity, problem-solving, and critical-thinking skills.

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HEIs thinking of investing in immersive technologies need to consider how to measure benefits against outcomes. They need to set concrete goals and be flexible in meeting needs while adopting different measures of success, such as search results and engagement scores. Regularly evaluating methods and carrying out user testing will help deliver a consistently positive user experience.

The objective of the VISIEN **Integration Framework** is to share the learnings from the REEdI program and research into immersive technologies as educational tools to mitigate some of the risk factors often associated with working across new mediums and cutting-edge technologies. This integration framework intends to remove some of the uncertainty around this new and evolving technology. Furthermore, it outlines what educational institutions need to consider before undertaking the integration of immersive technologies.

2. Define Educational Objectives

Aligning learning outcomes with the integration of immersive technologies ensures that these tools are not used for their novelty but to genuinely enhance teaching and learning. This alignment guarantees that the technology directly supports educational objectives, improves engagement, and provides measurable benefits to students' knowledge and skills. Without clear alignment, institutions risk investing in technologies that may not yield significant educational value, leading to wasted resources and reduced adoption by stakeholders. Successful integration of immersive technologies in educational institutions requires aligning the technology's unique capabilities with the educational needs of the subject area. Aligning learning outcomes with the use of immersive technologies maximises their impact while mitigating risks. For management, it ensures strategic and efficient resource use. For educators, it empowers teaching while introducing challenges that require training and adaptation. For students, it creates opportunities for meaningful engagement, provided issues of accessibility and usability are addressed. When alignment is well-executed, immersive technologies can be transformative, elevating education

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across disciplines By clearly linking these technologies to measurable learning objectives, educators can ensure their implementation adds meaningful value to student engagement and outcomes. For example:

Visualising Complex Concepts with AR: AR can help students explore intricate topics like human anatomy, architectural designs, or engineering models by overlaying interactive 3D visualisations onto the physical environment.

Simulating Real-World Scenarios with VR: VR creates fully immersive environments for applications such as medical training, virtual chemistry labs, or exploring controlled social science experiments, enabling safe and cost-effective experiential learning.

Blended Physical-Digital Experiences with MR: MR facilitates interactive, hands-on activities, such as conducting augmented physics experiments or enabling collaborative design workflows where digital objects interact seamlessly with real-world tools.

Extended Interactive Learning Environments with XR: XR combines AR, VR, and MR to support diverse use cases, including virtual campus tours for prospective students, collaborative research environments across disciplines, or fully immersive simulations tailored to various academic fields.

2.1 DICE and DELTA Frameworks for Immersive Technology Integration

The effective integration of immersive technologies into education requires a structured approach to identify their most impactful applications. The **DICE** and **DELTA** frameworks provide a clear methodology for assessing where these technologies can deliver significant value.

DICE focuses on defining scenarios where immersive technologies excel, ensuring their application aligns with challenges that are **Dangerous**, **Impossible**, **Counterproductive**, or **Expensive** to address through traditional methods. This framework helps institutions pinpoint use cases that maximise the safety, creativity, and cost-efficiency benefits of immersive tools.

DELTA explores how immersive technologies meet diverse educational and operational needs. It emphasises the role of immersive technology in **Design**, **Expertise & Education**, **Logistics**, **Try-Before-You-Buy**, and **Analytics**. By framing these capabilities, DELTA highlights opportunities for streamlined processes, enhanced learning experiences, and innovative problem-solving across disciplines and industries.

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Both frameworks are designed to ensure immersive technology adoption is purposeful and aligns with measurable outcomes, transforming how we learn, work, and innovate.

D-I-C-E
Defining situations where AR/VR are perfectly suited for.
DANGEROUS: Training for hazardous situations or in hazardous environments.
IMPOSSIBLE: Look inside impossible objects and explore new worlds through training.
COUNTERPRODUCTIVE: Encourage behavioural change by placing users in different scenarios e.g. body transfer for racial equality, cutting down a virtual tree encourages people to use less paper.
EXPENSIVE: Cut down travel costs, visit trade shows, etc.

D-E-L-T-A
How can AR/VR be applied to organizations' business needs?
DESIGN: Create specialized designs, reduce design times, design space in a virtual world, and partner with AI.
EXPERTISE & EDUCATION: How to assemble machinery and scale to team, remote and hands-free.
LOGISTICS: Disaster relief & warehouse management.
TRY-BEFORE-YOU-BUY: Try equipment before you buy and try recruitment before you apply (e.g. British Army Recruitment Process).
ANALYTICS: Represent complex data visually, and cross-team collaboration remotely.

3. The Role of Immersive Technologies in Education

Immersive technologies offer transformative opportunities for higher education institutions. However, their effective implementation requires careful consideration of their unique strengths, limitations, and the needs of different stakeholders. Each technology serves distinct purposes, enabling institutions to innovate in teaching, learning, and management while addressing challenges such as cost, scalability, and accessibility.

For management, these technologies enhance institutional reputation and support strategic initiatives, though they often require substantial investment in infrastructure and

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training. Educators benefit from the ability to visualise complex concepts, create engaging simulations, and foster collaborative learning, though content creation and technology adoption can present hurdles. Students gain access to interactive and immersive experiences that improve engagement and practical skills, though issues of accessibility and usability must be addressed.

By examining the benefits and challenges of immersive technologies across these groups, educational institutions can make informed decisions that maximise the educational value and transformative potential of immersive technologies.

3.1 Benefits of Integrating Immersive Technologies in Education

Immersive technologies offer transformative benefits in education, enhancing both teaching and learning experiences. These tools promote active learning by engaging students in multisensory ways, improving content retention and overall engagement. Immersive environments also broaden access to otherwise inaccessible places, processes, or phenomena, enabling experiential learning. Additionally, these technologies facilitate collaboration by encouraging teamwork in content creation and simulations, while tools like LiDAR scanners and 360-degree cameras help streamline content creation, making the development of custom educational materials more efficient and accessible. Immersive technologies enhance education by:

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3.2 Challenges of Integrating Immersive Technologies in Education

While immersive technologies hold immense potential for transforming education, several key challenges hinder their widespread adoption. These include high costs associated with devices, software, and maintenance, as well as the limited availability of quality content tailored to educational needs. Additionally, many institutions face infrastructure requirements, such as high-speed internet and advanced computing systems, that are critical for seamless implementation. Lastly, a lack of technical expertise among educators and staff presents barriers to effectively integrating and maintaining these technologies in learning environments. Addressing these challenges is essential to unlocking the full benefits of immersive tools in education.

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3.3 Immersive Technology Hardware Solutions: A Comparative Table

This table highlights the advantages and challenges of each immersive technology for managers, educators, and students in higher education.

Technology	Stakeholder	Pros	Cons
AUGMENTED REALITY	Managers	• Low cost with smartphone/tablet integration • Enhances institutional reputation for innovation	• Limited scalability without AR-enabled devices • Compatibility issues with varying hardware
	Educators	• Simplifies visualisation of	• Learning curve for content creation

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		abstract concepts (e.g., anatomy, engineering models) • Requires minimal hardware investment	• Less immersive than VR or MR
	Students	• Enhances real-world understanding through overlays • Increases engagement and interactivity	• Reliance on devices can limit focus • Less immersive compared to VR
VIRTUAL REALITY	Managers	• High-impact experiences support innovative institutional goals • Ideal for specialised training (e.g., medical simulations)	• High upfront cost for headsets and infrastructure • Requires dedicated space and technical resources
	Educators	• Ideal for simulating real-world scenarios in a safe environment • Engages students in experiential learning	• Expensive and time-consuming content creation • Potential motion sickness issues for some users
	Students	• Fully immersive learning enhances focus and retention • Safe space for practising complex or dangerous tasks	• Accessibility challenges for those without headsets • Can feel isolating compared to MR
MIXED REALITY	Managers	• Combines AR and VR benefits, offering versatile applications • Strengthens innovation portfolio	• High cost of devices (e.g., HoloLens, Magic Leap) • Requires advanced infrastructure and training

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	Educators	• Enables collaborative and interactive learning experiences • Supports real-world and digital blending	• Advanced skills needed for content creation • Limited off-the-shelf content availability
	Students	• Hands-on experiences with real-world relevance • Promotes teamwork in shared environments	• Steeper learning curve compared to AR/VR • Limited device availability can restrict adoption
EXTENDED REALITY	Managers	• Offers a holistic approach across AR, VR, and MR applications • Scalable for diverse educational initiatives	• Expensive to implement and maintain fully • Alignment with curricula can be challenging
	Educators	• Flexible tools tailored to specific objectives • Facilitates cross-disciplinary learning opportunities	• Complex to master multiple immersive technologies • Risk of misalignment with educational outcomes
	Students	• Exposure to the full spectrum of immersive tools prepares for tech-driven careers • Promotes diverse, engaging experiences	• Overwhelming for technology-inexperienced students • Accessibility barriers to comprehensive adoption

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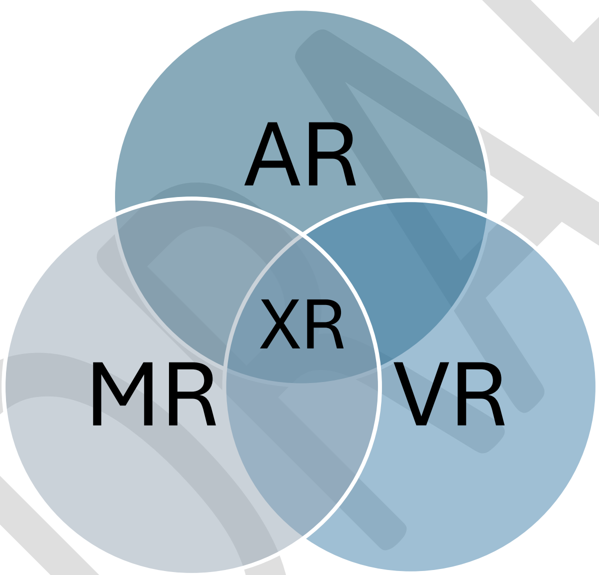
4. Fundamentals: Understanding Immersive Technologies

Immersive technologies are revolutionising the way we interact with digital content by seamlessly blending the physical and virtual worlds. These technologies offer unique capabilities: **AR** overlays digital information onto real-world environments, enhancing our understanding of complex concepts; **VR** creates fully immersive simulations that transport users to entirely virtual spaces; **MR** enables real-time interaction between physical and digital elements, creating dynamic blended experiences; and **XR** serves as an umbrella term, integrating all these technologies to deliver a continuum of immersive solutions. By understanding the distinctions and potential of each, educators, institutions, and learners can harness these tools effectively to transform teaching, learning, and collaboration across disciplines.



4.1 Augmented Reality (AR)

AR is a technology that overlays digital information and virtual objects onto the real-world environment in real time using devices like smartphones, tablets, or AR glasses, enhancing the user's perception of their surroundings. This fusion of physical and digital elements makes AR a powerful tool for immersive learning, professional training, and user engagement. AR is a view of a physical, real-world environment whose elements are augmented by computer-generated items (data, graphics, video, and sound). The real world is not blocked out, users can see the real world as well as virtual objects. AR delivers

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virtual elements as an overlay to the real world, however, interaction with virtual objects is limited.

AUGMENTED REALITY	
Core Technology	AR relies on a combination of hardware (e.g., cameras, sensors, displays) and software (e.g., computer vision, spatial mapping).
Device Types	• AR-enabled smartphones and tablets (e.g., through ARKit for iOS, ARCore for Android). • Wearable AR devices like smart glasses (e.g., Microsoft HoloLens, Magic Leap).
Display Types	AR utilises transparent displays, heads-up displays (HUDs), or screen-based augmentation through handheld devices.
Tracking	• **Marker-based AR**: Uses QR codes or specific images as triggers. • **Markerless AR**: Employs GPS, accelerometers, and gyroscopes to place digital content in real-world coordinates. • **SLAM (Simultaneous Localisation and Mapping)**: Enables AR to understand and interact with complex 3D spaces.
Data Integration	Integrates real-time data feeds for interactive and adaptive experiences.
3D Modelling	Supports digital overlays of 3D objects or animations onto physical environments.
Interactivity	Allows users to manipulate virtual objects through touch, gestures, or voice commands.
Latency	Aim for minimal delay (<20ms) to ensure seamless interaction.

4.2 Virtual Reality (VR)

VR is a fully immersive technology that creates a simulated environment, isolating users from the physical world and allowing them to interact with a computer-generated 3D space. VR's ability to transport users into entirely different environments makes it ideal for education, training, entertainment, and therapeutic applications. VR offer a digital recreation of a real-life setting and can replicate an environment, real or imagined, and simulates a user's physical presence and environment to allow for user interaction and sensory experiences. It is the most immersive experience – the real world is blocked out so users can only see the virtual world and virtual objects and are unaware of the environment around them. VR requires the user to have specialist equipment to experience it. This can

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range from cheap options like Google Cardboard to the more expensive end of the scale, like headsets from Samsung, Oculus (Meta), HTC, Pico and many more. The focus of VR activity is on experiences and emotional engagement.

<table>
<tr><th colspan="2">VIRTUAL REALITY</th></tr>
<tr><td>Core Technology</td><td>VR relies on real-time 3D rendering, spatial audio, and motion tracking to simulate immersive environments.</td></tr>
<tr><td>Device Types</td><td>Head-Mounted Displays (HMDs):
Standalone (e.g., Meta Quest 2 and 3, Pico 3 and 4, PlayStation VR).
Tethered (e.g., HTC Vive, Valve Index).
Smartphone-based (e.g., Google Cardboard, now less common).
Accessories: Controllers, haptic gloves, motion trackers, and omnidirectional treadmills enhance interaction.</td></tr>
<tr><td>Display Types</td><td>Screen-based augmentation through HMDs.</td></tr>
<tr><td>Display Quality</td><td>High-resolution screens (e.g., 4K or higher) minimise the "screen door effect".
Wide field of view (FOV), typically 100°–120°, for immersive perception.
High refresh rates (90Hz–120Hz) reduce motion sickness.</td></tr>
<tr><td>Tracking Systems</td><td>6DOF (Six Degrees of Freedom): Tracks head and body movements in three dimensions (Up/Down, Left/Right, Side to Side).
Inside-out tracking (cameras on the device) vs. outside-in tracking (external sensors).</td></tr>
<tr><td>3D Audio</td><td>Spatial sound enhances realism by mimicking directional audio sources.</td></tr>
<tr><td>Content Development</td><td>Built using engines like Unity, Unreal Engine, or WebXR for immersive and interactive experiences.</td></tr>
<tr><td>Latency and Performance</td><td>Low latency (<20ms) is critical for avoiding motion sickness.
Powerful GPU requirements for smooth and detailed environments.</td></tr>
</table>

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Interactivity	Allows interaction with virtual objects through motion controllers, hand tracking, or eye tracking.

4.3 Mixed Reality (MR)

MR is a hybrid technology that blends the physical and digital worlds, allowing real and virtual elements to coexist and interact in real-time. MR's ability to create interactive, context-aware experiences makes it a powerful tool for collaborative work, advanced simulations, and immersive education. MR refers to the combination of virtual environments and real environments that blends both AR and VR, allowing digital and physical objects to interact in real time. MR uses depth and spatial sensors to anchor interactive 3D digital elements into a user's environment. The user can easily navigate around virtual objects that will adjust for size as the user approaches them, for example. MR requires advanced sensors for spatial awareness and gesture recognition that have a nascent but growing solutions ecosystem.

MIXED REALITY	
Core Technology	MR combines the principles of AR and VR, using advanced spatial mapping and interaction models to merge digital content with the physical environment.

Device Types	• **Wearable Headsets**:
	  ○ Dedicated MR devices like Microsoft HoloLens and Magic Leap.
	  ○ MR-capable VR headsets (e.g., Meta Quest Pro or Meta Quest 3 with passthrough capabilities).
	• **Handheld Devices**: Limited MR experiences on high-end smartphones and tablets.

Display Types	• Transparent displays for holographic visuals. • High-quality colour passthrough cameras for virtual overlays on VR-like headsets.
Spatial Mapping	• Uses depth sensors, LiDAR, or cameras to map the physical environment in 3D. • Enables accurate placement of digital objects in the real world.

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Interaction Models	• Gesture-based controls using hand tracking. • Voice commands for seamless interaction with digital elements. • Eye tracking for focus-based navigation and interaction.
Tracking Systems	• Advanced SLAM (Simultaneous Localisation and Mapping) to understand and adapt to complex environments. • Room-scale tracking for freedom of movement and interaction.
Interactivity	• Real-time interaction between physical and virtual elements (e.g., manipulating a digital object resting on a real table). • Persistent digital content that remains anchored to specific locations.
Content Development	• Created using platforms like Unity (MRTK), Unreal Engine, and OpenXR. • Supports both immersive and non-immersive scenarios depending on the hardware.
Latency and Performance	• Requires ultra-low latency (<15ms) to synchronise real and digital elements effectively. • High processing power for simultaneous rendering and spatial analysis.

4.4 Extended Reality (XR)

XR is an umbrella term encompassing AR, VR, and MR, representing all immersive technologies that merge or replace the physical world with digital content, extending the user's experience in both physical and digital worlds.

EXTENDED REALITY	
Core Technology	XR integrates the hardware and software of AR, VR, and MR to provide a spectrum of immersive experiences.
Device Types	• XR-compatible devices include AR glasses, VR headsets, and MR devices.

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	• Standalone (e.g., Meta Quest) and tethered (e.g., HTC Vive Pro) headsets support XR applications.
Display Types	• Transparent displays for AR and MR. • High-resolution VR screens for fully immersive experiences. • Passthrough displays or dual-purpose devices for cross-reality functionality.
Tracking and Interaction	• Utilises 6DOF tracking for accurate head and body movement across AR, VR, and MR. • Hand tracking, voice recognition, and motion controllers for interactive elements. • Eye tracking for gaze-based navigation and enhanced focus.
Content Development	• Developed using versatile engines like Unity, Unreal Engine, and WebXR to target AR, VR, and MR experiences. • Supports cross-platform compatibility to enable seamless transitions between realities.
Latency and Performance	• Low latency (<20ms for AR/VR, <15ms for MR) is critical for realism and reducing motion sickness. • GPU-intensive processing for real-time 3D rendering, spatial mapping, and interaction.
Interactivity	• Adaptive interfaces allow dynamic transitions between immersive (VR) and integrated (AR/MR) modes. • Persistent environments enable users to resume where they left off, regardless of device.
Applications	• Cross-domain applications in education, healthcare, design, entertainment, and training.

	• Scalable solutions for remote collaboration and hybrid physical-digital workflows.

5. Cutting Edge Hardware: Key Considerations and Trends

Selecting the right hardware is a critical step in implementing immersive technologies in higher education. Hardware choices significantly impact accessibility, cost, and the quality of experiences these technologies can deliver. Each type of immersive technology has unique hardware requirements, ranging from cost-effective solutions like smartphones to advanced devices like mixed-reality headsets.

Institutions must balance affordability with functionality to ensure that the chosen hardware aligns with educational goals and institutional capacity. While some options, such as smartphone-based AR or mobile VR headsets, provide an accessible entry point, more advanced devices like tethered VR systems or mixed-reality glasses enable richer and more immersive experiences at a higher cost. Understanding the range of available hardware and their associated costs helps institutions plan effectively for scalable and impactful integration of immersive technologies.

These headsets represent the cutting edge of immersive technology, with options catering to both enterprise and consumer markets across AR, VR, MR, and XR. Each device has its strengths and trade-offs, depending on the specific use case, whether it be for education, industrial applications, professional training, or productivity.

Many of these headsets, particularly AR and MR devices, require developer licenses for creating or testing custom applications. Some devices, particularly enterprise-focused AR/MR headsets like HoloLens 2, Magic Leap 2, and Varjo XR-3, require special business licenses for commercial deployment. For consumer-oriented headsets like Oculus Quest 3 or Meta Quest Pro, licenses are generally not mandatory but are available for developers.

5.1 AR Head-Mounted Displays

AR hardware ranges from accessible smartphone-based solutions to advanced standalone **Head-Mounted Displays** (**HMDs**). Each category serves distinct purposes, from basic interactions to professional-grade simulations. AR technologies are emerging as transformative tools across educational and enterprise landscapes. They enable interactive, real-time overlays of information, enhancing learning, training, and

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productivity. By understanding the capabilities and constraints of AR hardware, educational institutions can select suitable devices for their unique needs. Continued collaboration with industry partners will be essential for expanding content ecosystems and addressing cost barriers to make AR more accessible.

5.1.1 Summary of AR Devices

The table below summarises key AR devices (at the time of publication), highlighting their strengths, limitations, and ideal use cases.

AUGMENTED REALITY HMDs

Device	Type	Cost (€)	Pros	Cons	Licensing
Microsoft HoloLens 2	AR/MR	3,500	Exceptional hand-tracking, enterprise integration, ergonomic design	High cost, limited field of view (52°), short battery life	Enterprise licenses (e.g., Microsoft Dynamics 365)
Magic Leap 2	AR/MR	3,299	Wide field of view (70°), superior visuals, lightweight design	Expensive, limited consumer content	Developer licenses
Google Glass Enterprise 2	AR	999	Lightweight, hands-free for industrial tasks	Limited AR functionality, small display	Custom industry-specific licenses
Vuzix Blade Upgraded	AR	800-1,000	Affordable, voice command functionality, portable	Smaller field of view, less powerful than premium devices	General and commercial licenses

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Epson Moverio BT-40	AR	699	Affordable, 1080p display, compatible with multiple devices	Primarily display-focused, limited interaction capabilities	No specific licenses required
Smartphones/Tablets	AR	Free-1,000	Widely accessible, extensive app ecosystem	Limited immersion, dependent on device quality	App-based subscriptions (varies)

5.1.2 Key AR Devices in Detail

Key devices enabling immersive technologies in education, from high-end AR/MR headsets like Microsoft HoloLens 2 to accessible tools like smartphones. Each device's features, applications, and challenges are outlined, helping educators and institutions choose the right tools to enhance learning outcomes effectively.

KEY DEVICES IN DETAIL

DEVICES	OVERVIEW	APPLICATIONS	CHALLENGES
Microsoft HoloLens 2	A premium AR/MR device designed for enterprise environments, featuring precise spatial mapping and integration with the Microsoft ecosystem.	Remote training, design visualisation, and medical simulations.	High cost and technical expertise are required for setup.
Magic Leap 2	Advanced AR headset with improved visuals and ergonomics, targeting developers and businesses.	Industrial prototyping, AR-enhanced product design, and interactive	Expensive with a maturing ecosystem.

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		educational content.	
Google Glass Enterprise 2	Lightweight AR glasses suited for industrial workflows, focusing on hands-free operation.	Manufacturing, logistics, and workflow optimisation.	Limited immersive capabilities.
Vuzix Blade Upgraded	Compact and affordable AR glasses designed for remote assistance and industrial use.	On-the-job training and real-time task support.	Smaller field of view and less computational power.
Epson Moverio BT-40	Cost-effective AR glasses provide basic augmented display features.	Basic AR tasks, such as information overlays in museums or exhibitions.	Limited advanced interaction.
Smartphones and/or Tablets	The most accessible entry point to AR, leveraging existing devices for AR applications.	Education, retail, and entertainment.	Limited immersive potential and dependent on hardware quality.

5.1.3 Emerging Trends and Use Cases

Emerging trends and practical applications of AR across key domains. In education, AR enhances interactive learning and medical simulations. In industry, devices like Magic Leap and Google Glass streamline training, troubleshooting, and workflows. Public engagement benefits from affordable AR tools in tourism and exhibitions, making immersive experiences widely accessible.

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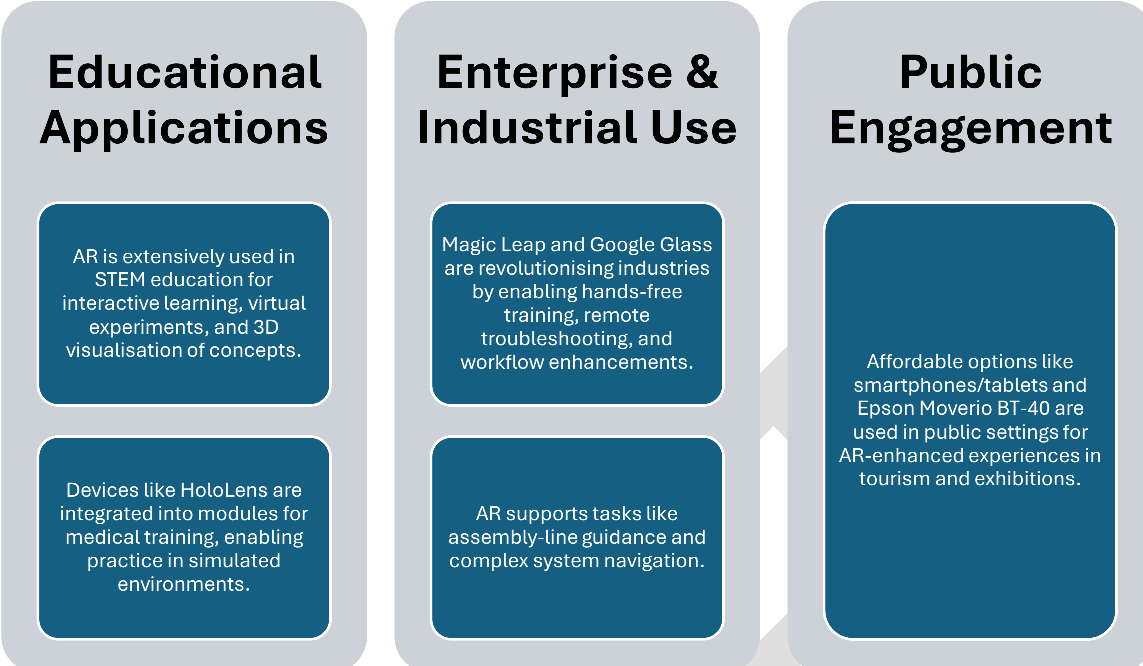

5.2 VR Head-Mounted Displays

Immersive technologies, particularly VR and related hardware, are reshaping educational landscapes globally. As these technologies advance, their integration into educational frameworks is becoming a focal point for institutions aiming to enhance engagement, learning outcomes, and skill development. The following section highlights the current state-of-the-art practical implementations, focusing on VR Headsets. Modern VR headsets vary in functionality, cost, and usability, serving diverse educational needs from casual exploratory learning to professional-grade applications. A comparative overview is provided to understand the capabilities, limitations, and suitability of leading hardware options.

5.2.1 Summary of VR Devices

The table below summarises key VR devices (at the time of publication), highlighting their strengths, limitations, and ideal use cases.

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VIRTUAL REALITY HMDs

Device	Type	Cost (€)	Pros	Cons	Licensing
Meta Quest 3	Standalone	550	Affordable, no PC/console needed, high resolution (2064x2208 per eye), lightweight	Limited for high-end gaming, requires Meta account	General licenses for apps/games
Valve Index	Tethered	1080	Superior tracking, high refresh rate (120-144Hz), excellent controllers	Requires a powerful PC, external sensors complicate setup	SteamVR games only
HTC Vive Pro 2	Tethered	475	Enterprise-grade tracking, high resolution (2448x2448 per eye)	Expensive, complex setup with external base stations	Vive Enterprise licenses for business use
HP Reverb G2	Tethered	1150	Best resolution for price (2160x2160 per eye), comfortable	Mediocre tracking compared to Valve Index	Windows Mixed Reality or SteamVR
Pico 4	Standalone	409	Lightweight, affordable, high resolution	Limited developer community, immature software ecosystem	Business licenses for enterprise use

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Sony PlayStation VR2	Console-based	637	Great for PlayStation 5, console gaming	Limited to PlayStation games, not suitable for educational diversity	No specific licensing

5.2.2 Key VR Devices in Detail

An in-depth overview of key VR headsets shaping immersive education and training. Each device is evaluated for its capabilities, applications, and limitations, helping educators and institutions select the most suitable technology for their needs. From standalone options like Meta Quest 3 and Pico 4 to advanced systems like Valve Index and HTC Vive Pro 2, these devices cater to a range of use cases, including simulations, soft-skills training, and specialised academic modules.

KEY DEVICES IN DETAIL

DEVICES	OVERVIEW	APPLICATIONS	CHALLENGES
Meta Quest 3	Ideal for immersive learning modules requiring standalone functionality. Lightweight and affordable for institutional use.	Effective for AR functionalities and moderate VR experiences like soft-skills training or interactive classrooms.	Performance lags behind tethered systems for high-fidelity simulations.
Valve Index	Exceptional tracking and visual quality make it ideal for complex simulations in engineering or healthcare education.	Advanced VR labs, engineering prototyping, and research.	High cost and setup complexity.

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HTC Vive Pro 2	Favoured in enterprise environments due to precision and resolution.	Used in professional training scenarios such as medical and industrial skill development.	High cost and challenging setup.
HP Reverb G2	Provides a balance of resolution and affordability for simulation-heavy applications.	Excellent for flight simulations, architecture, or environmental sciences.	Tracking precision is less than headsets with external sensors.
Pico 4	Low-cost alternative for standalone VR.	Suitable for institutions beginning to explore VR.	Lacks the content ecosystem of Meta or SteamVR platforms.
Sony PlayStation VR2	Accessible for educational settings focused on PlayStation ecosystems.	Targeted VR for gaming-related modules or creative media studies.	Limited to console applications, reducing flexibility for diverse educational use.

5.2.3 Emerging Trends and Use Cases

Emerging applications of VR, from enhancing STEM learning to streamlining industrial workflows and creating immersive public experiences, VR is transforming diverse sectors with its innovative capabilities.

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Educational Applications

- VR enables interactive STEM education, virtual experiments, and 3D visualisation of complex concepts.
- Devices like HoloLens are integrated into medical training, providing simulated environments for practical learning.

Enterprise & Industrial Use

- Magic Leap and Google Glass revolutionise workflows by enabling hands-free training, remote troubleshooting, and system navigation.
- VR supports complex tasks such as assembly-line guidance and operational efficiency.

Public Engagement

- Affordable VR tools, like smartphones, tablets, and Epson Moverio BT-40, enhance visitor experiences in tourism and exhibitions.
- These applications make immersive technology widely accessible to audiences.

5.3 MR Head-Mounted Displays

MR technologies are emerging as powerful tools that bridge the gap between physical and virtual worlds. These devices combine elements of AR and VR, offering users interactive and immersive environments for education, training, and professional applications. MR headsets are designed to cater to professional, educational, and enterprise needs. By providing seamless integration of digital content with real-world environments, MR HMDs are driving innovation across education and enterprise. Continued advancements in affordability and content ecosystems will make MR technologies increasingly accessible and impactful in diverse applications.

5.3.1 Summary of MR Devices

The table below summarises key MR devices (at the time of publication), highlighting their strengths, limitations, and ideal use cases.

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MIXED REALITY HMDs

Device	Type	Cost (€)	Pros	Cons	Licensing
Microsoft HoloLens 2	MR, AR	3,500	Advanced hand-tracking, professional-grade MR features	High-cost, limited consumer apps	Enterprise licenses (e.g., Microsoft Dynamics 365)
Magic Leap 2	MR, AR	3,299	Superior field of view (70°), lightweight design	Expensive, smaller app ecosystem	Developer licenses
Meta Quest Pro	MR, VR	999	Versatile for productivity and immersive applications	Mixed reality features still evolving	Optional developer licenses
Varjo XR-3	MR, XR	5,495/year	Best-in-class visual fidelity, ideal for simulations	Very expensive, requires high-end PC	Professional licenses
Lynx R-1	MR, AR	849	Affordable, open-source, versatile for developers	Limited software ecosystem, lower resolution	Developer or commercial licenses
HTC Vive XR Elite	MR, VR, XR	1,099	Lightweight, supports both VR and MR	Limited software ecosystem, lower field of view	Viveport platform licenses for enterprise use

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5.3.2 Key MR Devices in Detail

Examining leading MR headsets, highlighting their features, applications, and challenges. These devices bridge the gap between AR and VR, enabling advanced simulations, collaborative training, and interactive learning experiences. From enterprise-grade options like Microsoft HoloLens 2 and Varjo XR-3 to versatile models like Meta Quest Pro and HTC Vive XR Elite, this guide offers insights into their potential for education, research, and industry use.

KEY DEVICES IN DETAIL

DEVICES	OVERVIEW	APPLICATIONS	CHALLENGES
Microsoft HoloLens 2	A flagship MR device blending AR and VR functionalities with excellent hand-tracking and spatial mapping.	Enterprise-focused tasks like remote collaboration, advanced simulations, and interactive training modules.	High initial cost and expertise needed for content creation.
Magic Leap 2	Known for its wide field of view and enhanced visualisation capabilities, Magic Leap 2 targets professionals in design, healthcare, and engineering.	3D prototyping, surgical training, and interactive learning.	A developing ecosystem limits consumer and educational content.
Meta Quest Pro	Combines MR and VR, offering productivity tools and immersive environments at a relatively accessible price point.	Office productivity, creative design, and moderate MR experiences.	Some MR features are still under development.

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Varjo XR-3	Designed for industrial and enterprise applications, the XR-3 delivers unmatched visual fidelity.	High-end simulations, architectural visualisations, and professional-grade training.	Prohibitive cost and the need for a powerful PC setup.
Lynx R-1	Open-source MR headset offering flexibility and affordability, making it ideal for developers and experimental applications.	Educational projects, AR prototyping, and research.	Limited support compared to major brands.
HTC Vive XR Elite	A lightweight, versatile device supporting MR and VR with strong enterprise applications.	Professional training, design reviews, and collaborative environments.	Smaller field of view and a less robust software ecosystem.

5.3.3 Emerging Trends and Applications

MR headsets are transforming how we learn, work, and collaborate by merging physical and digital worlds. From interactive 3D learning experiences in classrooms to high-fidelity simulations in aerospace and healthcare, MR is unlocking new possibilities. This section explores emerging applications of MR, highlighting its growing role in enhancing engagement and innovation across sectors.

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Education

MR headsets like the HoloLens 2 are being used for immersive classroom learning, allowing students to interact with 3D models of molecules, historical sites, or engineering prototypes.

Enterprise

Devices such as Varjo XR-3 are tailored for high-stakes industries like aerospace and healthcare, providing precise simulations for training.

Research and Development

The Lynx R-1's open-source approach supports experimental MR projects in academia and industry.

Collaboration

MR facilitates remote collaboration, enabling geographically dispersed teams to interact in shared virtual spaces.

5.3.4 Feature Comparison of MR Devices

A comparative analysis of leading MR headsets. Key features such as field of view, resolution, weight, and specialised use cases are outlined to help educators, researchers, and enterprises identify the most suitable device for their specific needs, from professional MR applications to lightweight XR/VR experiences.

Feature	**HoloLens 2**	**Magic Leap 2**	**Meta Quest Pro**	**Varjo XR-3**	**Lynx R-1**	**HTC Vive XR Elite**
Field of View (°)	52	70	~70	115	90	110
Resolution (per eye)	2k	1440 x 1600	1800 x 1920	2880 x 2720	1600 x 1600	1920 x 1920
Weight (g)	566	260	722	840	360	625
Best For	Enterprise MR	Design &	Productivity & MR	Professional XR	Developers	Lightweight MR/VR

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	Trainin g				

5.4 XR Head-Mounted Displays

XR mixes requirements, balancing affordability and performance. XR headsets encompass the combined capabilities of AR, VR, and MR. These devices enable seamless transitions across immersive environments, making them versatile tools for education, enterprise, and creative applications. By providing immersive environments that blend real and virtual elements, XR technologies are expanding the boundaries of learning and professional workflows. Continued innovation in cost reduction and content development will be pivotal in making these devices accessible to a broader audience.

5.4.1 Summary of XR Devices

Designed to assist educators, developers, and enterprises, this table highlights the versatility and specialisation of each device (at the time of publication), from professional-grade solutions like Varjo XR-3 to more affordable options like Nreal Light, catering to a range of immersive technology applications.

Extended Reality Headsets

Device	**Type**	**Pros**	**Cons**	**Cost (€)**	**Licensing**
Varjo XR-3	XR, MR, VR	Industry-leading visuals, excellent for professional applications	Extremely expensive, requires high-end PC setup	5,495/year	Professional license
Meta Quest Pro	XR, MR, VR	Combines AR, VR, and MR; high resolution (1800x1920 per eye)	Expensive, limited MR ecosystem	999	Optional developer license
Microsoft HoloLens 2	XR, MR, AR	Best for enterprise XR; precise hand-tracking and spatial mapping	Expensive, enterprise focus limits consumer adoption	3,500	Enterprise and developer licenses

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Pico 4 Enterprise	XR, MR, VR	Affordable, designed for business use	Limited gaming and consumer applications	409	Business license required
HTC Vive Focus 3	XR, MR, VR	Wireless, combines VR and MR for enterprise use	Expensive for a standalone device	1,240	Viveport platform licenses
Nreal Light	XR, AR	Lightweight AR glasses with XR capabilities	Smaller field of view, limited advanced XR functionality	570	Developer and consumer licenses
Apple Vision Pro	XR, MR, VR	Premium build quality, unparalleled visual clarity (23M pixels across two displays), and seamless integration with the Apple ecosystem.	Extremely high cost, limited developer ecosystem for MR-specific content.	~3,500	App Store-based licenses.

5.4.2 Key XR Devices in Detail

From the professional-grade Varjo XR-3 with its unmatched visual fidelity to the affordable Nreal Light offering basic AR functionality, each device serves unique purposes. Versatile options like the Meta Quest Pro and HTC Vive Focus 3 cater to a mix of AR, VR, and MR applications, while enterprise-focused solutions like the Microsoft HoloLens 2 and Pico 4 Enterprise enable advanced training and collaboration. This guide helps identify the right tools for diverse educational, corporate, and industrial needs.

KEY DEVICES IN DETAIL

DEVICES	**OVERVIEW**	**APPLICATIONS**	**CHALLENGES**
Varjo XR-3	Designed for professional and industrial use, the	High-end simulations, architecture, and detailed training.	High annual subscription fee ($5,495) and demanding

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	Varjo XR-3 provides unparalleled visual fidelity (2880x2720 per eye).		hardware requirements.
Meta Quest Pro	A versatile device combining AR, VR, and MR functionalities with robust productivity tools.	Office collaboration, creative design, and training scenarios.	While offering great potential, its MR features are still maturing.
Microsoft HoloLens 2	An enterprise-focused XR device excelling in mixed reality applications with advanced spatial mapping.	Remote collaboration, medical training, and industrial workflows.	High price and limited appeal outside professional use.
Pico 4 Enterprise	An affordable, business-oriented XR headset ideal for immersive training and virtual collaboration.	Education, corporate training, and remote teamwork.	Lack of consumer-focused applications and limited software ecosystem.
HTC Vive Focus 3	Combines VR and MR in a wireless, standalone design tailored for enterprise environments.	Professional training, immersive meetings, and design visualisation.	High cost for a standalone device and reliance on HTC business services.
Nreal Light	Lightweight AR glasses offering basic XR capabilities at an affordable price point.	Information overlays, basic interactive tasks, and AR experiences.	Limited advanced functionality and smaller field of view.
Apple Vision Pro	A premium XR headset offering exceptional visual clarity (23 million pixels across two	Creative design, productivity, immersive collaboration, and	Extremely high cost (~€3,500) and a developing

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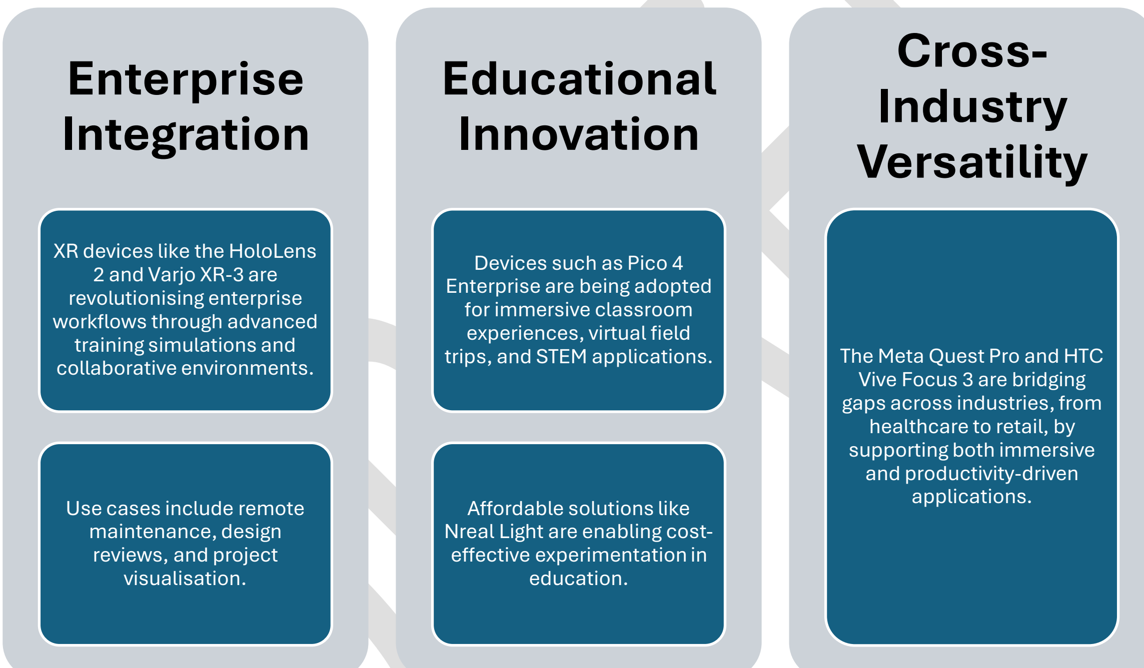
displays) and seamless integration with the Apple ecosystem.	AR-enhanced workflows.	ecosystem for MR-specific content.

5.4.3 Emerging Trends and Applications

The adoption of XR technologies is driving innovation across diverse sectors, transforming workflows, education, and industry practices. This section explores emerging trends and applications in enterprise integration, educational innovation, and cross-industry versatility. From advanced simulations and immersive classrooms to bridging industry-specific needs, XR devices are reshaping how we collaborate, learn, and innovate.



5.4.4 Feature Comparison of XR Devices

A comparative analysis of leading XR headsets. Key features such as field of view, resolution, weight, and specialised use cases are outlined to help educators, researchers, and enterprises identify the most suitable device for their specific needs, from professional XR applications to lightweight MR/VR experiences.

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Feature	**Varjo XR-3**	**Meta Quest Pro**	**HoloLens 2**	**Pico 4 Enterprise**	**HTC Vive Focus 3**	**Nreal Light**
Field of View (°)	115	~70	52	90	110	60
Resolution (per eye)	2880x2720	1800x1920	2k	3664x1920 (total)	2448x2448	1080x1080
Weight (g)	840	722	566	590	625	88
Connectivity	PC-required	Standalone	Standalone	Standalone	Standalone	Smartphone-tethered

3.5 Other

Immersive technologies extend beyond AR, VR, XR and MR to include tools like immersive rooms, touchscreens, projectors, LiDAR scanners, drones, 3D printers, and 360-degree cameras to expand the scope of immersive technology. These technologies can enhance learning environments and facilitate the creation of educational content across various disciplines.

Immersive rooms enable shared experiences using large-scale projections and interactive systems, ideal for collaborative simulations and group learning. 360 Capture cameras, often costing between €300 and €1,000, allow educators to create bespoke, location-based VR content, providing students with unique, real-world perspectives that enhance engagement and understanding. When used together, these technologies create a seamless ecosystem where physical and digital experiences converge, transforming how students learn and educators teach.

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Touch Screens

Immersive Applications: Touchscreens can serve as interactive portals to immersive experiences, allowing students to manipulate 3D models, navigate virtual environments, or engage with AR content in a collaborative setting.

Use in Education: Interactive learning stations classrooms allow students to engage with educational content in dynamic and tactile ways. These setups facilitate touch-based exploration of scientific models, such as molecular structures or engineering diagrams, enabling deeper understanding through hands-on interaction. Additionally, they support real-time collaboration on design projects or simulations, fostering teamwork and innovative problem-solving in immersive educational settings.

Content Creation: Touchscreens enable intuitive editing of digital assets, such as drawing overlays on virtual maps or annotating 3D models.

Interactive Rooms & Projectors

Immersive Applications: Advanced projectors can create large-scale immersive environments by displaying 360-degree visuals or interactive simulations on walls, floors, or domes. Immersive rooms create dynamic shared environments using large-scale projections and interactive systems, enabling students to experience virtual simulations, engage in interactive storytelling, or collaborate on group projects within a fully immersive setting.

Use in Education: Projection mapping transforms spaces into dynamic environments for historical reconstructions and cultural exhibits, bringing events and artefacts to life. Planetarium-style setups immerse students in astronomy or environmental studies, enhancing their understanding of complex concepts. Additionally, interactive group simulations enable collaborative learning in projected VR-like spaces, fostering teamwork and problem-solving in an engaging, immersive setting.

Content Creation: Projectors can be paired with motion sensors or touch-sensitive surfaces to design interactive educational content, such as virtual labs or visual storytelling.

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LiDAR Scanners

Immersive Applications: LiDAR scanners generate precise 3D models of physical environments, enabling the creation of digital twins for immersive simulations or AR applications.

Use in Education: LiDAR technology captures and digitises archaeological sites for virtual field trips, providing immersive historical exploration. It also supports urban planning and civil engineering by mapping urban areas with precision, enabling the design of infrastructure and spatial layouts. Additionally, LiDAR facilitates real-time environmental analysis for ecology, geography, and engineering applications, such as terrain modelling, structural analysis, and resource management.

Content Creation: LiDAR data can be used to design accurate 3D models for VR environments or AR overlays, enriching educational content with realistic representations of real-world locations.

Drones

Immersive Applications: Drones capture aerial perspectives and generate unique immersive content that can be integrated into educational experiences, such as virtual tours or ecological studies.

Use in Education: Drones play a vital role in education by monitoring environmental changes, such as deforestation and coastal erosion, to support science curricula. They also capture footage for virtual field trips, providing students access to remote or inaccessible locations. Additionally, drones are valuable tools for training students in aerodynamics, robotics, and operational skills, fostering hands-on learning in STEM disciplines.

Content Creation: High-resolution imagery and videos from drones can be converted into AR/VR-compatible formats or used as overlays in interactive maps and simulations.

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3D Printers

Immersive Applications: 3D printers bridge the gap between virtual design and physical creation, allowing students to turn digital models into tangible objects.

Use in Education: 3D printing enhances education by enabling the creation of anatomical models for medical studies and prototypes for engineering projects. It supports hands-on learning in design thinking and STEM disciplines, allowing students to bridge digital and physical worlds. Additionally, 3D printing facilitates the production of physical replicas of virtual objects from VR/AR experiences, enriching immersive learning and fostering creativity.

Content Creation: Students can design in VR or AR platforms and use 3D printers to bring their digital creations into the physical world, supporting iterative learning.

360-Degree Cameras

Immersive Applications: 360-degree cameras create fully immersive videos and environments, allowing students to explore real-world locations or events as if they were there.

Use in Education: 360-degree cameras enrich education by capturing environments for virtual field trips to historic landmarks or natural habitats, offering students immersive exploration opportunities. They are also used to record performances or experiments, enabling replay in immersive classrooms for enhanced understanding. Additionally, these cameras document student projects, providing valuable resources for review and collaborative learning.

Content Creation: Educators and students can use 360-degree footage to design VR experiences, AR applications, or interactive learning modules tailored to specific topics.

5.6 Key Highlights

From the enterprise-ready Microsoft HoloLens 2 for AR and MR to the cost-effective Oculus Quest 3 for VR, each device excels in its field. Advanced tools like the Varjo XR-3 for XR, Insta360 Pro 2 for 360° capture, and the Barco CAVE System for immersive group experiences represent the pinnacle of innovation in immersive education and professional applications.

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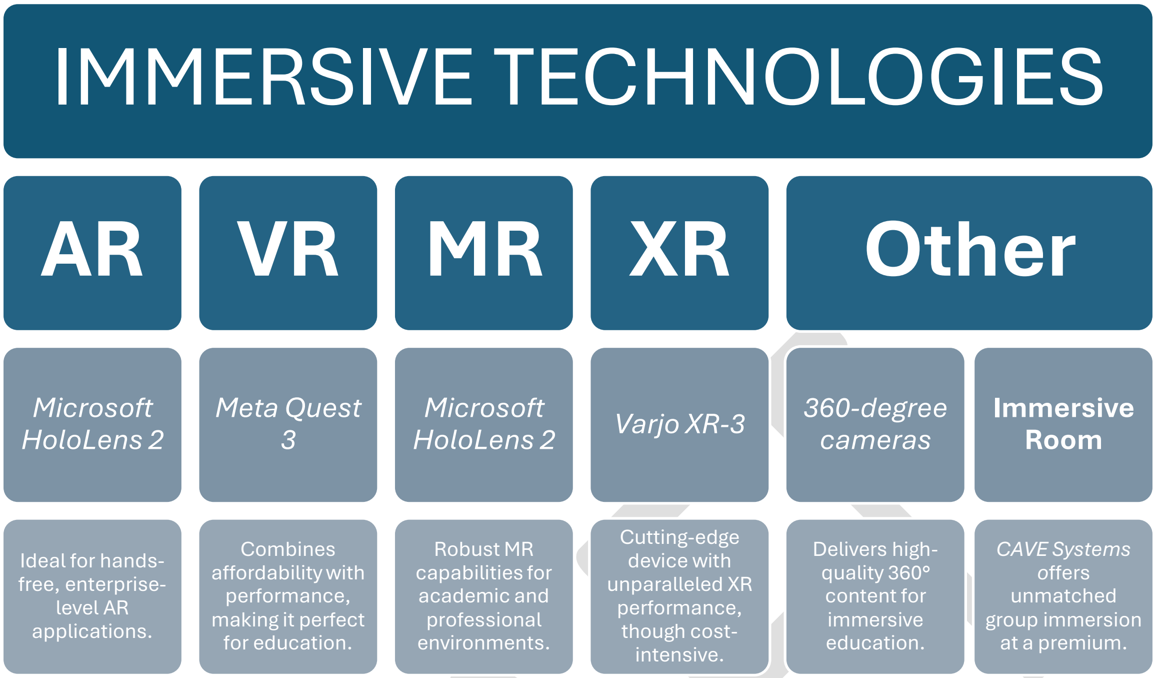

6. Advanced Software Solutions: Key Considerations and Innovation

Immersive technologies are reshaping education by offering tailored solutions for different academic disciplines. Selecting the appropriate technology for a specific subject is key to maximising its potential to enhance learning and engagement.

In **Medical and Health Sciences**, VR simulations provide safe, realistic environments for surgery practice, while MR enables interactive anatomy studies by overlaying digital models onto physical cadavers or mannequins. For Engineering and Architecture, AR facilitates detailed architectural walkthroughs by superimposing designs onto physical spaces, and XR allows for virtual construction experiences that simulate large-scale projects.

The **Social Sciences and Humanities** benefit from VR's ability to transport students to immersive historical tours, recreating significant events or sites, and AR's capacity to enrich museum exhibits with interactive storytelling. In the Natural Sciences, AR aids in visualising molecular structures or biological processes in 3D, while VR creates virtual laboratories where students can safely conduct experiments.

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Arts and Design students can leverage MR to create and interact with virtual objects in real-world contexts, enabling hands-on exploration of digital sculptures or interior designs.

Finally, **Distance Learning** is transformed by XR, which supports remote yet highly interactive and collaborative environments, connecting learners and educators in shared virtual spaces that mimic in-person engagement.

By aligning the strengths of each technology with the needs of specific departments, educational institutions can unlock innovative learning opportunities, fostering deeper understanding and practical skills across disciplines. Different subjects require different immersive technology applications.

Integrating immersive technologies into higher education requires robust software solutions tailored to the specific needs of various academic disciplines

6.1 Examples of Applications by Discipline

Immersive technologies offer students hands-on, interactive experiences that bridge the gap between theoretical knowledge and real-world applications. From Medical and Health Sciences to Distance Learning, immersive platforms enable simulations, design visualisation, and collaborative environments tailored to specific subject needs. Key applications range from surgical simulations and architectural walkthroughs to virtual laboratories and interactive classrooms, all requiring robust technical capabilities to deliver effective learning experiences.

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Medical & Health Sciences

VR Simulation Platforms: Software like *Osso VR* or *Surgical Theater* provides realistic environments for practising surgical procedures.

MR Anatomy Applications: Tools such as *AnatomyX* or *Visible Body* overlay digital models onto physical cadavers or mannequins for interactive anatomy studies.

Core Requirements: High-fidelity 3D modelling, haptic feedback support, and integration with learning management systems (LMS).

Engineering & Architecture

AR Design Tools: Applications like *ARki* or *Fuzor* enable detailed architectural walkthroughs by overlaying 3D designs onto physical spaces.

XR Construction Simulations: Platforms such as *Unity Reflect* or *Enscape* create virtual construction experiences for large-scale project simulations.

Core Requirements: CAD/BIM software integration, real-time rendering engines, and collaborative project-sharing features.

Social Sciences & Humanities

VR Historical Reconstruction: Tools like *TimeLooper* or *ChronoZoom* transport students to significant historical events and locations.

AR Museum Apps: Platforms such as *HP Reveal* or *AugmentifyIt* enhance exhibits with interactive storytelling and augmented content.

Core Requirements: Multimedia content creation, interactive storytelling capabilities, and seamless deployment on mobile or headset devices.

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Natural Sciences

AR Molecular Visualisation: Applications like Molecule Viewer or Chemistry AR allow students to manipulate 3D molecular structures.

VR Virtual Labs: Platforms such as Labster or zSpace create safe, immersive laboratory environments for experiments.

Core Requirements: Accurate scientific simulations, real-time interactivity, and extensive pre-built educational scenarios.

Arts & Design

MR Creative Tools: Software like Tilt Brush or Adobe Aero enables students to create and interact with virtual objects in real-world contexts.

3D Design and Prototyping Platforms: Applications such as Gravity Sketch or Shapr3D facilitate hands-on exploration of virtual sculptures or designs.

Core Requirements: Cross-platform compatibility, advanced design tools, and support for exporting files to 3D printing or animation software.

Distance Learning

XR Collaborative Platforms: Tools like Engage XR or AltspaceVR provide remote learning environments that mimic in-person engagement.

Interactive Classrooms: Applications such as Spatial or VirBELA allow real-time interaction and collaboration in shared virtual spaces.

Core Requirements: Cloud-based deployment, low-latency communication, and compatibility with multiple hardware devices (PC, mobile, VR headsets).

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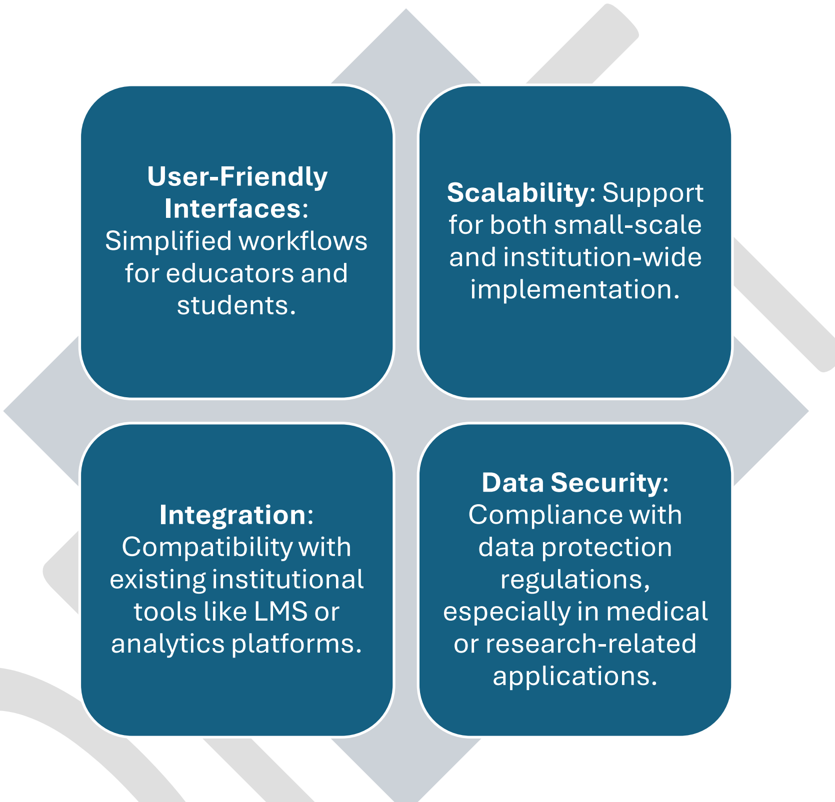
6.2 Core Software Requirements

By selecting software that aligns with immersive technologies' strengths and specific departments' needs, educational institutions can create transformative learning experiences that foster deeper understanding and practical skills across disciplines. **Appendix E** offers a comprehensive overview of software solutions for immersive technologies. Across disciplines, certain software requirements remain consistent:



7. Cost: Evaluating Factors and Budgeting Strategies

Integrating immersive technologies into education requires careful cost planning to ensure successful implementation and sustainability. Costs can vary widely depending on the scale of deployment, from small-scale departmental projects to campus-wide integration. Key expenses include hardware acquisition, software licensing or custom development, and ongoing maintenance and upgrades. This section provides a detailed breakdown of these cost considerations, helping institutions understand the financial investment required to adopt and scale immersive technologies effectively. Costs vary depending on the scale of implementation:

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CATEGORY	DETAILS	COST (€)
HARDWARE	Budgeting for devices such as headsets, computers, and mobile devices.	-
SMALL-SCALE IMPLEMENTATION	A few devices for specific departments.	€5,000–€30,000
CAMPUS-WIDE INTEGRATION	Hardware for multiple departments and immersive classrooms.	€100,000+
SOFTWARE LICENSING AND DEVELOPMENT	Universities can either purchase existing software or develop custom solutions.	-
EXISTING SOLUTIONS	Licensing for immersive education software (e.g., Labster for VR labs).	€500–€10,000 per year
CUSTOM DEVELOPMENT	Developing tailor-made immersive applications with programmers and designers.	€50,000–€250,000+
MAINTENANCE & UPGRADES	Keeping the technology up to date, ensuring devices and infrastructure are maintained.	Ongoing significant costs

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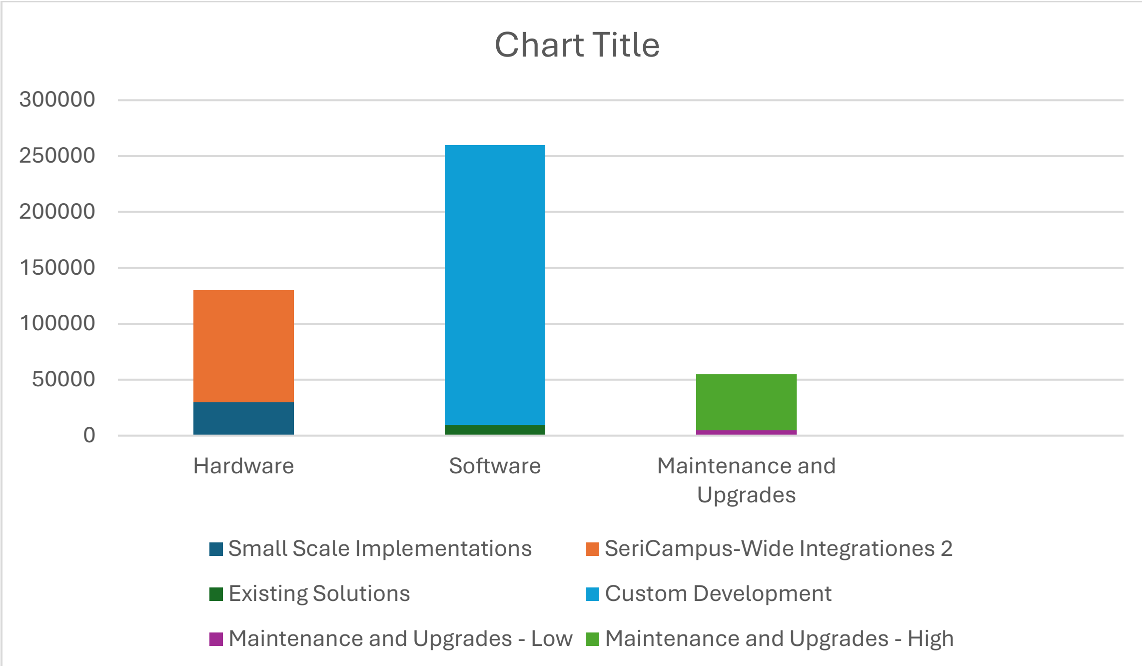

7.1 Subscriptions and Software: Managing Recurring Costs for Immersive Technologies

The total cost of ownership for immersive technologies extends beyond hardware expenses. Subscriptions and software licenses are critical factors that institutions must consider to ensure smooth, scalable integration. These ongoing costs can include software licenses for hardware, access to educational content, and subscriptions to platforms that manage immersive experiences. Thoughtful planning around software and subscription costs ensures that immersive technologies remain both impactful and financially sustainable for higher education institutions.

7.1.1 Software Licenses

Certain immersive technology devices, like Varjo VR headsets, require proprietary software licenses for optimal performance.

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Mandatory Software Licenses: High-end VR devices, such as Varjo headsets, often depend on specialised software to function. These licenses enable advanced features like high-fidelity rendering, eye-tracking, and enterprise-level controls.

Recurring Costs: Licenses may be offered on a subscription basis (e.g., annual or monthly fees), adding to long-term expenses. For example, Varjo's enterprise software licenses can range from €1,000 to €3,000 annually.

Additional Features: Some licenses unlock extra features such as analytics tools or compatibility with other immersive applications, which may be valuable for educational institutions.

7.1.2 Educational Content

The availability and cost of VR content tailored to academic needs are significant considerations:

Pre-Made Educational Content: Many VR platforms offer off-the-shelf educational modules for subjects like anatomy, engineering, or history. Costs for these modules may range from €50 to €500 per license, depending on the content complexity and licensing model.

Custom Content Development: Developing bespoke VR experiences to align with specific curriculum needs is often more expensive. Costs include hiring developers or licensing development tools like Unity or Unreal Engine. Custom content development can range from €5,000 to over €50,000 per module.

Subscription-Based Applications: Some educational applications operate on a subscription model. For instance, VR anatomy platforms or physics simulations may require annual institutional subscriptions costing €2,000–€10,000.

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7.1.3 Platform Subscriptions

Platforms that host or manage VR content and experiences may require separate subscriptions, especially for multi-user environments:

Hosting Platforms: Platforms like Engage, AltspaceVR, etc. allow institutions to host virtual classes, conferences, or collaborative experiences. These platforms often operate on tiered subscription models ranging from free for basic features to €1,000+ annually for advanced options.

Content Distribution: Subscription-based services like SteamVR or Oculus Store provide access to a library of VR content. Institutions may need to purchase individual licenses for students or secure bulk licensing agreements for broader access.

Management Systems: Enterprise VR solutions often include management tools for device monitoring, user access control, and analytics. These systems may involve additional subscription fees, typically €500–€2,000 annually.

7.2 Strategies to Managing Subscription and Software Costs

Managing subscription and software costs effectively is crucial for institutions adopting immersive technologies. Key strategies include aligning software purchases with academic needs to avoid overpaying for unnecessary features and leveraging educational discounts offered by providers. Open-source platforms can significantly reduce recurring expenses while providing essential functionalities. Collaborative efforts with other institutions to share or co-develop VR content can further minimise costs. Centralised management systems streamline the allocation of licenses and monitor usage efficiently. Additionally, budgeting for ongoing updates and maintenance ensures sustainability as technology evolves, securing long-term benefits for educational objectives.

Evaluate Institutional Needs: Identify software features or subscriptions that align closely with academic objectives. Avoid overpaying for advanced features that may not add value to the educational experience.

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Negotiate Educational Discounts: Many software and platform providers offer discounted pricing for educational institutions. Ensure that these opportunities are explored during procurement discussions.

Adopt Open-Source Platforms: Where possible, use free or open-source VR tools, such as Mozilla Hubs, to host and manage content. These platforms reduce recurring costs while offering basic functionalities for education.

Content Sharing and Partnerships: Collaborate with other institutions to co-develop or share VR content, reducing the burden of custom development costs.

Centralised Management: Use platform subscriptions with centralised administration tools that allow efficient distribution of content licenses and user monitoring.

Budget for Updates and Maintenance: Plan for ongoing expenses related to software updates, bug fixes, and additional subscriptions as technology evolves.

7.3 Educational Impact

Effective management of software and subscription costs enables universities to maximise the potential of immersive technologies. By adopting affordable and well-structured plans, institutions can scale their offerings across departments, fostering broader access and integration. Strategic cost management also supports diverse learning needs by providing a variety of VR content tailored to different disciplines. Additionally, maintaining financial sustainability ensures immersive technology programs remain viable over the long term, avoiding budgetary constraints while enhancing educational outcomes. By carefully managing software and subscription costs, universities can:

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Enhance Scalability: Affordable, well-planned subscriptions enable institutions to expand the use of immersive technologies across departments.

Support Diverse Learning Needs: Access to a wide range of VR content ensures a comprehensive educational offering tailored to multiple disciplines.

Ensure Sustainability: Effective cost management avoids budget overruns, ensuring the long-term viability of immersive technology programs

7.4 Off-the-Shelf Apps vs Custom-Created Content: Pros and Cons

When integrating immersive technologies into education, institutions often face a choice between using off-the-shelf apps or investing in custom-created content. Each approach has distinct advantages and challenges depending on the goals, budget, and technical resources available. By balancing these factors, institutions can make informed decisions on whether to adopt off-the-shelf apps or invest in custom-created content for immersive technologies. In many cases, a hybrid approach - using off-the-shelf apps for general needs and custom solutions for specific goals - can offer the best of both worlds.

Factor	Off-the-Shelf Apps	Custom-Created Content
Cost	**Pros:** Lower initial cost; subscription-based, spreading expenses over time.	**Pros:** Long-term savings if widely used; tailored to specific needs.
	Cons: Ongoing subscription costs can accumulate over time.	**Cons:** High upfront costs for design, development, and testing.

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Time to Implementation	**Pros:** Immediate availability; ideal for rapid integration.	**Pros:** Addresses unique needs not available in off-the-shelf options.
	Cons: Limited customisation for curriculum needs or local standards.	**Cons:** Development requires weeks to months, including testing and adjustments.
Customisation	**Pros:** Standardised, ready-made solutions that often cater to broad educational needs.	**Pros:** Fully tailored to align with institutional goals, cultural contexts, and curriculum standards.
	Cons: Limited ability to tailor to specific curriculum or institutional needs.	**Cons:** Requires significant time and resources for development.
Quality and Depth	**Pros:** High production values, pre-developed by experienced vendors; tested for usability.	**Pros:** Potential for unique, high-quality solutions directly addressing educational objectives.
	Cons: Content quality depends on vendor expertise and may not align perfectly with all educational contexts.	**Cons:** Quality depends on the expertise of hired developers and quality control processes.
Scalability	**Pros:** Designed for scalability; cloud-based solutions simplify updates and multi-device compatibility.	**Pros:** Can be updated or expanded to meet evolving needs across courses or institutions.
	Cons: Scaling beyond the initial design may require significant additional investment.	**Cons:** These may involve redesigns and require institutional infrastructure upgrades for larger-scale use.
Technical Expertise	**Pros:** Minimal expertise needed; plug-and-play functionality simplifies use.	**Pros:** Internal teams gain technical skills through the creation process.

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	Cons: Heavy reliance on vendor support for troubleshooting or adjustments.	**Cons:** Requires significant expertise and resources for development and ongoing maintenance.
Learning Curve	**Pros:** User-friendly designs cater to a broad audience, ensuring ease of adoption.	**Pros:** Educators and students engage deeply through tailored interfaces.
	Cons: Limited features may restrict deep educational engagement.	**Cons:** Training required for effective use; higher initial learning curve.
Support and Updates	**Pros:** Vendor-provided updates, bug fixes, and customer support; access to user communities.	**Pros:** Control over updates and issue resolution; tailored solutions reduce dependency on external vendors.
	Cons: Dependent on vendor stability and responsiveness.	**Cons:** Internal resources or external contracts required for ongoing updates and maintenance.
Long-Term Value	**Pros:** Quick access to diverse, pre-built educational experiences; useful for enhancing specific lessons.	**Pros:** Once developed, reusable content can be updated internally without ongoing external costs.
	Cons: May involve recurring costs; limited flexibility to adjust for long-term objectives.	**Cons:** High initial costs and resource requirements.
Educational Impact	**Pros:** Provides immediate enhancement to lessons with diverse, high-quality experiences.	**Pros:** Custom alignment ensures relevance to objectives and fills gaps left by generic solutions.
	Cons: May not fully align with all educational goals or cover niche topics.	**Cons:** Development timelines may delay the availability of content.

7.4.1 When to Choose Off-the-Shelf Apps

- Institutions need **quick, cost-effective solutions** for immediate integration.

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- Educational goals align closely with available apps (e.g., anatomy or physics simulations).
- Limited **technical resources** or expertise for content creation.
- Institutions are exploring immersive technologies for the first time and want to test their impact before committing to custom development.

7.4.2 When to Choose Custom-Created Content

- The curriculum requires **specialised or niche experiences** not available in off-the-shelf apps.
- Institutions have access to **technical expertise or partnerships** for development.
- Long-term plans involve heavy reliance on immersive technologies, making custom content more cost-effective.
- Institutions aim to create a **unique, branded educational experience** that sets them apart from competitors.

8. Network: Essential Infrastructure Requirements

Implementing immersive technologies in education requires a robust and well-prepared IT infrastructure. Key considerations include network and bandwidth capabilities to support high-speed, low-latency connections, as well as storage and processing power for complex simulations. Integration with Learning Management Systems (LMS) ensures that immersive applications align with existing platforms to track student progress effectively. Additionally, institutions must ensure Wi-Fi infrastructure can support multiple devices and that hardware compatibility with existing systems is prioritised to enable seamless deployment and usage.

To enable group-shared immersive experiences using immersive HMDs, the network speed and infrastructure play a crucial role in ensuring smooth, synchronised experiences. The exact requirements can vary depending on the complexity of the experience, the number of users, and the type of immersive technology being used.

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Network and Bandwidth

- Immersive technologies, especially VR and MR, require robust network capabilities. High-speed internet, low-latency networks, and in some cases, 5G connectivity, are essential. High-quality VR experiences require substantial bandwidth. Ensuring that the institution's network can handle the increased load is crucial.

Storage and Processing Power

- For VR and MR applications, especially when rendering complex simulations, powerful PCs or cloud computing resources may be necessary.

Learning Management Systems (LMS) Integration

- Universities need to ensure that the immersive applications can integrate with their existing LMS (like Moodle, and Blackboard) to track student progress and outcomes.

Wi-Fi Infrastructure

- Adequate Wi-Fi coverage and strength to support multiple VR headsets simultaneously.

Hardware Compatibilit

- Ensure compatibility with existing IT infrastructure, including computers and servers.

8.1 Network Speed Considerations

Key considerations include network speed, bandwidth, and latency, all of which impact the performance and responsiveness of shared immersive environments. For applications like multiplayer VR simulations or AR-enhanced learning, the network must handle high-resolution graphics, real-time interactions, and synchronized communication without lag.

Institutions must evaluate their network types - including wired Ethernet, Wi-Fi 6/6E, and 5G - based on user density, classroom demands, and mobility requirements. Emerging technologies like cloud computing, edge computing, and compression techniques further optimise network performance by reducing latency and bandwidth usage. Special considerations are also needed for scaling immersive experiences for large groups, requiring high-capacity infrastructure to deliver consistent quality. By addressing these factors, institutions can ensure that their network capabilities align with the growing

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demands of immersive education. A breakdown of the network speed considerations for such experiences is summarised below:

	NETWORK SPEED CONSIDERATIONS
Bandwidth Requirements	For group-shared immersive experiences, each user's device needs to send and receive large amounts of data in real time. The network bandwidth must accommodate: • **High-resolution 3D graphics:** Rendering complex 3D models and environments in VR/MR. • **Real-time interactions:** Synchronising movements, interactions, and voice communications across all participants. • **Multiplayer environments:** Allowing multiple users to inhabit the same virtual space without lag.
General Bandwidth Estimates	• VR experiences require a minimum of 50-100 Mbps per user for optimal performance, especially in multi-user environments with high-quality graphics. • AR/MR experiences tend to require less bandwidth than VR, as AR overlays onto the real world rather than rendering entirely virtual environments. A typical AR/MR experience may require 20-50 Mbps per user. • For group experiences (e.g., 10 users in a shared VR space), the collective bandwidth needed would scale up. For instance, 10 users could collectively require 500 Mbps to 1 Gbps or more depending on the complexity of the shared experience.
Latency Requirements	Latency is a critical factor in immersive experiences, especially in VR and MR, where real-time interaction is key to avoiding disorientation and ensuring smooth communication between users. • **VR and MR headsets:** Require extremely low latency (below 20 milliseconds) to ensure responsiveness in interactions and reduce motion sickness.

	• **AR applications:** Have a slightly higher tolerance for latency but should still aim for less than 50 milliseconds to maintain a seamless experience.
	• **Multi-user immersive environment:** In a multi-user immersive environment, low latency is especially important to:
	  ○ Ensure smooth communication and interaction.
	  ○ Avoid lag between user actions and the environment's response.
	  ○ Maintain synchronisation between different users' viewpoints and positions.

Network Type	• **Wired Connections (Ethernet):** For high-quality, shared immersive experiences with multiple users, a wired connection is generally preferable, especially when high data transfer rates and low latency are critical. A typical gigabit Ethernet connection (1 Gbps) can comfortably support multiple users sharing a group experience.
	• **Wi-Fi (Wireless):**
	  ○ **Wi-Fi 5 (802.11ac):** Can deliver speeds up to 1 Gbps in ideal conditions but may struggle with multiple simultaneous users and heavy data loads.
	  ○ **Wi-Fi 6 (802.11ax):** Better suited for multi-user environments, as it offers improved data rates, efficiency, and reduced latency compared to Wi-Fi 5. Speeds of up to 10 Gbps are possible, but more importantly, it is optimised for high-density environments like classrooms.
	  ○ **Wi-Fi 6E:** Expands Wi-Fi 6 capabilities into the 6 GHz band, reducing congestion and further improving performance in dense environments.
	• **5G Networks:** 5G offers ultra-low latency (under 10 milliseconds in ideal conditions) and high speeds (up to 10 Gbps), making it an excellent option for untethered, shared immersive experiences, especially in outdoor or larger

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	campus settings. However, the quality of 5G performance depends on the local infrastructure.
Cloud-Based Immersive Experiences	Many immersive experiences leverage cloud computing to offload some of the processing work from the headset to remote servers. In these cases, fast network speeds are crucial to ensure seamless communication between the local device and the cloud.
Edge Computing	Using edge computing, where data is processed closer to the user (e.g., through local data centers), can further reduce latency and bandwidth requirements. This is especially useful for group experiences where the environment is rendered in real time and sent back to the users with minimal delay.
Peer-to-Peer vs. Server-Based Networks	• **Peer-to-Peer Networks:** These allow each user's device to communicate directly with the others in the group, reducing the need for a central server. This can reduce overall network load but still requires sufficient bandwidth for each user to interact with every other participant. • **Server-Based Networks:** A central server processes and synchronizes all user interactions. This can simplify synchronization but may require higher bandwidth and lower latency to avoid bottlenecks.
Compression and Streaming Technologies	Some immersive experiences use advanced compression and streaming techniques to reduce the bandwidth required for high-quality graphics and real-time interactions. Technologies like NVIDIA CloudXR or foveated rendering can dynamically reduce the resolution of peripheral vision in VR/AR headsets, focusing high-quality graphics only where the user is looking. This can lower bandwidth demands, especially in multi-user scenarios.
Scaling for Large Groups	For large-scale group immersive experiences (e.g., a virtual classroom of 50 students): • **Bandwidth per user:** 20-100 Mbps depending on the level of immersion and complexity of the graphics. • **Network infrastructure:** High-capacity routers, switches, and sufficient backhaul bandwidth (1 Gbps to 10 Gbps) to ensure consistent performance across all users.

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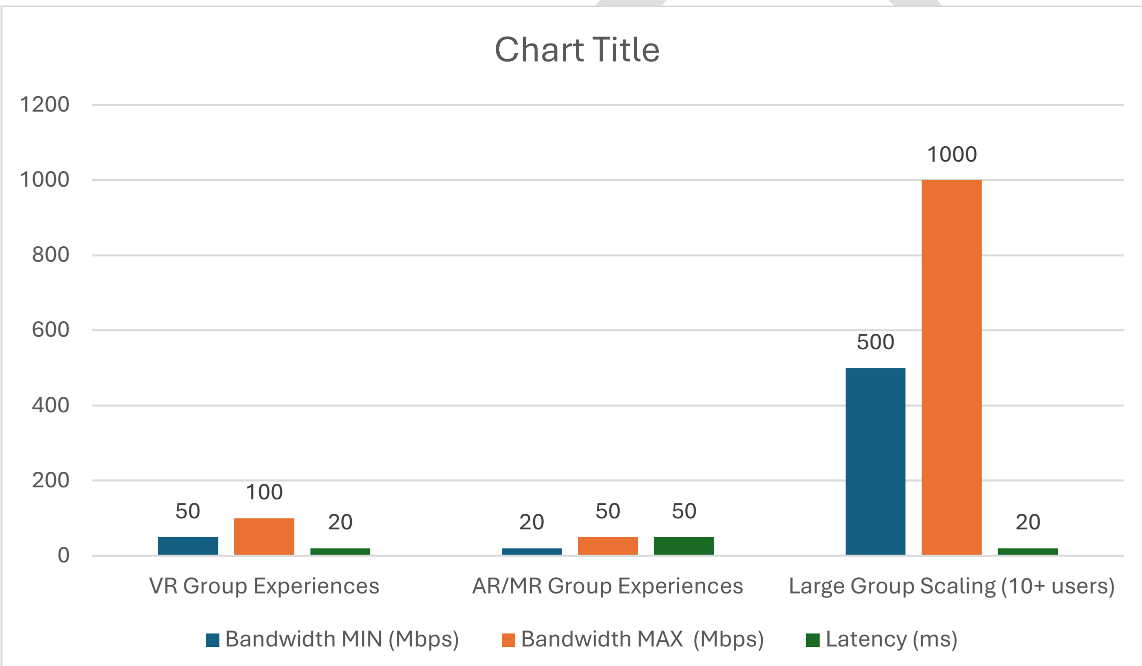
8.2 Network Requirements Recommendations

When implementing immersive technologies such as VR and AR for educational purposes, it is crucial to establish robust network requirements to ensure a seamless and effective experience. For group VR experiences, each user requires a bandwidth of 50–100 Mbps with latency under 20 ms, ideally facilitated through wired connections or high-quality Wi-Fi 6/5G networks. In AR/MR scenarios, bandwidth needs range from 20–50 Mbps per user, with latency requirements being less than 50 ms for AR and under 20 ms for MR, supported by similarly strong wireless or wired infrastructure. Scaling to larger groups necessitates cumulative bandwidths exceeding 500 Mbps to 1 Gbps or more, tailored to the complexity of the experience. These benchmarks highlight the importance of investing in high-performance networks to unlock the full potential of immersive education.



8.3 Network Infrastructure Recommendations

For all configurations, it's critical to incorporate redundancy to avoid downtime and plan for scalability to accommodate growing user numbers and more demanding applications in the future. By investing in these infrastructural elements, educational institutions can effectively support both small-scale group sessions and large-scale immersive experiences.

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VR Group Experience Infrastructure Requirements

- **Wired Connections**: A wired Ethernet connection is preferred for VR experiences, as it provides the highest bandwidth and lowest latency, ensuring smooth interactions and minimizing interruptions during group sessions.
- **High-Quality Wireless Networks**:
  - **Wi-Fi 6**: Offers enhanced bandwidth, reduced latency, and the ability to handle multiple devices simultaneously without degradation in performance, crucial for high-density user environments.
  - **5G Networks**: Essential for untethered VR experiences, particularly in environments where mobility is critical. 5G's ultra-low latency and high data rates make it suitable for real-time interactions.
- **Access Points and Distribution**: Multiple access points should be strategically distributed to avoid network congestion and ensure consistent signal strength across the space.
- **Traffic Management**: Networks should employ Quality of Service (QoS) protocols to prioritize VR traffic, ensuring consistent performance.

AR/MR Group Experience Infrastructure Requirements

- **Wireless Connectivity**:
  - **Wi-Fi 6 or 5G**: These are crucial for untethered AR/MR devices to deliver high-resolution visuals and seamless real-world overlays. They support high data throughput and reduce latency to levels necessary for interactive experiences.
- **Wired Connections for Optimal Performance**: For fixed or semi-fixed setups, wired connections offer stability and reliability, crucial for mixed-reality applications where interruptions can disrupt the user experience.
- **Edge Computing**: Deploying edge servers close to the users can help process AR/MR data locally, reducing latency and improving performance for real-time applications.

Large Group Scaling Infrastructure Requirements

- **Cumulative Bandwidth Planning**:
  - For 10 or more users, the cumulative bandwidth needs often exceed 500 Mbps to 1 Gbps or more. This depends on the nature of the VR/AR/MR experiences, with high-fidelity or interactive sessions requiring greater capacity.
- **Multiple Access Points (APs)**:
  - Deploy multiple APs with Wi-Fi 6 capabilities and mesh networking to ensure load balancing and minimise dead zones.
  - Configure each AP to handle a limited number of devices effectively to avoid bandwidth competition.
- **Backhaul Connectivity**:
  - Ensure robust backhaul connections, such as fibre-optic links, to support the aggregated data requirements of the group.
- **Network Load Balancers**:
  - Use load balancers to evenly distribute traffic across the network, preventing any single point from becoming a bottleneck.
- **Infrastructure Design**:
  - Use dedicated VLANs for immersive technologies to isolate traffic and improve security and performance.
- **Power Over Ethernet (PoE)**: Supports high-density setups by simplifying power distribution to multiple APs in large environments.

9. Training and Support

Effective training and support are critical for maximising the benefits of immersive technologies in education. Both educators and students need tailored resources to ensure smooth adoption and usage. Faculty training should focus on integrating VR/AR tools into curricula and pedagogical strategies, while students benefit from onboarding sessions

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and technical literacy support. Dedicated IT personnel, centralised device management, and real-time assistance ensure seamless operation. Collaboration in training and alignment with learning management systems (LMS) enhance effectiveness. With annual costs ranging from €10,000 to €50,000, sustainable investment in training ensures long-term success and inclusivity in immersive learning environments.

Category	**Training and Support Details**
EDUCATORS	
Faculty Training	- Workshops, webinars, certification programs, and peer mentorship. - Ongoing support to stay updated on tools, features, and best practices.
Curriculum Development	- Assistance in redesigning curricula to incorporate immersive technologies. - Align VR/AR tools with learning outcomes and assessments.
Pedagogical Training	- Strategies for immersive learning, e.g., facilitating virtual discussions and ensuring accessibility.
STUDENTS	
Onboarding Sessions	- Guided tutorials, safety guidelines, and usage tips for VR/AR devices.
Technical Literacy	- Basic troubleshooting skills for minor issues. - Guidance on using immersive tools in projects and collaboration.
Accessibility Support	- Specialised training or adjustments for students with disabilities. - Alternative engagement methods, like non-VR versions of experiences.

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IT SUPPORT & DEVICE MANAGEMENT	
Dedicated IT Personnel	- Staff trained to manage devices, troubleshoot hardware/software, and integrate with institutional systems.
Device Management Systems	- Platforms for centralised software updates, device configurations, and license tracking.
Support Desk	- Real-time assistance for technical issues, available to both students and faculty.
INTEGRATION AND COLLABORATION	
LMS and Tools Integration	- Training to integrate VR/AR tools with existing learning management systems (LMS) and software.
Collaborative Training	- Sessions involving both educators and students to explore immersive technologies. - Peer-led workshops or student ambassadors to enhance learning support.
COSTS AND SUSTAINABILITY	
Cost Considerations	- Annual costs of €10,000–€50,000 for training and support, depending on scale. - Budget for long-term training programs to ensure sustainability.
Ongoing Development	- Participation in conferences, certifications, and communities of practice focused on immersive technology.

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10. Long-Term Objectives: Sustainability and Scalability

To ensure immersive technologies provide lasting value in higher education, universities must develop strategies that address their long-term sustainability and scalability. While pilot programs and initial implementations help to introduce these tools, institutions must plan for their ongoing growth, relevance, and impact. By addressing these areas strategically, universities can ensure that immersive technologies are not just a short-term novelty but a transformative and enduring part of their educational framework. Universities should consider the long-term sustainability of immersive technology integration:

- **Expanding Use:** As technology becomes more embedded, universities might want to scale up, requiring additional hardware and software.
    - **Increased Hardware Investments:** Procuring additional devices, such as VR headsets or AR glasses, to meet the growing demand from students and faculty.
    - **Broadening Access:** Ensuring equitable access to immersive technology, particularly for remote learners or students with disabilities.
    - **Enhanced Infrastructure:** Upgrading networks, storage, and computing power to support more devices and users, especially as experiences become more resource-intensive.
- **Content Updates:** Immersive content (especially in VR/AR simulations) needs regular updates to stay relevant and accurate.
    - **Regular Revisions:** Updating VR simulations or AR overlays with the latest research findings, industry practices, or educational standards.
    - **Dynamic Content Management:** Partnering with developers or adopting software platforms that simplify content updates and distribution across devices.
    - **Faculty Engagement:** Training educators to co-develop or adapt content, ensuring relevance while reducing dependence on external vendors.
- **Funding** Universities may need to explore grants, partnerships with technology companies, or student fees to support long-term use.
    - **Grants and Partnerships:** Seeking government grants, research funding, or partnerships with technology companies to reduce costs. Initiatives like Horizon Europe can support projects involving cutting-edge educational technologies.
    - **Cost-Sharing Models:** Introducing optional student fees for access to specialised tools, labs, or content subscriptions.

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  - **Revenue Streams:** Exploring opportunities to monetise immersive content by licensing or collaborating with industry partners.
- **Future Proofing:** Considering future needs and technological advancements to ensure that the investment remains relevant over time.
  - **Hardware Longevity:** Select modular or upgradable devices, such as standalone VR headsets with firmware support or AR glasses with removable components.
  - **Interoperability:** Choosing software and platforms that are compatible with multiple hardware types to avoid being locked into a single vendor ecosystem.
  - **Tracking Trends:** Staying informed about advancements in immersive technologies, such as the integration of AI in simulations or 6G network capabilities for enhanced experiences.
- **Long-Term Benefits of Sustainability and Scalability:**
  - **Increased Adoption:** Providing reliable, updated, and accessible tools builds confidence among faculty and students, encouraging widespread use.
  - **Reputation for Innovation:** Universities leading in immersive technology adoption are more attractive to prospective students and faculty, boosting enrolment and funding opportunities.
  - **Educational Impact:** Scalable, well-maintained immersive solutions enable a broader range of disciplines to benefit, enriching the overall learning experience and ensuring alignment with workforce demands.

A structured overview of how educational institutions are achieving long-term sustainability and scalability in immersive technologies with real-world examples.

Category	Real-World Examples
EXPANDING USE	
Increased Hardware Investments	Arizona State University provides standalone VR headsets like Meta Quest to students, enabling broader access and reducing reliance on shared resources.
Broadening Access	Dublin City University offers virtual campus tours and immersive environments, ensuring remote and disabled learners can participate equally in educational activities.

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Enhanced Infrastructure	The University of Cambridge upgraded its networks to support AI-enhanced simulations in virtual labs, facilitating the seamless use of immersive technologies.
CONTENT UPDATES	
Regular Revisions	Harvard Medical School updates VR surgical training modules annually to include the latest medical research and practices.
Dynamic Content Management	Munster Technological University collaborates with developers for centralised VR content updates, allowing easy distribution across devices.
Faculty Engagement	University of Glasgow trains educators in platforms like Unity and Unreal Engine, empowering them to co-create and tailor immersive content for curricula.
GRANTS AND PARTNERSHIPS	
Grants and Partnerships	HEA HCI funds projects like REEdI, enabling Irish universities to scale immersive tools for engineering education.
Cost-Sharing Models	The University of Southern California introduces optional tech fees for students accessing immersive labs, balancing affordability with sustainability.
Revenue Streams	The University of Oxford licenses proprietary VR simulations to healthcare providers, generating revenue while sharing resources with industry.
FUTURE-PROOFING	
Hardware Longevity	Stanford University uses modular VR headsets, extending device lifespans through upgradable components and firmware updates.
Interoperability	MIT utilises open-source platforms like Mozilla Hubs to ensure compatibility across multiple hardware ecosystems, avoiding vendor lock-in.
Tracking Trends	Imperial College London integrates AI into VR simulations, preparing for advancements like personalised, adaptive learning experiences.
BENEFITS IN ACTION	

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Increased Adoption	University of Maryland's VR-integrated engineering curriculum has seen greater faculty and student participation, encouraging adoption across other disciplines.
Reputation for Innovation	The University of Melbourne uses immersive technology to attract international students and form global partnerships, boosting its reputation.
Educational Impact	Purdue University applies immersive labs across fields like veterinary science and aviation, aligning student skills with workforce demands and enhancing learning outcomes.

11. Accessibility: Ensuring Inclusive and Comfortable Use

Accessibility is a critical consideration for integrating immersive technologies like VR, AR, and MR into higher education. To deliver equitable and effective learning experiences, universities must address both physical accessibility for students with disabilities and user comfort to ensure that immersive environments are safe and inclusive for all. Making immersive technologies accessible is not just a legal and ethical obligation; it is a strategic imperative to maximise their impact and ensure all students benefit equally from the transformative potential of these tools.

11.1 Physical Accessibility

Immersive technologies must be designed and implemented to accommodate students with varying physical, sensory, and cognitive abilities:

Accessible Hardware: Select hardware that accommodates diverse needs, such as headsets with adjustable straps for users with limited dexterity or devices compatible with assistive technologies like screen readers or voice controls.

Alternative Input Methods: Provide options for alternative input devices, such as eye-tracking systems or adaptive controllers, to ensure students with mobility impairments can interact seamlessly with VR and AR environments.

Space Considerations: Ensure VR setups are housed in spaces that are wheelchair-accessible, including clear pathways, appropriate furniture height, and sufficient room for movement.

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Inclusive Content Design: Develop or select VR and AR content that avoids relying on specific physical movements or sensory modalities. For example, replacing auditory cues with visual indicators ensures inclusivity for hearing-impaired students.

Compliance Standards: Adhere to established accessibility guidelines, such as the Web Content Accessibility Guidelines (WCAG) for digital content or regional regulations for physical accommodations.

11.2 User Comfort

Immersive experiences must be designed to minimise discomfort and ensure a positive experience for all users:

Motion Sickness Mitigation	•Use headsets with high refresh rates (90Hz or more) to reduce lag and minimise motion sickness. •Design content with smooth transitions, stable camera perspectives, and limited rapid movements. •Offer shorter VR sessions or breaks during extended use to accommodate users prone to discomfort.
Physical Ergonomics	•Provide adjustable and lightweight headsets to ensure they fit comfortably on users of different ages and head sizes. •Consider hygiene by offering disposable face covers for shared devices.
Customisable Experience	•Allow users to adjust visual settings, such as brightness, field of view, or text size, to cater to individual preferences or needs.
Training and Guidance	•Educate users on how to adjust equipment for optimal comfort and how to handle any discomfort, such as dizziness or eye strain.

11.3 Additional Strategies to Enhance Accessibility

Ensuring accessibility in immersive technologies is essential to creating inclusive educational environments that cater to all students. Key strategies include offering remote access options for those unable to use physical setups, providing assistive training to staff to address diverse student needs, and fostering ongoing student feedback to identify and overcome barriers. Additionally, establishing support ecosystems with dedicated teams ensures technical issues are resolved effectively, enabling students to maximise their learning experience with immersive tools.

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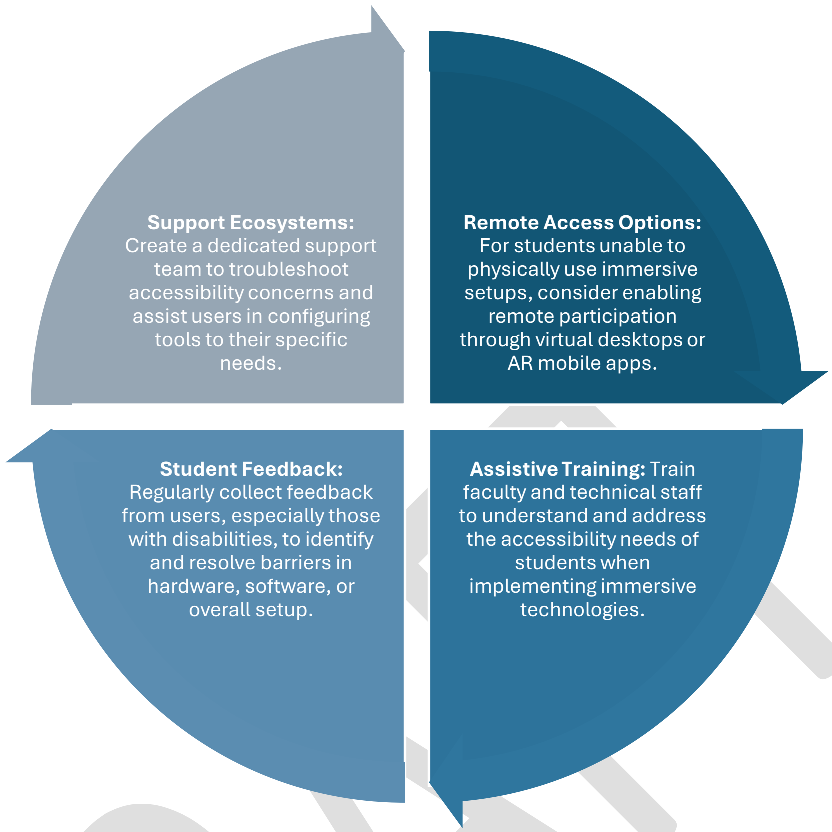

11.4 The Educational Impact of Accessible Immersive Technologies

Accessibility in immersive technologies plays a critical role in creating equitable and inclusive learning environments. By ensuring that all students can engage with these tools, institutions can promote equity, giving every learner an equal opportunity to succeed. Accessible content and tools also enhance learning outcomes by improving knowledge retention and skills acquisition. Furthermore, prioritising accessibility helps foster institutional reputation, demonstrating a strong commitment to inclusivity and setting a standard for best practices in education. When accessibility is prioritised, immersive

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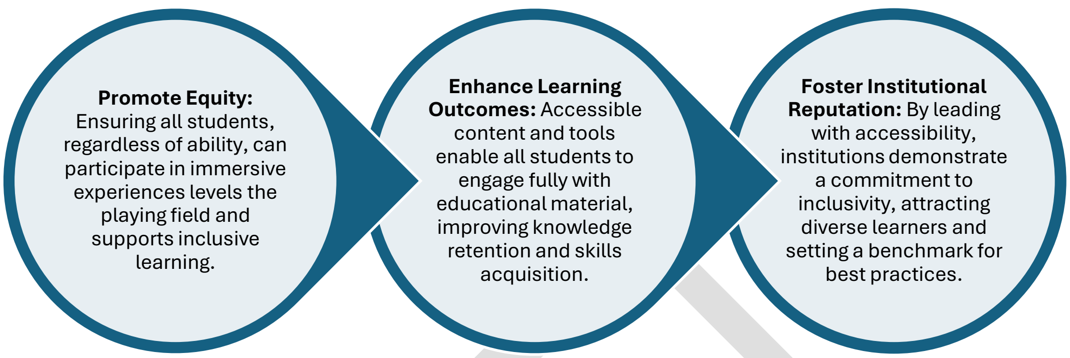
technologies can:



11.5 Ensuring Accessibility in Immersive Technologies: Strategies and Examples

Accessibility to immersive technologies is essential to fostering an inclusive and equitable educational environment. By prioritising physical accessibility, user comfort, and adaptive strategies, educational institutions can ensure that immersive technologies are effective for all students, including those with disabilities. Practical measures, such as accessible hardware, alternative input methods, and inclusive content design, address diverse needs. Meanwhile, investments in remote access options, assistive training, and ongoing user feedback further enhance inclusivity. These efforts not only promote equity and improved learning outcomes but also elevate institutional reputation by demonstrating a commitment to accessibility and innovation.

Category	Practical Real-World Examples
PHYSICAL ACCESSIBILITY	
Accessible Hardware	Meta’s Quest 3 VR headsets include adjustable straps and lightweight designs, improving usability for individuals with limited dexterity.

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Alternative Input Methods	Tobii's eye-tracking technology enables users with mobility impairments to navigate VR environments using gaze control.
Space Considerations	The University of California, Berkeley ensures VR labs are wheelchair accessible, with adjustable furniture and clear pathways for ease of movement.
Inclusive Content Design	Microsoft's "Seeing AI" app integrates with AR environments, providing audio descriptions for visually impaired users and ensuring sensory inclusivity.
Compliance Standards	Universities like Stanford adhere to WCAG 2.1 standards for VR content to ensure digital accessibility and meet regulatory requirements.
USER COMFORT	
Motion Sickness Mitigation	Oculus' VR headsets use 90Hz refresh rates and low-latency design to reduce motion sickness, while VR apps like Wander focus on smooth transitions for comfort.
Physical Ergonomics	HP's Reverb G2 VR headsets include ergonomic designs, and disposable face covers to enhance comfort and hygiene for shared use.
Customisable Experiences	Google Expeditions allows users to adjust text size, brightness, and display settings, ensuring accessibility for various vision needs.
Training and Guidance	MIT provides users with detailed guides and workshops on optimising headset settings and managing potential discomfort during extended VR sessions.
ADDITIONAL STRATEGIES	
Remote Access Options	Zoom's AR integration and platforms like Mozilla Hubs enable remote access to immersive environments for students unable to use physical setups.
Assistive Training	Dublin City University trains staff on accessibility tools like voice controls and adaptive controllers to ensure inclusivity in immersive technology adoption.

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Student Feedback	The University of Melbourne collects regular feedback through surveys to identify and resolve barriers faced by users with disabilities in immersive setups.
Support Ecosystems	Purdue University has established dedicated VR support teams to assist with configuring accessibility tools and troubleshooting issues for students with special needs.
EDUCATIONAL IMPACT	
Promote Equity	The University of Glasgow's VR labs provide equal access for all students, ensuring immersive learning opportunities are inclusive of those with disabilities.
Enhance Learning Outcomes	Harvard Medical School uses accessible VR surgical simulations, improving learning outcomes for students with diverse physical abilities.
Foster Institutional Reputation	Imperial College London's focus on accessibility in its VR programs has earned it recognition as a leader in inclusive education practices.

12. Legal And Ethical Considerations: Establishing Responsible Use of Immersive Technologies

The integration of immersive technologies like VR, AR, and MR into higher education introduces new legal and ethical challenges. Institutions must proactively address these considerations to ensure compliance with laws, safeguard users, and maintain the integrity of educational practices. Developing robust usage policies and promoting ethical practices are central to achieving this goal. By addressing these legal and ethical considerations, universities can create a foundation for the responsible and impactful use of immersive technologies in education.

12.1 Usage Policies

Clear and comprehensive usage policies provide a framework for the responsible deployment of immersive technologies in educational settings:

Acceptable Use: Define what constitutes acceptable use of VR technologies, outlining appropriate behaviours for students and staff. Policies should address issues such as misuse, tampering with hardware, or unauthorised access to content.

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Supervision Guidelines: Establish protocols for monitoring the use of immersive technologies, particularly for younger students or first-time users, to ensure their safety and well-being during VR sessions.

Time Limits: Prolonged use of immersive technologies can lead to physical discomfort, eye strain, or overexposure. Policies should set reasonable time limits for sessions to safeguard health while ensuring optimal learning experiences.

Data Privacy and Security: Address how user data, such as biometrics or behavioural analytics collected during VR interactions, will be stored, used, and protected. Compliance with laws like GDPR is essential to maintain trust and avoid legal repercussions.

Content Ownership and Licensing: Clarify ownership rights for any VR content developed or used within the institution, ensuring compliance with copyright laws and preventing unauthorised distribution.

12.2 Ethical Use

The ethical implementation of immersive technologies ensures they are used in ways that align with the institution's values and promote positive learning experiences:

Appropriate Content: Institutions must vet VR content to ensure it is age-appropriate, culturally sensitive, and aligned with educational objectives. For instance, simulations involving sensitive topics like conflict or trauma should be carefully designed to avoid harm or distress.

Informed Consent: Students and staff should be informed about the purpose of VR use, any potential risks (such as motion sickness), and how their data will be handled. Obtain explicit consent before participation, particularly in experimental or research-based applications.

Accessibility and Inclusivity: Ethical use ensures all students, regardless of ability or background, have equitable access to VR tools and experiences. Excluding certain groups due to physical, financial, or technical barriers undermines the principles of fairness and inclusion.

Avoiding Manipulation: Immersive technologies can deeply influence perceptions and behaviours. Institutions must avoid using VR in ways that could manipulate users unethically, such as presenting biased content or imposing specific ideologies.

Transparency in Learning Outcomes: Ensure students understand the purpose of VR in their learning journey and how it complements traditional educational methods, avoiding any overreliance on technology as a substitute for effective pedagogy.

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12.3 Additional Legal and Ethical Challenges

Simulated Environments: Some VR applications simulate real-world scenarios involving ethical dilemmas or controversial topics. Guidelines should address how these scenarios are designed and debriefed to prevent harm.

AI and VR Intersections: As AI becomes integrated into immersive experiences, ensure that its applications—such as automated feedback or adaptive learning—adhere to ethical standards, avoiding biases or unintended consequences.

Third-Party Partnerships: Collaborations with external VR developers or vendors should include agreements on ethical standards, data protection, and intellectual property rights.

12.4 Educational and Institutional Benefits

Addressing legal and ethical considerations proactively can:

Build Trust: Clear policies and ethical use demonstrate the institution's commitment to student and staff well-being, fostering trust among stakeholders.

Enhance Reputation: By upholding high standards for the use of innovative technologies, institutions position themselves as leaders in responsible tech integration.

Prevent Legal Risks: Robust compliance with privacy laws, copyright regulations, and accessibility standards reduces the likelihood of legal challenges or penalties.

Support Positive Learning Outcomes: Ethical practices ensure immersive technologies contribute meaningfully to education without compromising safety, inclusivity, or fairness.

13. Security: Protecting Users and Systems

The use of immersive technologies like VR, AR, and MR in higher education introduces unique security challenges that institutions must address to safeguard user data, prevent unauthorised access, and maintain the integrity of their systems. Effective security measures are essential for building trust among students, faculty, and stakeholders, particularly as these technologies collect and process sensitive data. Institutions can protect users and maintain trust by addressing data privacy, network security, and user authentication while evaluating vendor agreements like Meta's terms. These proactive measures ensure compliance with legal requirements and foster a secure and ethical environment for immersive learning.

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13.1 Data Privacy

Using immersive technologies in education involves collecting and managing various types of user data, including sensitive information such as biometrics, usage patterns, and geolocation details. To protect user privacy and ensure compliance with regulations, institutions must prioritise secure data storage through encryption and protocols like GDPR. Adopting a limited data collection approach, where only necessary information is gathered, helps mitigate risks while ensuring transparency. Additionally, clear and user-friendly consent forms are essential to inform users about what data is collected, how it will be used, and who may access it. Protecting the privacy of users is critical, as immersive technologies often collect a wide range of personal and behavioural data.

Types of Data Collected

- VR systems may capture sensitive information such as biometrics (e.g., eye-tracking data, physical movements), usage patterns, and performance metrics. AR and MR tools might also use geolocation and environmental data from users' devices.

Secure Data Storage

- Institutions must ensure that all collected data is securely stored using encryption and other advanced security protocols. Storage solutions should comply with data protection regulations such as GDPR.

Limited Data Collection

- Adopting a minimal data collection approach can reduce risks. Only necessary data for educational objectives should be collected, and users should have transparency on what is being stored.

User Consent

- Provide clear, user-friendly consent forms detailing what data is collected, how it will be used, and with whom it may be shared.

13.2 Network Security

The integration of immersive technologies in education requires robust security measures to protect data and ensure safe usage. Institutions must prioritise firewalls and encryption to safeguard sensitive information from hacking or interception. Additionally, implementing secure Wi-Fi networks dedicated to VR systems helps reduce vulnerabilities by isolating them from general-use networks. Regular security audits are essential to identify and address potential weaknesses across network, hardware, and software systems, ensuring a secure and resilient immersive learning environment. Secure

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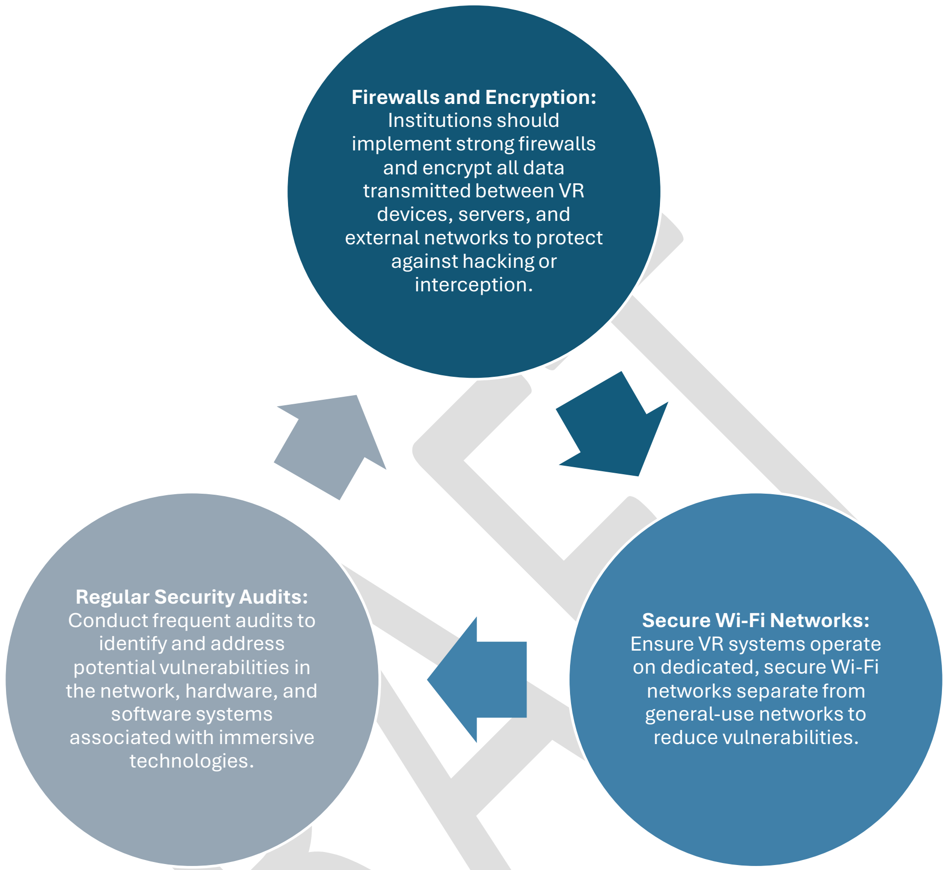
networks are essential for preventing unauthorised access to immersive technologies and the data they process.



13.3 User Authentication

Ensuring secure access to immersive technologies is essential to protect sensitive content and maintain institutional integrity. Key measures include implementing Two-Factor Authentication (2FA), which adds an extra layer of security by requiring additional verification steps. Biometric authentication, such as fingerprint or iris scans, further enhances security and is supported by many immersive devices. Additionally, Role-Based Access Control ensures that only authorised users, like educators or administrators, can access specific content or settings, safeguarding both data and functionality in immersive learning environments. Strong user authentication methods prevent unauthorised access to VR systems, devices, and content.

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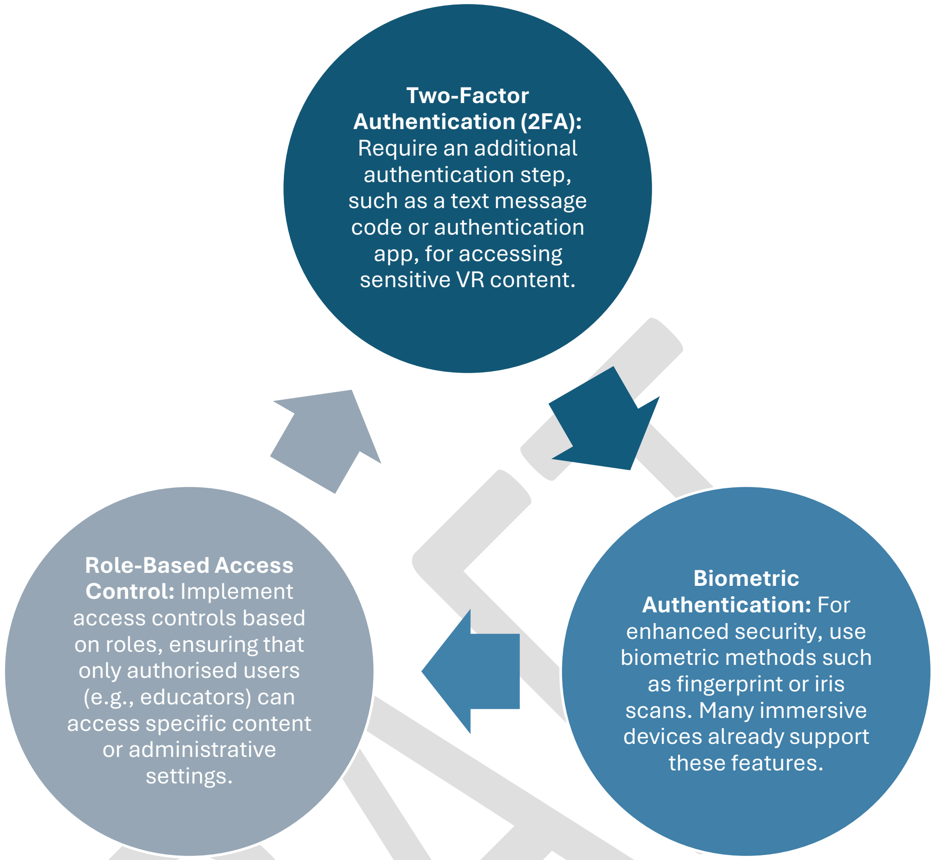

13.4 Meta User Agreement and Data Permissions

Because the Meta Quest headset is the preferred choice for many educational institutions (low cost, widely supported etc), it is worth highlighting Meta's policies around user permissions and the importance of understanding the terms of service when using devices like Meta's VR headsets (e.g., Meta Quest).

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*"**3. The permissions you give us.** We need certain permissions from you to provide our services: Permission to use content that you create and share: Some content that you share or upload, such as photos or videos, may be protected by intellectual property laws. You retain ownership of the content that you create and share on Facebook and other Meta Company Products that you use, and nothing in these Terms takes away the rights that you have to your own content. You are free to share your content with anyone else, wherever you want. To provide our services, however, we need you to give us some legal permissions to use this content. **However, to provide our services, we need you to give us some legal permissions (known as a "Licence") to use this content. This is solely for the purposes of providing and improving our Products and services as described in Section 1 above. Specifically, when you share, post or upload content that is covered by intellectual property rights on or in connection with our Products, you grant us a non-exclusive, transferable, sub-licensable, royalty-free and worldwide licence to host, use, distribute, modify, run, copy, publicly perform or display, translate and create derivative works of your content (consistent with your privacy and application settings). This means, for example, that if you share a photo on Facebook, you give us permission to store, copy and share it with others (again, consistent with your settings) such as Meta Products or service providers that support those products and services.** This licence will end when your content is deleted from our systems."* In summary, users retain ownership of their content on Meta platforms but grant Meta a non-exclusive, transferable, sub-licensable, royalty-free, and worldwide licence to use, store, distribute, and modify it for service improvement. This licence extends to hosting, translation, and creating derivative works. Meta may share user content with service providers, which could raise privacy concerns. The licence is revoked when users delete their content, though it may temporarily persist in backups.

- **Ownership of Content:** While users retain ownership of their content, Meta requires a licence to use, store, distribute, and modify the content shared on their platforms.
- **Scope of Licence:** Meta's licence is non-exclusive, transferable, sub-licensable, royalty-free, and worldwide. It covers hosting, distribution, translation, and derivative work creation but is limited to improving their services.
- **Data Sharing with Partners:** Meta reserves the right to share user content with service providers that support their products, raising potential privacy concerns.
- **Revocation of Licence:** The licence ends when users delete their content from Meta's systems. However, deleted content may persist in backups for a limited time.

13.4.1 Ethical Concerns Around Meta's Practices

As immersive technologies like Meta devices become increasingly integrated into educational settings, ethical considerations surrounding their use must be critically examined. Key concerns include transparency regarding data permissions, potential privacy risks, and the unique challenges posed within educational contexts. Institutions need to understand and evaluate the implications of these practices to safeguard student data and ensure the ethical implementation of such technologies.

Transparency Issues: While Meta's terms describe their practices, many users may not fully understand the implications of granting such broad permissions.

Privacy Risks: Behavioural and content data collected by Meta could potentially be analysed or shared in ways that users did not anticipate.

Educational Context: When using Meta devices in education, institutions must carefully evaluate the implications of these policies, especially when student-generated content or sensitive data is involved.

13.5 Best Practices for Educational Institutions

To address growing concerns around data privacy and transparency in the use of immersive technologies, institutions must adopt a proactive and strategic approach. This includes creating clear policies for data collection, negotiating vendor agreements that prioritise privacy, educating stakeholders on data implications, and exploring alternative platforms with enhanced controls. These steps collectively empower institutions to protect user privacy, maintain compliance with standards, and ensure informed use of third-party technologies.

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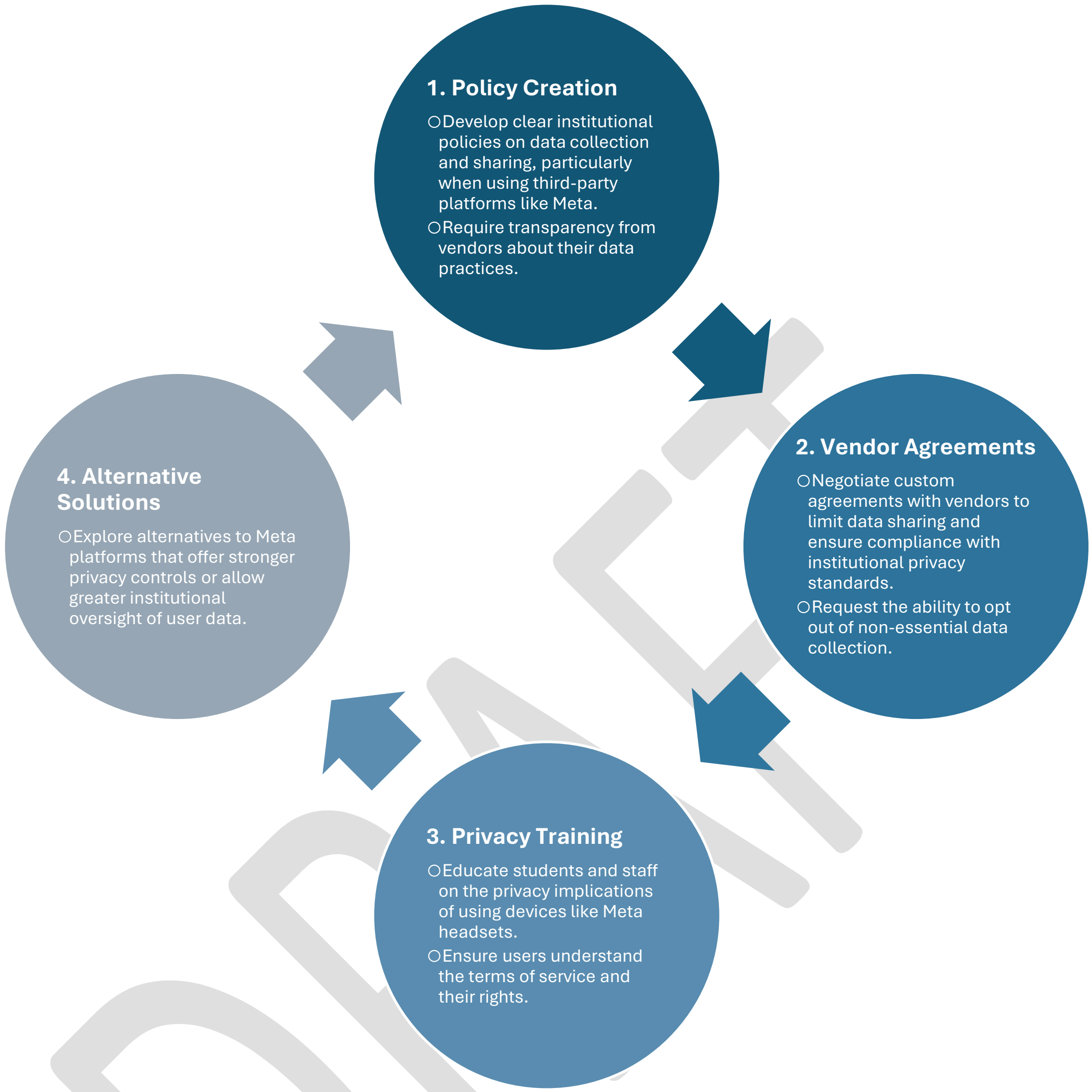

14. User Experience: Enhancing Engagement and Continuous Improvement

The success of immersive technologies in higher education hinges on delivering a high-quality user experience. Ensuring that VR, AR, and MR tools effectively engage students while being easy to use for both learners and educators is crucial for achieving positive learning outcomes. Two key components of optimising user experience are measuring student engagement and implementing robust feedback mechanisms to refine and improve the overall experience. By consistently measuring student engagement and implementing effective feedback mechanisms, institutions can ensure immersive

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technologies remain impactful, user-friendly, and aligned with the needs of students and educators alike.

14.1 Student Engagement

Immersive technologies offer unparalleled opportunities to enhance engagement by placing learners in interactive, dynamic environments. However, their impact on engagement must be measured and understood to ensure they deliver meaningful educational value:

Assessing Learning Outcomes: Use metrics such as test scores, retention rates, and skill acquisition to evaluate how immersive experiences influence learning outcomes compared to traditional methods. For example, VR simulations for medical students practising surgical techniques can be assessed for accuracy, confidence, and real-world application.

Behavioural Engagement: Track how students interact with the immersive environment, including the duration of engagement, the number of completed tasks, and their level of curiosity or enthusiasm. Metrics such as headset usage time or task completion rates can provide insights into user involvement.

Affective Engagement: Evaluate emotional responses to immersive experiences through surveys or observation. Immersive environments that evoke curiosity, excitement, or empathy are more likely to resonate with students and lead to long-term retention. For instance, VR simulations depicting environmental challenges can spark emotional engagement with sustainability issues.

Personalisation and Adaptability: Tailor immersive experiences to match individual learning styles or pace. Personalisation can help students feel more connected to the material, boosting engagement and reducing frustration.

14.2 Feedback Mechanisms

To ensure the ongoing success and usability of immersive technologies, continuous feedback from both students and educators is essential. This feedback drives improvements and helps institutions adapt the technology to meet evolving needs.

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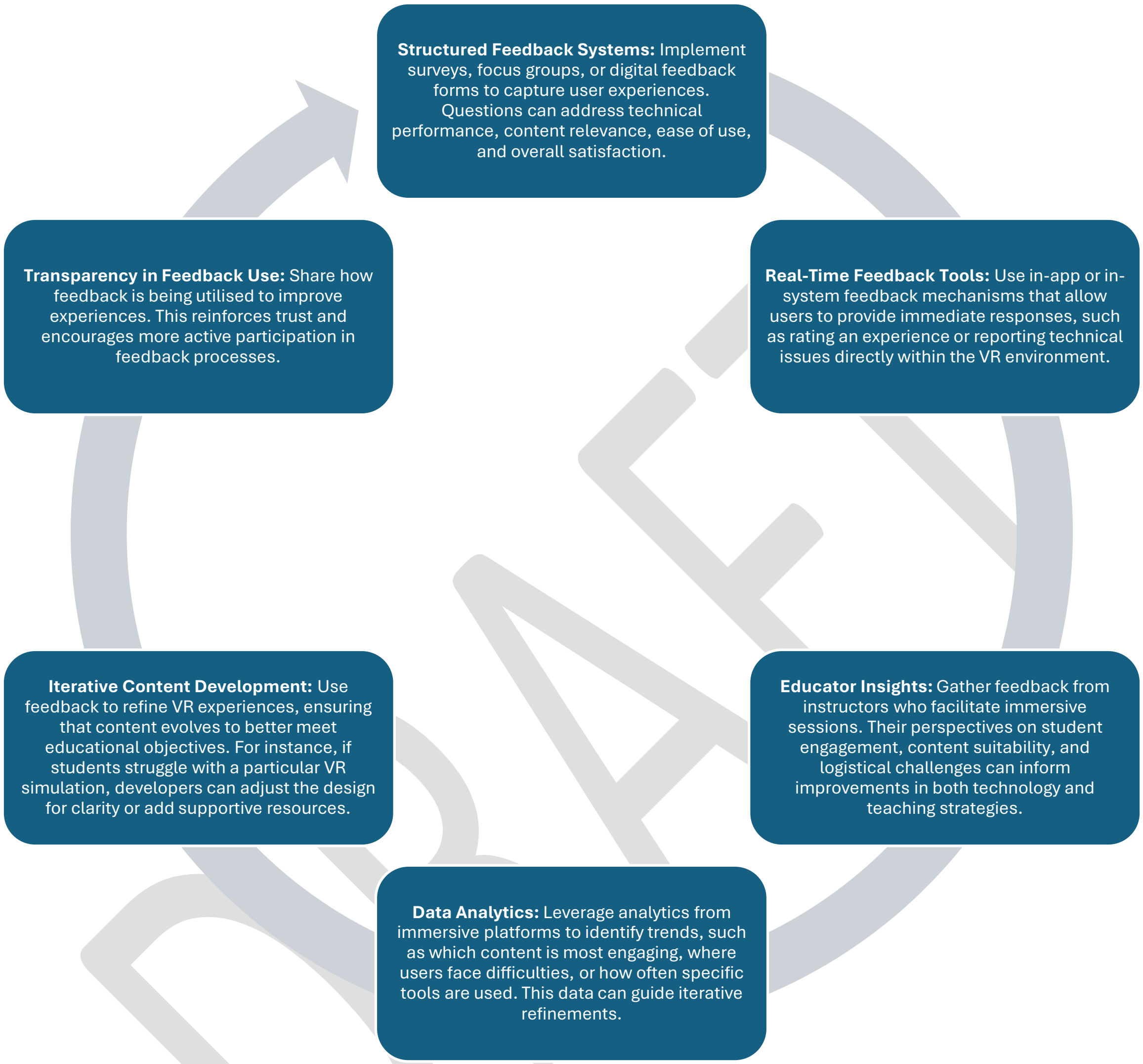

14.3 Enhancing the User Experience

The successful integration of immersive technologies in education relies on delivering a positive and engaging user experience. By focusing on adoption rates, learning outcomes, institutional innovation, and long-term sustainability, institutions can maximise the value of these tools. A well-structured approach ensures greater acceptance among students and educators, improved learning retention, and a sustainable investment that positions

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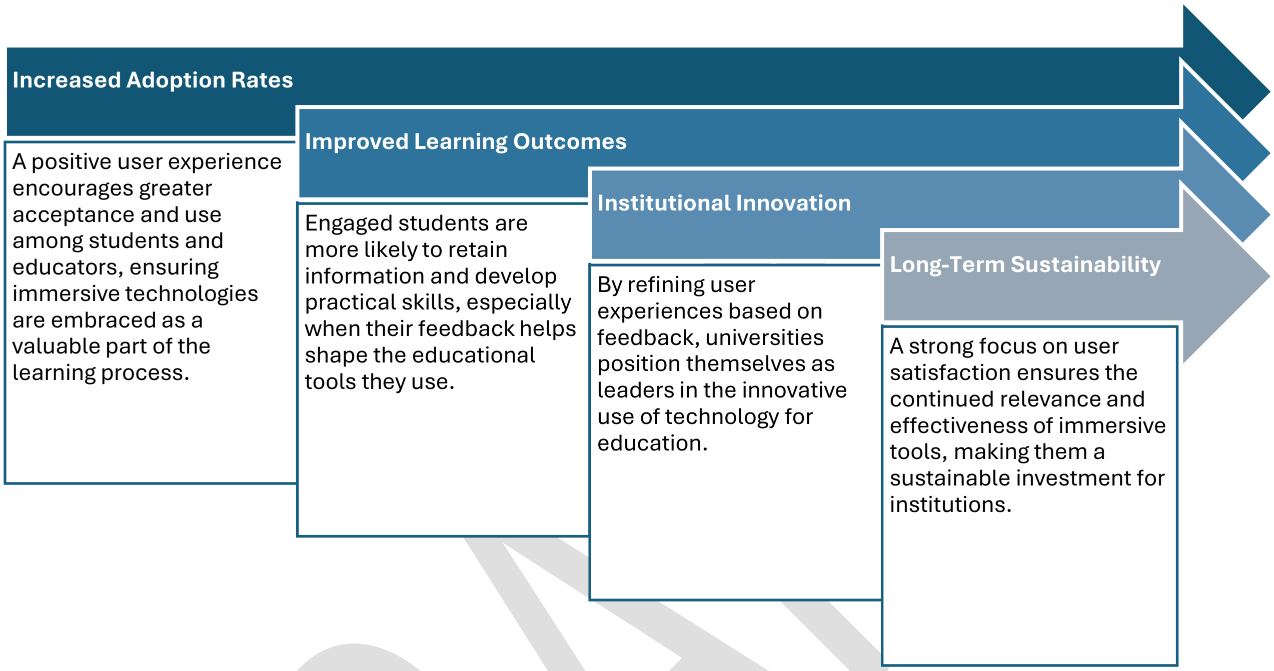
universities as leaders in educational technology. A focus on user experience leads to significant benefits for immersive technology adoption in higher education.



15. Health and Safety: Considerations for Integrating Immersive Technologies in Education

Immersive technologies offer transformative educational opportunities, but they also introduce specific health and safety risks that institutions must address to ensure student and staff well-being. Key considerations include conducting risk assessments, obtaining legal permissions, and implementing guidelines around age limits and usage durations. By addressing these health and safety considerations, institutions can create a safe and inclusive environment for using immersive technologies, maximising their benefits while protecting users.

15.1 On-Site and Off-Site Risk Assessments

The safe use of immersive technologies, whether on-site or off-site, requires careful risk assessment and proactive measures to protect users. On-site considerations include addressing physical hazards like tripping, collisions, and ventilation, particularly for VR

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environments where spatial awareness is reduced. For off-site AR or outdoor experiences, environmental factors such as terrain, weather, and proximity to hazards must be evaluated. By implementing safety guidelines, ensuring proper equipment management, and maintaining hygiene protocols, institutions can create secure and effective immersive learning environments. **Appendix A and B** are sample templates of the Risk Assessment carried out before delivering immersive experiences both on-site and off-site.

On-Site Risks	Off-Site Risks
Assess physical spaces where immersive technologies will be used to identify and mitigate risks such as tripping hazards, collisions, or overcrowding.	For field-based immersive experiences, such as AR-enhanced outdoor learning, assess environmental hazards like uneven terrain, weather conditions, or proximity to roads.
Ensure the area is clear of obstacles and has adequate ventilation, lighting, and space for safe movement, particularly for VR, where users may be unaware of their physical surroundings.	Provide clear guidelines for safely using devices outside, including how to maintain awareness of real-world surroundings.
Evaluate electrical safety for devices requiring power, ensuring cables are secured and not a trip hazard.	
Implement safeguards for shared devices, including regular cleaning and disinfecting to prevent hygiene issues.	

15.2 Legal Permissions and Waiver Forms

Appendix C is a sample template of the Permissions and Waivers that all users need to read, understand and agree to before taking part in immersive experiences. These samples have been cleared by the Legal Team and applied to REEdI at MTU. Each institution that wishes to adopt or modify these documents for its purpose will need to clear them past their Legal teams and processes.

User Consent	Require users (or their guardians, if underage) to sign waivers acknowledging the potential risks associated with immersive technologies, such as motion sickness, eye strain, or disorientation.	
	Include detailed information about data privacy, explaining how user data may be collected, stored, and used, in compliance with regulations such as GDPR.	
Liability Waivers	Include clauses in waiver forms to protect the institution from liability in cases of minor injuries or discomfort resulting from immersive technology use.	
	Ensure waivers specify that users must follow safety guidelines and instructions provided by staff or embedded in the technology.	
Medical Disclosures	Ask users to disclose any pre-existing conditions that could be exacerbated by immersive experiences, such as epilepsy, vertigo, or motion sensitivity.	
Accessibility Accommodations		Address accessibility needs in the forms, ensuring users can request modifications or alternative formats to participate safely in immersive experiences.

15.3 Recommendations for Age Limits

Establishing age limits and guidelines for using immersive technologies in education ensures both the safety and suitability of these tools for learners. VR and AR offer transformative potential, but their use must be aligned with the developmental stages and well-being of students. Adhering to manufacturer recommendations, securing parental consent, and ensuring age-appropriate content are key strategies to maximise the benefits while minimising risks associated with these technologies.

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Age-Appropriate Use

- Follow manufacturer guidelines for minimum age requirements, which typically recommend VR use for users aged 13 and above due to potential impacts on vision development and susceptibility to discomfort.
- For younger students, consider AR tools that use tablets or smartphones, which are less immersive and pose fewer health risks.

Parental or Guardian Consent

- For users under 18, obtain explicit consent from a parent or guardian, and ensure they understand the potential risks.

Content Suitability

- Verify that the immersive content is age-appropriate, avoiding simulations or experiences that could cause distress, confusion, or harm.

15.4 Recommendations for Time Using Immersive Technologies

The effective use of immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR), requires careful consideration of user comfort and well-being. Recommendations for session duration, break intervals, and user acclimatisation are vital to prevent discomfort and enhance the overall experience. These guidelines are especially important for younger users and first-time participants to ensure a safe and positive introduction to immersive learning.

Timed Sessions and Regular Breaks: Limit VR sessions to 20–30 minutes for younger users and 30–60 minutes for adults, depending on the intensity of the experience. Prolonged use can lead to eye strain, fatigue, or discomfort. Encourage breaks of at least 10–15 minutes between sessions to allow users to rest their eyes, reorient themselves, and reduce the risk of overexposure.

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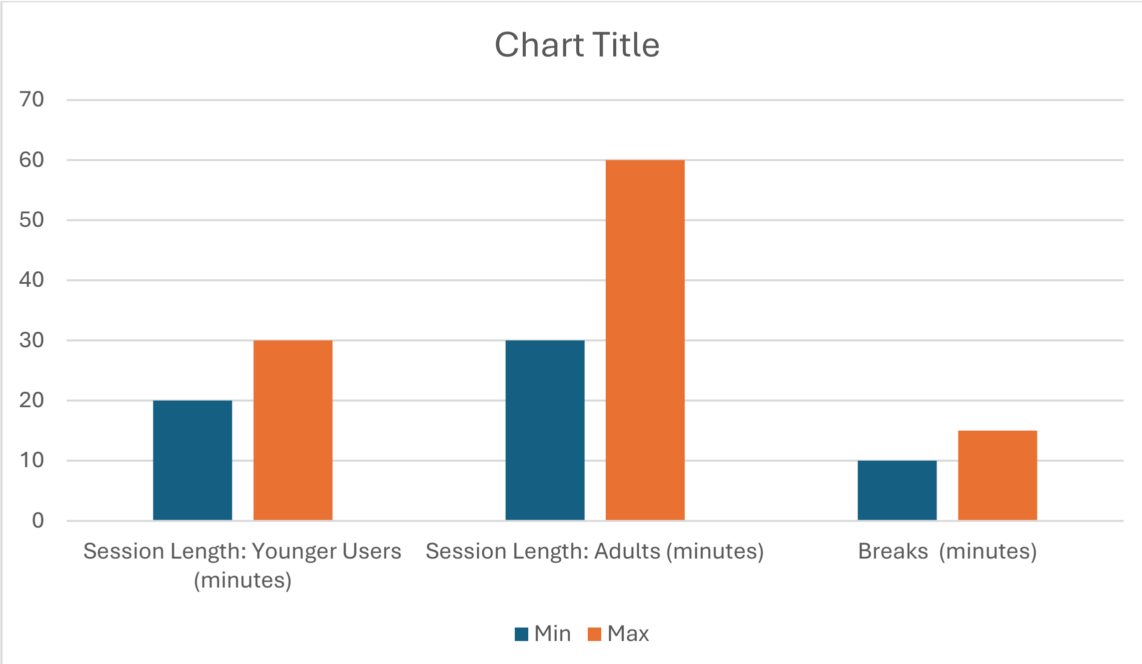

Gradual Acclimatisation: For first-time users, start with shorter sessions to help them adjust to immersive experiences and minimise the risk of motion sickness or dizziness.

Monitoring Discomfort: Instructors or facilitators should monitor users for signs of discomfort, such as nausea, headaches, or disorientation, and intervene promptly if necessary.

15.6 Best Practices for Implementation

Safety Training: Train staff to manage immersive technology use, including how to set up equipment safely, supervise users, and respond to any health or safety concerns.

Signage and Instructions: Display clear instructions in immersive technology areas, outlining safe usage practices, time limits, and emergency procedures.

Hygiene Protocols: Establish hygiene standards for shared devices, such as providing disposable headset covers and sanitising equipment between uses.

Feedback Mechanisms: Allow users to report health and safety issues, ensuring continuous improvement of protocols and risk management.

Appendix A – C are templates utilised at REEdi and MTU for Health and Safety assessments for all users of immersive technologies. It is recommended that these are assessed by individual institutions' Health and Safety, as well as Legal teams.

16. The Human Factor: Resources and Skillsets Required

Successfully integrating immersive technologies into education requires a diverse range of expertise spanning technical, pedagogical, and administrative domains. By assembling a multidisciplinary team with these skillsets, educational institutions can effectively plan, deploy, and sustain immersive technologies to enhance teaching and learning experiences.

16.1 Overview of Key Rolls and Skills

Below is an overview of the key roles and the skills they bring to the implementation, management, and scaling of these technologies:

16.1.1 Developers

- **Responsibilities:**
  - Design and develop custom VR, AR, or MR applications tailored to educational goals.
  - Use tools such as Unity, Unreal Engine, or WebXR for content creation.
  - Implement interactive features and optimise performance for various devices.
- **Required Skills:**
  - Proficiency in programming languages like C#, Python, or JavaScript.

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- Experience with 3D modelling and animation integration.
- Knowledge of device-specific software development kits (SDKs) for platforms like Oculus, Magic Leap, or HoloLens.

16.1.2 Learning Technologists

- **Responsibilities:**
  - Bridge the gap between technology and pedagogy by aligning immersive tools with curriculum objectives.
  - Train educators on how to integrate immersive technologies into their teaching practices.
  - Evaluate the educational impact of immersive tools and recommend improvements.
- **Required Skills:**
  - Expertise in instructional design and digital pedagogy.
  - Familiarity with immersive platforms and educational technologies.
  - Strong communication and training skills.

16.1.3 Technicians

- **Responsibilities:**
  - Manage the installation, maintenance, and troubleshooting of immersive technology hardware.
  - Ensure devices such as VR headsets, AR glasses, projectors, and sensors are functioning optimally.
  - Set up and support immersive classrooms, labs, or studios.
- **Required Skills:**
  - Proficiency in hardware and software troubleshooting.
  - Understanding of networking, device compatibility, and integration.
  - Ability to provide on-the-spot technical support during immersive sessions.

16.1.4 Content Creators

- **Responsibilities:**
  - Develop immersive educational content, such as 3D models, animations, simulations, and virtual tours.
  - Use tools like Blender, Maya, or Adobe Creative Suite for designing visual assets.
  - Collaborate with subject matter experts (SMEs) to ensure content accuracy and relevance.

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- **Required Skills:**
  - Strong 3D design, animation, and video editing expertise.
  - Knowledge of user experience (UX) design principles for immersive environments.
  - Creative skills to design engaging and interactive content.

16.1.5 Procurement Specialists

- **Responsibilities:**
  - Identify and evaluate hardware and software solutions that align with institutional needs and budgets.
  - Negotiate with vendors and manage licensing agreements.
  - Ensure compliance with institutional procurement policies and legal standards.
- **Required Skills:**
  - Expertise in vendor management and contract negotiation.
  - Knowledge of immersive technology hardware and software markets.
  - Budget planning and financial analysis capabilities.

16.1.6 Finance Professionals

- **Responsibilities:**
  - Develop budgets for immersive technology implementation, maintenance, and scaling.
  - Identify funding sources, including grants, partnerships, or institutional allocations.
  - Monitor and report on financial performance and ROI for immersive projects.
- **Required Skills:**
  - Strong financial planning and analysis capabilities.
  - Understanding of funding mechanisms and cost management.
  - Ability to forecast long-term financial sustainability of technology initiatives.

16.1.7 Educators and Subject Matter Experts (SMEs)

- **Responsibilities:**
  - Provide content expertise to guide the development of immersive educational materials.
  - Test immersive tools and offer feedback to improve usability and relevance.
  - Integrate immersive experiences into lesson plans and deliver them effectively.

The Rethinking Engineering Education in Ireland (REEdI) Project at Munster Technological University (MTU) is funded by the Higher Education Authority (HEA) Human Capital Initiative (HCI) Pillar 3 Programme.

- **Required Skills:**
  - Deep subject knowledge and curriculum design experience.
  - Willingness to adapt to new technologies and teaching methodologies.
  - Strong communication and feedback skills for collaboration with developers and technologists.

16.1.8 IT Support Staff

- **Responsibilities:**
  - Manage the technical infrastructure for immersive technologies, including networks, servers, and cloud services.
  - Ensure data security and compliance with privacy regulations.
  - Provide ongoing technical support for users and administrators.
- **Required Skills:**
  - Expertise in IT infrastructure, cybersecurity, and cloud management.
  - Knowledge of immersive technology systems integration.
  - Troubleshooting and user support skills.

16.1.9 Project Managers

- **Responsibilities:**
  - Oversee the end-to-end implementation of immersive technology projects.
  - Coordinate between departments, vendors, and stakeholders to ensure timely delivery.
  - Monitor project milestones, budgets, and outcomes.
- **Required Skills:**
  - Strong organisational and leadership skills.
  - Knowledge of project management methodologies like Agile or PRINCE2.
  - Ability to manage cross-functional teams effectively.

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16.2 Summary of Roles and Their Contributions

Role	Key Contribution
Developers	Create custom software and applications for immersive learning experiences.
Learning Technologists	Ensure alignment of immersive technologies with educational goals and provide training for educators.
Technicians	Maintain and troubleshoot hardware and software systems for smooth operation.
Content Creators	Design interactive and engaging educational materials for immersive platforms.
Procurement Specialists	Manage the acquisition of hardware and software, ensuring cost-effectiveness and compliance.
Finance Professionals	Budget planning, funding allocation, and financial oversight for immersive projects.
Educators and SMEs	Provide subject expertise and integrate immersive tools into teaching practices.
IT Support Staff	Manage technical infrastructure and ensure data security for immersive systems.
Project Managers	Coordinate and deliver immersive technology projects within scope, budget, and timeline.

17. Maximising Educational Value

The true potential of immersive technologies in higher education lies in their ability to enrich learning experiences and improve outcomes. To realise this value, universities must strategically align these tools with curriculum goals, invest in content development, and provide robust training for educators. By focusing on curriculum integration, high-quality content development, and comprehensive teacher training, universities can maximise the educational value of immersive technologies and create transformative learning experiences.

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Curriculum Integration: Immersive technologies must be intentionally woven into the curriculum to ensure they contribute meaningfully to educational objectives. First, aligning these tools with specific learning outcomes is essential; for instance, VR simulations can help bring abstract scientific concepts to life or provide practical training in clinical skills. Additionally, universities can customise the use of immersive tools to address discipline-specific needs, such as using AR in architecture to visualize designs in real-world settings or employing MR in engineering for collaborative problem-solving. Beyond functionality, immersive technologies enhance engagement by immersing students in active learning environments. For example, students can explore historical landmarks in VR or simulate real-world business scenarios, fostering deeper engagement and better retention of material. Ultimately, integrating these tools strategically can significantly improve educational outcomes.

Content Development: Creating or sourcing high-quality, curriculum-aligned content is critical to the success of immersive technologies. Institutions can collaborate with developers or utilise in-house resources to create bespoke VR and AR modules that reflect local educational standards and cultural contexts. Alternatively, universities can partner with established providers to access pre-designed simulations and content libraries tailored to academic disciplines. It is vital to ensure that the content is interactive and adaptable, accommodating various learning styles to make it more inclusive and effective. For instance, gamified VR simulations can cater to both visual and experiential learners. Furthermore, regular updates to immersive content ensure alignment with evolving academic fields, keeping materials relevant and accurate to meet changing educational standards.

Teacher Training: Educators are pivotal in leveraging immersive technologies effectively, and comprehensive training ensures they are confident and prepared to integrate these tools into their teaching practices. Training should cover technical skills, such as setting up, operating, and troubleshooting hardware and software like VR headsets or AR-enabled apps. Pedagogical approaches also need to be developed, helping educators design instructional strategies that integrate immersive technologies to complement traditional teaching methods. For example, educators could use VR to simulate fieldwork or AR for interactive lab sessions. Moreover, content creation training can empower educators to customise or develop immersive content that aligns with their teaching goals. Finally, establishing ongoing support systems, such as helpdesks or peer collaboration networks, can help educators resolve technical or instructional challenges, ensuring their sustained confidence and effectiveness in using these tools.

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18. Maximising Educational Impact

The true potential of immersive technologies in higher education lies in their ability to enrich learning experiences and improve outcomes. To fully harness this potential, universities must strategically align these tools with curriculum goals, invest in high-quality content development, and provide robust training for educators. When implemented effectively, immersive technologies can yield numerous benefits, including enhanced learning outcomes, increased inclusivity, improved educator confidence, and a strengthened institutional reputation.

Enhanced Learning Outcomes: Immersive experiences make abstract concepts more tangible, enabling students to better grasp difficult material. By engaging students in interactive and hands-on activities, these technologies improve skill acquisition and retention rates. For example, virtual reality (VR) simulations can allow students to explore complex scientific phenomena or practice medical procedures in a safe and controlled environment, leading to deeper learning and application of knowledge.

Greater Inclusivity: The customisable and interactive nature of immersive content ensures that it can accommodate diverse learning styles and abilities. By catering to visual, auditory, and experiential learners, these technologies create a more inclusive educational environment. For instance, students with disabilities can benefit from tailored simulations that adapt to their needs, removing barriers to participation and fostering equitable access to education.

Improved Educator Confidence: With the right training and ongoing support, educators are more likely to embrace immersive technologies and integrate them consistently into their teaching practices. When educators feel confident using tools like VR or augmented reality (AR), they can deliver more impactful lessons and experiment with innovative approaches, ensuring students benefit fully from these technologies.

Institutional Reputation: Successfully integrating immersive technologies can position universities as leaders in educational innovation, attracting prospective students, faculty, and research opportunities. Institutions that demonstrate a commitment to cutting-edge teaching methods are more likely to gain recognition and secure partnerships with industry leaders, further enhancing their prestige.

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19. Pilot Programs: A Strategic Approach to Immersive Technology Integration

Pilot programs are an essential step in the thoughtful adoption of immersive technologies within higher education. By implementing small-scale trials before committing to institution-wide integration, higher education institutions can evaluate the practical implications of using immersive tools, ensuring they meet educational objectives and align with budgetary and operational constraints. Pilot programs serve as a low-risk, high-value approach to ensure immersive technologies deliver on their potential while aligning with the strategic goals of the institution.

19.1 The Role of Pilot Programs in Evaluating and Scaling Immersive Technology Integration

Before full-scale integration, launching a pilot program to test the effectiveness and feasibility of immersive technology integration can help. They provide institutions with the opportunity to evaluate the effectiveness of tools like VR and AR in enhancing learning outcomes while gathering valuable feedback from students and faculty on usability and impact. These programs also help to identify technical or pedagogical challenges, such as device compatibility or integration into curricula, and allow institutions to adjust cost estimates based on real-world use. Furthermore, pilots are instrumental in building stakeholder confidence by demonstrating measurable benefits, such as increased engagement and skill acquisition, encouraging further investment and adoption.

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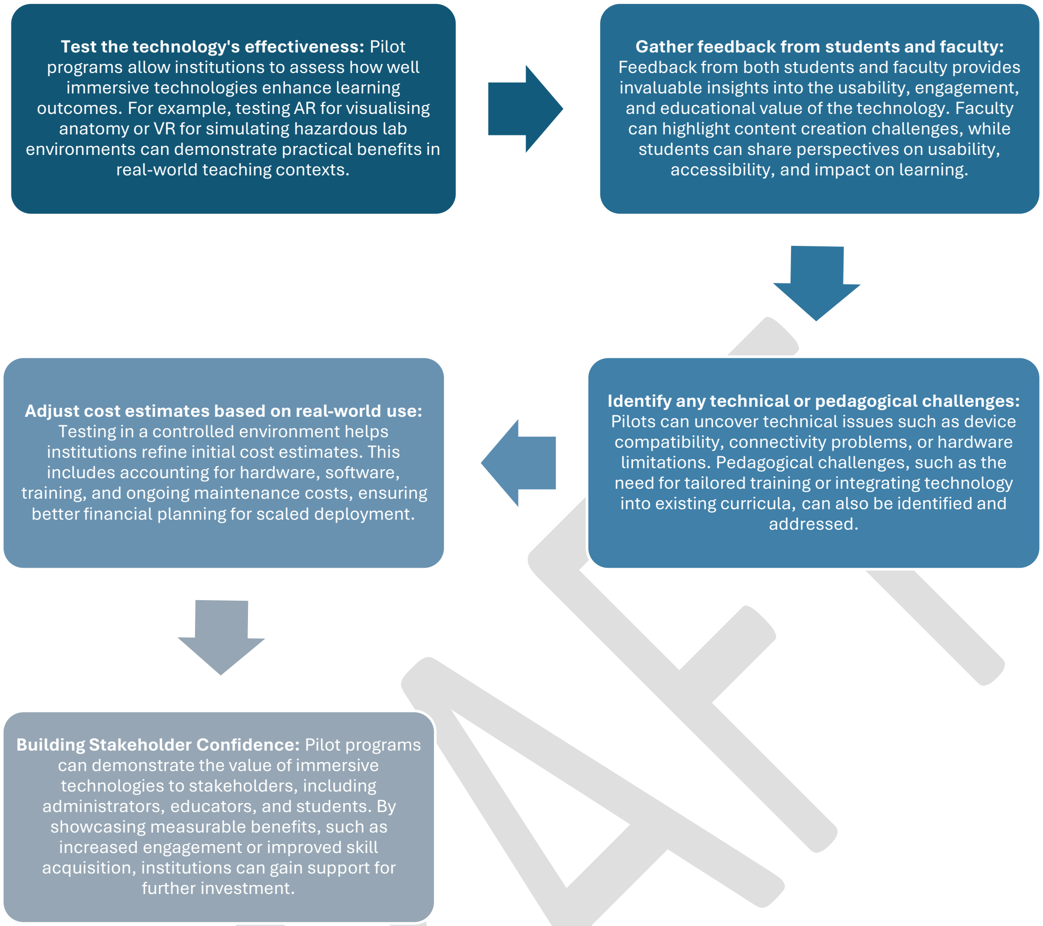

19.2 Example Pilot Strategies: Exploring Targeted and Collaborative Applications

Each of these pilot strategies serves as a stepping stone toward understanding the practicalities, benefits, and challenges of integrating immersive technologies into education. By tailoring these pilots to specific use cases, institutions can gather the insights needed to scale implementation effectively and maximize the impact of these tools in a variety of learning contexts.

Department-Level Trials: Starting with department-specific pilots allows institutions to test immersive technologies in areas where they have immediate and practical applications. For instance, in the engineering department, VR can simulate complex machinery, enabling students to explore components and functionality without requiring physical equipment. Similarly, in healthcare education, MR can be used for clinical simulations, such as virtual anatomy dissections or practising surgical techniques in a risk-free environment. These trials provide an opportunity to evaluate the effectiveness of

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the technology in discipline-specific scenarios, identify potential challenges such as hardware limitations or usability issues, and gather targeted feedback from faculty and students who are directly engaged with the tools.

Student Cohort Pilots: Focusing on a specific cohort of students allows for a controlled environment to test how AR or other immersive technologies enhance learning outcomes. For example, AR-enabled course materials can be used to help students visualize abstract or complex concepts in subjects like mathematics, physics, or chemistry. A cohort pilot could involve integrating AR to demonstrate molecular structures in real-time or overlaying 3D visualisations on engineering blueprints. By gathering detailed feedback from the cohort, institutions can assess how well the technology improves comprehension, engagement, and retention of the material, as well as any adjustments needed for effective implementation across larger groups.

Cross-Disciplinary Pilots: Cross-disciplinary pilots allow institutions to explore how immersive technologies can foster collaboration between different fields of study. For example, a pilot combining VR in engineering and MR in architectural design could simulate real-world projects where students work together to design and analyze structural models in virtual environments. These pilots can also involve interdisciplinary applications, such as using VR for environmental studies (e.g., simulating ecosystems) while combining it with AR for data overlays during field research. Such collaborative pilots provide insights into how immersive technologies can break down silos between disciplines, promote teamwork, and offer a broader range of educational benefits.

19.3 Scaling After the Pilot: Building a Robust Implementation Plan

Once the pilot program concludes, institutions can thoroughly analyse the results to create a comprehensive and effective implementation plan for scaling immersive technologies. This phase is crucial to ensure that the broader deployment addresses the challenges encountered during the pilot and leverages its successes to maximise impact. Institutions can develop a robust scaling strategy that not only enhances the adoption of immersive technologies but also ensures sustainable and impactful usage across all levels of their educational framework. Key considerations for scaling include expanding infrastructure, training staff, and optimising processes for smoother adoption:

Expanding Infrastructure Based on Feedback and Identified Needs: The pilot phase often highlights gaps in existing infrastructure, such as insufficient hardware, network capacity, or space for immersive technology setups. Based on the feedback from pilot users, institutions can identify specific needs, such as acquiring additional VR headsets,

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upgrading server capabilities, or creating dedicated spaces for immersive experiences. Addressing these needs ensures that the technology can scale effectively without compromising performance or user experience. For instance, enhancing Wi-Fi connectivity in classrooms or investing in standalone VR hardware might be necessary to accommodate larger user bases.

Training Additional Faculty and Support Staff: Scaling immersive technologies requires a well-trained team to support both technical and pedagogical needs. During the pilot, initial training may have been limited to a small group of educators and IT staff. For broader adoption, additional faculty and support staff must be trained to confidently integrate the technology into their teaching workflows. This training should go beyond basic operations to include advanced troubleshooting, innovative instructional strategies, and ongoing professional development to keep up with technological advancements.

Incorporating Lessons Learned to Optimise Technology Usage: The pilot provides valuable insights into what works and what doesn't. Institutions should incorporate these lessons into their scaling strategy to streamline technology usage and minimize potential challenges. For example, if certain content delivery methods or interaction designs were found to be particularly effective, these can be standardized across programs. Conversely, any issues, such as VR motion sickness or compatibility problems, should be addressed proactively by refining user guidelines, improving content quality, or updating hardware specifications. By integrating this feedback into the deployment plan, institutions can ensure a smoother transition to full-scale implementation.

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APPENDIX A

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

DOCUMENT: IMMERSIVE TECHNOLOGY RISK ASSESSMENT

COURSE: MECHANICAL AND MANUFACTURING ENGINEERING, RETHINKING ENGINEERING EDUCATION IN IRELAND (REEDI)

HARDWARE: IMMERSIVE TECHNOLOGY HMDS INCLUDING META QUEST 2/3, MICROSOFT HOLOLENS ETC

	RISK ASSESSMENT NUMBER: MTU-KY_		**Assessor(s):**	**Risk Assessment Date :**	
			(H&S Officer)	**Safety Group Responsible:**	
MTU - Kerry Campus	**Risk Assessment Area being assessed:**	Using VR headsets		**Person Responsible for this RA:**	

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	Previous revision reference:		N/A										
Hazards													
Area	**Hazard**	**Risk Associated**	**Existing Procedures and Controls**	**L**	**S**	**LxS**	**Risk Rating**	**Actions, Improvements and Additional Controls**	**L**	**S**	**LxS**	**Risk Rating**	**Person responsible**
				1	5	5	L		1	5	5	L	
All Scenarios: Wearing of VR headsets	Users may experience motion sickness and/or eye strain. Slips, trips, falls and collisions. Wearing a headset may cause seizures in extremely rare cases.	Falling, eye strain, fatigue, headaches, nausea, choking, seizures (extremely rare)	All team members have received First Aid training. Users are encouraged to remove the headset as soon as negative symptoms present. Users are limited to max 15 minutes per			0		Users to read and sign/agree waivers of risks associated with VR headsets - Waivers approved by MTU Legal. Controlled use and time spent using VR headsets. Recommended age limits in place to ensure users <			0		REEdI Team

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			session with 10-minute breaks. Users are seated in designated areas.					12 years old do not have access to VR headsets.					
MTU Kerry North Campus and any lecture hall/classroom throughout MTU Kerry including KSA	Slips trips and falls as the users' field of view is completely blocked. Collisions with objects including other users.	Slips trips and falls. Struck by other users using VR controllers. Bumping into objects if not seated.	Users are seated in designated areas with enough clearance (2m x 2m) for each user when using headsets. The number of users is limited to the space available. Time limits on continuous use of headsets per session - max 15 mins per session with 10 mins breaks.			0		Users to read and sign/agree with waivers of risks associated with VR headsets - Waivers approved by MTU Legal. Controlled use and time spent using VR headsets. Adequate and appropriate space is allocated for using VR headsets. Adequate staff/user ratios for effective management of group sizes.			0		REEdI Team

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Off site visits such as schools or public spaces	Slips trips and falls as the users' field of view is completely blocked. Collisions with objects including other users.	Slips trips and falls. Struck by other users using VR controllers. Bumping into objects if not seated.	Users are required to be seated in designated areas with enough clearance when using headsets. Number of users limited to the space available. Protocols left to individual off-site managers to provide adequate space for using headsets. Time limits on continuous use of headsets per session - max 15 mins per session with 10 mins breaks. Pre-assessment of areas to ensure			0		Users to read and sign/agree waivers of risks associated with VR headsets - Waivers approved by MTU Legal. Managers to comply with requirements and sign waivers on behalf of users where needed. Adequate and appropriate space allocated for using VR headsets. Adequate staff/user ratios for effective management of group sizes. Recommended age limits in place to ensure users < 12 years old do not have access to VR			0		REEdI Team present on day. Representative(s) at visiting location.

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			location is adequate - Off-site venues to confirm suitability of locations via MTU checklist based on MTU requirements as stipulated in Waivers.					headsets.					

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APPENDIX B

DOCUMENT: IMMERSIVE REALITY TRAINING | RISK ASSESSMENT, MITIGATION AND RESPONSES | RISK ASSESSMENT PROTOCOL FOR TRAINING USERS USING IMMERSIVE TECHNOLOGIES

COURSE: MECHANICAL AND MANUFACTURING ENGINEERING, RETHINKING ENGINEERING EDUCATION IN IRELAND (REEDI)

HARDWARE: IMMERSIVE TECHNOLOGY HMDS INCLUDING META QUEST 2/3, MICROSOFT HOLOLENS ETC

Purpose:

This risk assessment protocol aims to identify the risks associated with using VR headsets for training purposes and establish appropriate risk mitigation protocols and risk responses to ensure the safety of personnel and property.

Risk Assessment:

Property Damage:

Risk: VR headsets can be damaged if they are not handled properly or if they are dropped, resulting in potential property damage.

Risk Mitigation: Train users on the proper handling and care of VR headsets, provide a secure storage location for headsets when not in use, and establish a policy for reporting damage immediately.

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Risk Response: Repair or replace damaged headsets as necessary.

Hardware Malfunction:

Risk: Hardware malfunction can occur during use, resulting in the potential loss of data or personal injury.

Risk Mitigation: Conduct regular maintenance checks on VR headsets, establish a protocol for users to report any hardware issues immediately, and keep spare hardware on hand for replacement if necessary.

Risk Response: Repair or replace malfunctioning hardware as necessary, and back up data to prevent data loss.

Health and Safety:

Risk: Prolonged use of VR headsets can cause motion sickness, eye strain, and other health issues. Additionally, users may trip, fall or collide with other objects or individuals in the real-world environment while using the VR headset.

Risk Mitigation: Limit VR headset use to shorter durations, provide breaks between sessions, train users on proper posture and movement while using the headset, and establish a safe and secure training environment.

Risk Response: Provide medical attention or first aid as necessary in the event of an injury or illness and address any safety concerns or hazards promptly.

Personal Injury:

Risk: Users may trip, fall, or collide with other objects or individuals in the real-world environment while using the VR headset, resulting in personal injury.

Risk Mitigation: Establish a safe and secure training environment, limit VR headset use to shorter durations, provide breaks between sessions, and train users on proper posture and movement while using the headset.

Risk Response: Provide medical attention or first aid as necessary in the event of an injury and address any safety concerns or hazards promptly.

Conclusion:

The risks associated with using VR headsets for training purposes can be mitigated through proper training, maintenance, and risk response protocols. Regularly assessing and

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addressing risks will ensure a safe and secure training environment for all personnel involved.

APPENDIX C

DOCUMENT: IMMERSIVE TECHNOLOGIES PERMISSIONS AND WAIVERS FORM (SEPT 2022 – JULY 2025)

COURSE: MECHANICAL AND MANUFACTURING ENGINEERING, RETHINKING ENGINEERING EDUCATION IN IRELAND (REEDI)

HARDWARE: META QUEST 3 INCL. BATTERY + STRAP AND CARRY CASE

Requests for Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and Extended Reality (XR) Permissions and Waivers Form for all users.

Users' utilisation of Immersive Technologies - henceforth referred to as Immersive Technologies – including software and hardware such as head-mounted displays differ based on factors such as their usage preferences, device choice, physical environment (e.g., a VR lab versus a chair in a library), personal restrictions, facility constraints, desired outcomes for events or classes, number of participants involved, etc. This Permission and Waiver Form encompasses the unique circumstances and requirements of Munster Technological University, Kerry, and its facilities. ***Information shared during online registrations or interactions, whether through software, apps, or online access, is protected by strict international privacy laws, such as the EU GDPR and other privacy regulations. These laws specifically apply to children under the age of 13.***

Acknowledgment

I, the below-signed participant, or designated representative, acknowledge that I have voluntarily chosen to use Immersive Technologies provided by Munster Technological University, Kerry. I understand that using Immersive Technologies involves certain risks, and I agree to release and hold harmless Munster Technological University, Kerry from any liability arising from my use of Immersive Technologies.

Assumption of Risk

I am aware that participating in Immersive Technologies involve potential risks, including but not limited to:

- Physical injury or discomfort, such as motion sickness (cybersickness)*, dizziness, eyestrain, nausea, increased heart rate, increased body temperature, disorientation, vertigo, seizures, injury from other players, self-injury due to user confusion, for example, bumping into walls or objects, tripping, jumping or throwing, etc., tripping, falling, or colliding with objects or persons due to impaired vision or altered perception**, injury due to improper or excessive use of Immersive Technologies equipment.
- Emotional or psychological distress caused by exposure to virtual environments or stimuli.

While using Immersive Technologies:

- Flickering screens and flashing images could trigger underlying health conditions.
- Equipment may affect medical devices such as cardiac pacemakers etc.
- The media content of some experiences may affect those with pre-existing medical or mental health conditions.
- It is possible to feel claustrophobia, panic, or feel other phobias.
- Objects in the real world may not be visible in the virtual world.
- Objects in the virtual world may not exist in the real world.
- You must self-monitor your health and pause or stop if you become unwell.
- Negative health effects may not present immediately.

Fitness to Practise and Study and Student Health

The Rethinking Engineering Education in Ireland (REEdI) Project at Munster Technological University (MTU) is funded by the Higher Education Authority (HEA) Human Capital Initiative (HCI) Pillar 3 Programme.

Fitness to study is described as the possession of the requisite skills, knowledge, health (mental or physical), character, and ability to participate in studies at Munster Technological University safely and effectively. Students are required to have adequate health to undergo their chosen course of study and profession. It is important to note that this does not mean that students must be free of any disability. Munster Technological University, Kerry will comply with Equal Status legislation and make appropriate reasonable accommodations. A student on a Relevant Programme is required to complete a health declaration on first registration and thereafter annually. Where there is a fitness to practice and/or study concern requirement regarding a student's health, the student may be referred to a relevant healthcare professional. The student is obliged under this Policy to attend such medical consultation as required. A process under this Policy can proceed notwithstanding the failure of the student to attend the nominated healthcare professional.

Guidelines

Before using Immersive Technologies, make sure the "*playing area*" is free of any obstructions such as chairs, backpacks, or other objects that might pose a tripping hazard, and allow for 2x2 meter sq. space between users.

Be respectful of people using the Immersive Technologies. No horseplay in the Immersive Technologies Area.

Take at least a 10-to-15-minute break for every 30 minutes of use.

Release of Liability

In consideration for being permitted to use the Immersive Technologies, I hereby release, waive, discharge, and covenant not to sue Munster Technological University, Kerry, its officers, employees, agents, representatives, and affiliates from any and all liability, claims, demands, actions, or causes of action arising out of or related to any loss, damage, or injury, including death, that may be sustained by me or to any property belonging to me, whether caused by negligence or otherwise, while using the Immersive Technologies.

Medical Fitness

I acknowledge that I am in good health and free from any conditions that may be aggravated by using Immersive Technologies. If I have any pre-existing medical conditions, I have notified Munster Technological University, Kerry of these conditions before engaging

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in Immersive Technologies, or I have consulted with a qualified healthcare professional and obtained their approval to use Immersive Technologies.

Indemnification

I agree to indemnify and hold harmless Munster Technological University, Kerry from any and all claims, actions, suits, costs, expenses, damages, or liabilities, including attorney fees, arising from my use of Immersive Technologies.

Privacy and Age Restrictions

Information shared during online registrations or interactions, whether through software, apps, or online access, is protected by strict international privacy laws, such as the EU GDPR and other privacy regulations. These laws specifically apply to children under the age of 13. Generally, individuals under 13 years old should refrain from accessing various VR platforms and stores like META Quest VR, as well as social VR apps such as AltspaceVR and VR Chat. This Permissions and Waiver Form ensures compliance with both local laws and Munster Technological University, Kerry requirements, which users must agree to in accordance with the privacy policy. It is important to note that individual virtual apps may have their own age restrictions and recommendations for usage.

Binding Agreement

I (or my child/dependent/minor) understand that this waiver is a binding agreement and that by signing it, I acknowledge that I have read and understood all the terms of this release form and that I am giving up substantial legal rights.

I understand that Munster Technological University, Kerry has taken reasonable measures to ensure my safety, including providing instructions and guidelines for the use of Immersive Technologies. I agree to follow all provided instructions and use the Immersive Technologies responsibly.

I (or my child/dependent/minor) am using the Immersive Technologies voluntarily.

I (nor my child/dependent/minor) have any known physical, mental, or health-related reasons or problems that should preclude or restrict my or my child’s/dependents/minor's participation in the included activities.

I am the parent or legal guardian of the child/dependent/minor named below. I have the legal right to consent to and, by signing below, I hereby do consent to the terms and conditions of this Release of Liability.

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I assume all the physical, psychological, and financial risks associated with the use of Immersive Technologies.

PLEASE NOTE: You will not be able to take part in the Immersive Technologies without agreeing with and signing this waiver.

Immersive Technologies Health and Safety Permissions and Waivers Form	
Full Name	
T (MS) Number	
Student MTU Email	
Date	

** Cybersickness: Research into cybersickness, VR sickness, and motion sickness experienced in VR headsets has been found to impact a percentage of users, and adaptation to overcome the nauseous feeling can be minimised or controlled with at least three sessions. Other studies have shown that chewing mint or ginger-flavoured gum relieves the nauseous feeling for some VR users.*

*** Users with visual impairments like photo-sensitivities and physical and health impairments or conditions may struggle to use VR.*

*** Users with visual impairments like photo-sensitivities and physical and health impairments or conditions may struggle to use VR.*

APPENDIX D

The Rethinking Engineering Education in Ireland (REEdI) Project at Munster Technological University (MTU) is funded by the Higher Education Authority (HEA) Human Capital Initiative (HCI) Pillar 3 Programme.

DOCUMENT: STUDENT LOAN AGREEMENT (SEPT 2022 – JULY 2025)

COURSE: MECHANICAL AND MANUFACTURING ENGINEERING, RETHINKING ENGINEERING EDUCATION IN IRELAND (REEDI)

HARDWARE: META QUEST 3 INCL. BATTERY + STRAP AND CARRY CASE

1. General

1.1 This Agreement is made between Munster Technological University, Kerry (MTU Kerry) ("the University"), and the student ("You"/ "Your") for the loan of an META Quest 3 VR Headset and any associated accessories and equipment ("the IT equipment") as outlined below. This Agreement will prevail over any previous agreement relating to the IT equipment. No variation to this Agreement will be binding unless made in writing and agreed by both parties.

1.2 To be eligible for the loan of IT equipment from the University, You must be a current student at the University and have a valid MTU Student ID Card, IT Username (T/MS Number), and password.

1.3 You agree to use the IT equipment following the University's IT policies of use and sign the IT equipment Loan Record (Appendix 1).

1.4 You must agree to and sign the University *Permissions and Waivers Form* before being able to use the IT equipment.

2. Loan and Return of IT equipment

2.1 The University agrees to loan You the IT equipment as itemised in the '*IT Equipment Loan Record and Movement Order Form"* (Appendix 1), in accordance with these terms and conditions.

2.2 The IT equipment may be collected by You at a specified time and location from a pre-determined University IT Service Desk.

2.3 The IT equipment must be returned at the end of each academic year at a specified date to a pre-determined University IT Service Desk. If you are unable to return the IT equipment at this date for any reason, this should be clearly communicated to Mechanical and Manufacturing Engineering Faculty Staff (MMEFS) and you must make alternative arrangements to return the IT equipment at the earliest opportunity at a date and location that is suitable for the Mechanical and Manufacturing Engineering Faculty Staff (MMEFS).

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2.4 The IT equipment must be returned to the IT Service Desk immediately if You are suspended, excluded, withdraw from, or complete Your studies at the University.

2.5 If You fail to return the IT equipment by the specified date, this will result in a fine being charged at a rate of €5 per day. Failure to return any overdue IT equipment within one week of the return date will result in your IT account being disabled and/or examination results being withheld and/or a ban from using the loan service in the future. The University reserves the right to take appropriate action to recover the IT equipment or to charge You for the full cost of replacing an updated version of the IT equipment.

3. Your Responsibilities

3.1 Upon receipt of the IT equipment, You undertake to maintain it appropriately.

3.2 Any software installed, or files downloaded to the IT equipment must be in accordance with the appropriate software licensing, MTU IT Policies, and adhere to Irish copyright law.

3.3 Any work saved to the hard drive of any of the IT equipment by You must be deleted upon its return.

3.4 You are required to inform the University as soon as possible of any faults with the IT equipment. Where the fault occurs on a weekend or in the evening You must inform MMEFS on the next available working day, making it clear that the IT equipment is a loan item. You must not attempt to fix any hardware problems yourself as this could invalidate the warranty and leave you liable for damage/ replacement costs.

3.5 You must return the IT equipment to the University in the same condition as You received it in, except for reasonable wear and tear. You must return the IT equipment in person so that it can be inspected for any visible damage.

3.6 In the event that You do not return the IT equipment to the University, and the University as a result in accordance with Clause 2.6 charges You for the cost of the IT equipment, You agree to comply with any laws governing the disposal of electronic equipment at the expiry of the life of the IT equipment and indemnify the University for any liability it may incur as a result of your breach of this clause.

4. Damage to or Loss of the IT equipment

4.1 You accept full responsibility for any loss or damage to the IT equipment caused by Your negligence or improper use. “Improper Use” includes (but is not limited to), using the IT equipment otherwise than in accordance with the manufacturer’s and/ or the University’s instructions, using the IT equipment for a purpose other than intended or

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allowing the equipment out of your control and custody and failing to protect it from loss or damage.

4.2 You undertake that You have sufficient household insurance to afford protection to the IT equipment both inside and outside of Your place of residence. If the IT equipment is lost or damaged as a consequence of Your failure to comply with the above clause 4.1, You will be required to reimburse the University for the cost of repairing or replacing the hardware.

5. Third Party Rights

5.1 It is a condition of this Agreement that You will not use or allow the IT equipment to be used in any way that will breach any third-party rights, including but not limited to any rights in respect of confidential information or trade secrets, patent, copyright, design right, design registration, trademark or any other intellectual property rights or title.

5.2 You will indemnify the University and ensure that the University is fully and effectively indemnified against any claims by third parties for infringement of their rights caused by Your use of the IT equipment. Furthermore, You will ensure that the University is indemnified in respect of any loss or expense including legal fees which the University may incur in connection with any such claim or threatened claim by a third party.

5.3 If You breach any of the provisions in sub-clause 5.1 above, the University may at its discretion terminate this Contract forthwith in which event the provisions in Clause 2 will apply.

6. Contact (Rights of Third Parties) Act 1999

6.1 This Agreement does not create, confer or purport to confer any benefit or right enforceable by any person not a party to it.

7. Liability

7.1 The University will indemnify You and keep you fully and effectively indemnified against loss or damage to any property or injury to or death of any person caused by any negligent act or omission or wilful misconduct by the University, its employees, agents, or sub-agents.

7.2 The University shall not in any event be liable for any consequential loss or loss of profits or of contract whatsoever.

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7.3 Except in respect of injury to or death of any person, for which no limit applies, the University's liability under this Contract or in tort in respect of each event or series of connected events shall not exceed the total value of the IT equipment.

8. Termination

8.1 The University may suspend or terminate this Agreement for the loan of IT equipment if You fail to make any payment when due or otherwise default in any of Your obligations under this Agreement or become bankrupt or insolvent or have a trustee in bankruptcy or liquidator or receiver or administrative receiver or administrator appointed over Your assets or if the University in good faith believes that any of these instances may occur. Where the Agreement is terminated You will be required to return the IT equipment to the University forthwith and the provisions of Clause 2 will apply.

9. Data Protection

9.1 All information and supporting documentation supplied by you with this Agreement will be used for the sole purpose of providing the IT equipment and related software to enable the IT equipment functionalities. Your IT Loan Record and related information will be held and maintained in accordance with the provisions of Data Protection Legislation. The data will not be passed to any other third party without your consent, except when the University is required to do so by law.

9.2 The General Data Protection Regulation (GDPR) applies from 25 May 2018. It has general application to the processing of personal data in the EU, setting out more extensive obligations on data controllers and processors, and providing strengthened protections for data subjects. In Ireland, the national law, which, amongst other things, gives further effect to the GDPR, is the Data Protection Act 2018. The GDPR places direct data processing obligations on businesses and organisations at an EU-wide level. According to the GDPR, an organisation can only process personal data under certain conditions. For instance, the processing should be fair and transparent, for a specified and legitimate purpose and limited to the data necessary to fulfil this purpose. Full details can be found online at https://www.ittralee.ie/en/InformationAbout/GDPR/. For any queries please contact: Data Protection Office, Munster Technological University - Kerry Campus, Co. Kerry V92 CX88, Telephone: 066 -7191813, Email: dataprotection@ittralee.ie

10. Waiver of Remedies

10.1 No forbearance, delay, or indulgence by the University in enforcing the provisions of this Agreement shall prejudice or restrict its rights in any way, nor shall any waiver of the

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University's rights operate as a waiver of any subsequent breach nor in any way affect the validity of the whole or any part of this Contract nor prejudice the University's rights to take subsequent action.

11. Severability

11.1 If any of these conditions is considered void, voidable or otherwise unenforceable by a tribunal or proceedings of competent jurisdiction then it must be severed from the Agreement in question which will otherwise remain in full force and effect.

12. Notices

12.1 Any notice to be given under this Agreement will be in writing and transmitted by email, facsimile, or delivered, or forwarded by first class prepaid letter to the receiving party.

13. Law

13.1 The construction and performance of these conditions will be governed by Irish law. All disputes which may arise under, out of or in connection with or in relation to these conditions will be submitted to the Irish Courts.

Appendix 1

IT Equipment Loan Record & Movement Order

IT Equipment and Student Details

FOR STUDENT USE

I hereby acknowledge receipt of the equipment listed above. I have read and understood this agreement and will comply with the terms and conditions the

DOCUMENT: STUDENT LOAN AGREEMENT (SEPT 2022 – JULY 2025) **COURSE:** MECHANICAL AND MANUFACTURING ENGINEERING, RETHINKING ENGINEERING EDUCATION IN IRELAND (REEDI) **HARDWARE:** META QUEST 3 INCL. BATTERY + STRAP AND CARRY CASE
META Quest 3 Headset

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				Please tick as received			
Student ID	***Headset ID***	***Student Signature***	***O-CPT Signature***	***Bundle Pack****	***Battery + Strap***	***Carry Case***	***Loan Date***
	Course_Y24_S1						
	Course _Y24_S2						
	Course _Y24_S...						

APPENDIX E

AR USE CASES

	MAINTENANCE - WORKER
DESCRIPTION	**Maintenance Training On Equipment And Machinery.**
USE CASES	• Machine maintenance on workstation machinery. Some shop floor machinery may require periodic maintenance. Workers can carry out these maintenance tasks using an AR Headset that overlays information on the physical object. This can include regular cleaning of certain parts, how to get access to components, how to remove or replace parts etc. • Customers depend on contractors to perform equipment maintenance and repairs. Using Remote AR applications, customers can have contractors service the equipment in a much more efficient way. • AR-enabled wearables in manufacturing can help measure changes, identify unsafe working conditions, and visualize design components and structures. With field-service knowledge engineers and technicians can monitor the field and provide remote expert support in real-time. Organizations are also using AR to improve productivity in out-of-office or away-from-desk jobs.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar) or AR-enabled mobile devices (phones or tablets).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).

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PROS	• Reduced equipment downtown and support costs • Reduction in service trips and a reduction in labour costs. • Reduced human errors. • Reduced execution time. • Reduced breakdowns. • Increased productivity. • Increased operation speed. • Increased fix rates. • Increased compliance. • Increased profit margins. • Increased diagnosis success rate.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing training scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://upskill.io/landing/ge-aviation-case-study/ • https://upskill.io/landing/ge-renewables-case-study/ • https://www.ptc.com/en/service-software-blog/augmented-reality-maintenance-and-repair • https://www.re-flekt.com/reflekt-one
TECHNOLOGY PROVIDERS	• https://daqri.com/ • https://upskill.io/ • https://www.scopear.com/solutions/work-instructions/ • https://www.ptc.com/en/service-software-blog/augmented-reality-maintenance-and-repair • https://www.re-flekt.com/reflekt-one • https://www.fieldbit.net/ • https://pale.blue/ • https://www.linup.it/

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CASE STUDY

Reinventing aerospace manufacturing and supply chain operations -

Boeing Tests Augmented Reality in the Factory

Installing electrical wiring on an aircraft is a complex task that leaves zero room for error. That is why Boeing is testing augmented reality as a possible solution to give technicians real-time, hands-free, interactive 3D wiring diagrams - right before their eyes.

"A person working in an industrial setting has a lot of distractions in that environment and a lot of data to think about and process. Traditionally technicians had to look at and interpret a two-dimensional twenty-foot-long drawing and construct that image in their mind and attempt to wire based on this mental model," said Brian Laughlin, IT Tech Fellow. "By using augmented reality technology, technicians can easily see where the electrical wiring goes in the aircraft fuselage. They can roam around the airplane and see the wiring renderings in full depth within their surroundings and access instructions hands-free."

Paul Davies, Boeing Research & Technology Associate Technical Fellow, is working closely with the program and Boeing IT to develop and test augmented reality technology on the Tanker. "Our theory studies have shown a 90 percent improvement in first-time quality when compared to using two-dimensional information on the airplane, along with a 30 percent reduction in time spent doing a job."

Bruce Dickinson, Vice President and General Manager of the 767/747 Program, said, "The cross-functional team working on this technology has made a step-change break-through in our quality and productivity by following their passion to pursue a great idea. We don't often see 40% improvements in productivity, and I'm convinced that it was a culture of innovation and leaders who are willing to say 'yes' that enabled this idea to come to life."

https://www.boeing.com/features/2018/01/augmented-reality-01-18.page

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MAINTENANCE - CUSTOMER

DESCRIPTION	**Maintenance Tutorials On Equipment And Machinery.**
USE CASES	• Manufacturers of complex industrial machinery often face two main challenges with their customers. First, how can they effectively educate their potential customers on key technical differentiators that separate their products from their competitors? Machinery is often too large to bring to a customer, too expensive to dismantle, or too complex for a simple explanation. How can the manufacturers support customers in a cost-effective way that maintains machinery and increases uptime without involving expensive specialists? • Using Object Markers, customer can visually explore the components and features of their physical equipment by scanning the equipment with an AR-enabled device (mobile or tablet) and get a 3D overlay onto the physical equipment. The overlay can feature callouts and points of interest to the customer. The customer can click on any of these points to get basic maintenance tutorials e.g. how to replace a routinely serviced part e.g. removing and replacing air filters, cleaning, setting parts to required spec etc. • In addition, customers can learn how to do a parts exchange through an easy-to-follow step-by-step guide in AR—allowing inexperienced users and technicians to maintain equipment on their own.
TECHNOLOGY USED	AR-enabled mobile devices (phones or tablets).
COST	High. Development of software. Requires AR-enabled handheld devices (phones or tablets)
PROS	• Reduced equipment downtown and support costs. • Increased diagnosis success rate. • Reduction in service trips. • Reduction in labour costs.
CONS	• Cost of developing scenarios. • Requires high-end AR-enabled handheld device. • Users' resistance to change.
REAL WORLD EXAMPLES	• https://newatlas.com/hyundai-introduces-3d-augmented-reality-owners-manuals/40339/

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	• https://www.caranddriver.com/features/a23786553/mercedes-genesis-augmented-reality-owners-manual/
TECHNOLOGY PROVIDERS	• https://daqri.com/ • https://upskill.io/ • https://www.scopear.com/solutions/work-instructions/ • https://www.ptc.com/en/service-software-blog/augmented-reality-maintenance-and-repair • https://www.re-flekt.com/reflekt-one • https://www.fieldbit.net/ • https://pale.blue/ • https://www.helmes.com/ • https://eonreality.com/

ASSEMBLY AND INSTALLATIONS

DESCRIPTION	**Assembly And Installation Of After-Market Parts.**
USE CASES	An AR app that overlays digital instructions onto existing products to provide details on the assembly and installation of service or aftermarket parts. Or how to connect different components. Using the advances in camera technology, users can also turn their smart device into a tape measure to measure spaces to ensure the correct fit of machinery.
TECHNOLOGY USED	AR-enabled mobile devices (phones or tablets)
COST	Low. Only requires AR-enabled handheld device (phones or tablets)
PROS	• 90% Improvement in first-time quality when compared to using two-dimensional information. • Decreased time required to do work by up to 30%.
CONS	• Cost of developing scenarios. • Requires high-end AR-enabled handheld device. • Users' resistance to change.
REAL WORLD EXAMPLES	• https://www.dezeen.com/2018/03/23/ikea-assembly-made-easier-through-augmented-reality-app/
TECHNOLOGY PROVIDERS	•

STANDARD OPERATING PROCEDURES (SOP)

DESCRIPTION	**DIGITISING STANDARD OPERATING PROCEDURES**

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USE CASES	Using AR Headsets, SOPs can be digitised and always accessible by workers. This can apply to all situations where complex tasks need to be performed, and the working environment allows for it. These can include machine start-up/shutdown procedures, safety precautions, emergency stop procedures, fire training etc.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar)
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Increased efficiency and reduced downtime. • Increased worker confidence. • Increased level of support.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://www.vksapp.com/case-studies/clearpath-robotics-has-reduced-training-using-vks • https://www.vksapp.com/case-studies/10-reasons-carpentry-school-went-building-11-88-stairs
TECHNOLOGY PROVIDERS	• https://upskill.io/ • https://www.vksapp.com/ • https://www.ptc.com/en/product-lifecycle-report/augmented-reality-strategy

TRAINING – WORKER

DESCRIPTION	**AR-Based Hands-Free On-The-Job Training For New And Current Employees.**
USE CASES	• A key contribution of augmented reality is in training. The technology enables trainees to familiarize themselves with farm machinery without having to operate it in the actual sense. • AR-based hands-free devices are proving to be an engaging and efficient training tool, as they can overlay virtual tutorials onto wearable equipment to provide new personnel with quick, visual demonstrations. It is

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	much easier to learn when viewing a digitally rendered 3D model than a 2D diagram. • New staff can also learn on the job, rather than repeatedly checking the training manual. As such, the use of Augmented Reality in manufacturing training and other related fields is becoming increasingly popular. • Augmented Reality enterprise use cases like this are especially effective when it comes to highly complex tasks, such as large machinery/equipment assembly and maintenance.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar)
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Reduce production time by 25% and lower error rates to nearly zero. • Improving safety and enhancing the consistency of SOPs. • AR can provide supplemental training for workers. These easily consumable training experiences can improve comprehension and reduce training time by 60%. • There can be up to 35-50% reduction in overall technician time. • 90-99% reduction in time to information.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://upskill.io/skylight/use-cases/ • https://www.vaderstad.com/en/
TECHNOLOGY PROVIDERS	• https://upskill.io/ • https://www.vsight.io/

	SALES - WORKER
DESCRIPTION	**Sales Conversion Tool And Techniques.**
USE CASES	Using an AR-enabled device, the Salesperson can launch their catalogue of products in front of potential customers without having the physical products present. This is especially useful

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	in instances where equipment is too big to transport to customers, or where customers live far away from showrooms. Salesperson launches AR models in front of customers on an enterprise-only app.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar) or AR-enabled mobile devices (phones or tablets).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Increased confidence and efficiency. • Can be placed in any number of scenarios and environments.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	• https://daqri.com/ • https://upskill.io/ • https://www.scopear.com/solutions/work-instructions/ • https://www.ptc.com/en/service-software-blog/augmented-reality-maintenance-and-repair • https://www.re-flekt.com/reflekt-one • https://www.fieldbit.net/ • https://pale.blue/

SALES - CUSTOMER

DESCRIPTION	**3D AR View Of Products In Your Personal Space. Virtual Showroom. Low-Cost Visualisation Of High-Cost Assets.**
USE CASES	• High-cost assets often carry a high-cost sales cycle because customers hesitate to purchase something they cannot properly visualise. Using AR, models of high-cost assets can be developed at a much lower cost, increasing accessibility. • Sales conversion - End users launch AR models in their locations via the app store available app. In today's physical retail environment, shoppers are using their smartphones more than ever to compare prices or look

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	up additional information on products they are browsing. Companies can develop an AR app that customers can use at home to launch and view products. Users can also customize it using the app to see which colours and features they might like. • Sales Conversion - Machine Servicing - customers can perform basic machine servicing (oil, water top-up etc.) by following along with instructional content. • A 3D app can include high-quality digital 3D versions of products so customers can view them in their space before purchasing. • 5G can optimize warehouse resources, enhance store traffic analytics, and enable beacons that communicate with shoppers' smartphones.
TECHNOLOGY USED	AR-enabled mobile devices (phones or tablets).
COST	Low. Only requires AR-enabled handheld devices (phones or tablets).
PROS	• Real-word visualisation of products. • Better engagement.
CONS	• Cost of developing scenarios. • Requires high-end AR-enabled handheld device. • Users' resistance to change.
REAL WORLD EXAMPLES	• https://www.dezeen.com/2019/05/09/nike-fit-app-ar-ai-trainers/ • https://www.dezeen.com/2020/04/17/all-show-augmented-reality-exhibition-sebastian-errazuriz/ • https://futurestores.wbresearch.com/blog/loreal-augmented-reality-virtual-reality-in-store-experience-strategy • https://techcrunch.com/2019/02/04/warby-parker-dips-into-ar-with-the-launch-of-virtual-try-on/ • https://newsroom.inter.ikea.com/news/ikea-place-app-launches-on-android--allowing-millions-of-people-to-reimagine-home-furnishings-using-/s/28215cac-8f4e-4ee5-87a4-56a998290856
TECHNOLOGY PROVIDERS	• https://www.alibaba.com/ • https://daqri.com/ • https://upskill.io/ • https://www.scopear.com/solutions/work-instructions/

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	• https://www.ptc.com/en/service-software-blog/augmented-reality-maintenance-and-repair • https://www.re-flekt.com/reflekt-one • https://www.fieldbit.net/ • https://pale.blue/

HEALTH & SAFETY

DESCRIPTION	**Emergency Procedures Training Tool.**
USE CASES	• Where to locate emergency stops on machinery using Model Marker solutions. • First responders wearing AR glasses can be alerted to danger areas and show in real-time individuals that need assistance while enabling them to still be aware of their surroundings. • For those in need, geolocation-enabled AR can show them directions, and the best route to, safe zones and areas with firefighters or medics.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Increased confidence and efficiency. • Can be placed in any number of scenarios and environments. • Real word visualisation and better engagement.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

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	REMOTE TROUBLESHOOTING, ASSISTANCE AND KNOWLEDGE SHARING
DESCRIPTION	**Remote Troubleshooting Tool Using AR/XR Systems Including XR Headsets Or Mobile Devices (Phones Or Tablets).**
USE CASES	The loss of expertise in its companies due to retirement, and lack of know-how among newer hires, can lead to costly downtime in facilities. The solution to this is a live AR support application that allows technicians to collaborate with experts remotely. Users can share their view of a situation with a remote expert, and the AR maps work instructions and expert collaboration directly onto an object or area.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar) or AR-enabled mobile devices (phones or tablets).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• 50% Reduction in downtime in facilities where the AR tools are in use, creating a direct ROI of 1,717% of the initial investment. • Costly and time-consuming downtimes can be avoided. • With a connection to a server, companies can document errors and consider them to be included in future maintenance plans. • Employees feel empowered to problem-solve and improve their daily work processes. • Decreasing costly repeat technician visits by increasing First Time Resolution rates. • Extending expert reach. • Streamlining the training of novice technicians.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. Users' resistance to change. Wearing cumbersome headwear for long periods. Battery life of the hardware. Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://techsee.me/blog/vodafone-innovation-augmented-reality/ • https://www.samsung.com/it/business/insights/case-study/joinpad-e-tablet-samsung/ • https://upskill.io/skylight/use-cases/ • https://www.youtube.com/watch?v=z5HOHNECW20&feature=youtu.be

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TECHNOLOGY PROVIDERS	• https://upskill.io/

USER MANUALS - CUSTOMERS

DESCRIPTION	**Digitising User Manuals For Online And Offline Viewing.**
USE CASES	• Replacing paper user manuals with immersive, visual AR instruction manual experiences helps customers navigate various steps including initial product setup, configuration, troubleshooting, and routine maintenance. The most advanced AR user manuals are built around Computer Vision technology, which auto-identifies an issue and guides the customer toward self-resolution. For example, utilising the original diagrams in paper instructions can be overlaid with animation and life-size references to simplify any assembly process. • AR-enabled app that allows the user to point their smartphone at different parts of equipment, at which point AR instructions appear, overlaying information such as how to change the air filter, engine oil, or brake fluid.
TECHNOLOGY USED	AR-enabled mobile devices (phones or tablets).
COST	Low. Only requires AR-enabled handheld devices (phones or tablets).
PROS	• AR instructions achieve better results, significantly alleviating the pressure on customer service departments. • Decreased calls to contact centres • Less need to dispatch technicians to customers' homes. • Decreased return rates due to lack of customer product knowledge.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.

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REAL WORLD EXAMPLES	• https://techsee.me/blog/diy-product-unboxing-taking-the-visual-experience-to-the-next-level/ • https://techsee.me/consumer-electronics/
TECHNOLOGY PROVIDERS	• https://techsee.me

OPERATIONS AND LOGISTICS

DESCRIPTION	**Better Warehouse Operations And Logistics.**
USE CASES	• AR can be used to improve navigation around large spaces (e.g. warehouses, large installations). AR can also assist with behavioural analytics, people movement (where people go), simulations (how claustrophobic would people be in certain places), and scenario planning (emergency/disaster-mandated planning). • AR technology empowers logistics staff by providing the right information at the right time and in the right place, an efficiency that is especially important to complex distribution networks. For example, a worker can see task instructions overlaid on their HMD, which can be configured to assist with GPS navigation within the facility or with auto-reading of barcodes. • Smart glasses help personnel locate, scan, sort, and move inventory without handheld scanners. The company gives warehouse workers smart glasses (e.g. Google Glass Enterprise Edition) which help them locate, scan, sort, and move inventory without using handheld scanners or referencing paper forms. The integrated heads-up display overlays key information within the company's logistics hubs, scans barcodes, and relays instructions in real-time. Workers using the glasses are 15% more productive, according to DHL. The glasses could eventually be upgraded with object recognition.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Can cut production time by 25% and lower error rates to nearly zero, while improving safety and enhancing the consistency of SOPs.

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	• AR can provide supplemental training for workers. These easily consumable training experiences can improve comprehension and retention.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://www.skoda-storyboard.com/en/press-releases/skoda-auto-tests-video-mapping-augmented-reality-helps-when-loading-pallets-in-logistics/ • https://upskill.io/landing/ge-healthcare-case-study/ • https://www.youtube.com/watch?v=z5HOHNECW20&feature=youtu.be
TECHNOLOGY PROVIDERS	• https://upskill.io/

	IMMERSIVE ANALYTICS
DESCRIPTION	**Better Visualisation Of Complex Analytical Data.**
USE CASES	• With growing volumes of data, 2D visualizations and manual processes limit companies' abilities to detect data patterns and derive actionable insights. • AR can provide new ways to visualize and make better sense of these complex datasets, providing real value to business leaders. Immersive analytics is the combination of immersive technology and Machine Learning. • Together, multiple departments can view, analyse, and collaborate by visualizing data in 3D.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Bette visualisation of complex data sets. • Real-time interaction with date.

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	• More immersive experience. • Collaborative sessions facilitated remotely.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://medium.com/design-ibm/ibm-immersive-data-augmented-reality-for-data-visualization-898587b2a57c • https://medium.com/@alfredo.ruiz/bringing-data-to-life-with-ibm-immersive-insights-9423687c9ffe • https://www.youtube.com/watch?v=6WRNqdOMXmc&feature=emb_logo
TECHNOLOGY PROVIDERS	• https://www.ibm.com/cloud/watson-studio

MARKETING AND ADVERTISING

DESCRIPTION	**Better Marketing Through Interactive Brochures, Real-Time Demos And Product Visualisations.**
USE CASES	• AR experiences created in Vuforia Studio can provide service instructions and marketing information for the benefit of both customers and retailers/dealers. Customers and dealers can use the 3D in-context instructions to streamline the service of equipment. • Dealers can showcase features, help with service and parts inventory replenishment, and provide brand messaging to customers. • The AR experience also provides a key voice-of-the-product feedback loop for the team, in addition to differentiating the service experience.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar) or AR-enabled mobile devices (phones or tablets).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Better customer engagement.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change.

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	• Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://www.nextechar.com/advertising-ar
TECHNOLOGY PROVIDERS	• https://www.nextechar.com/

DESIGN, DEVELOPMENT AND MODELLING

DESCRIPTION	**Helping Designers Visualise Designs In Real-Time And 3D.**
USE CASES	• One of the major uses for AR in the customer experience journey is the ability to design spaces, experiences and products for customers virtually and be able to test, refine and enhance these at a much lower cost and quicker turnaround than testing physical prototypes. • AR is helping professionals visualize their final products during the creative process. • Use of headsets enables architects, engineers, and design professionals to step directly into their designs to see how their designs might look, and even make virtual on-the-spot changes. • Any design or modelling jobs that involve spatial relationships are a perfect use case for AR tech.
TECHNOLOGY USED	AR/XR Headsets (e.g. Microsoft HoloLens or similar).
COST	High. Development of software. Purchase of hardware (Microsoft HoloLens or similar).
PROS	• Quicker workflows. • Better understanding of physical size. • Better design and maintenance.
CONS	• Cost of hardware (Microsoft HoloLens or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.

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REAL WORLD EXAMPLES	• http://armeasure.com/?utm_medium=website&utm_source=archdaily.com • https://eonreality.com/portfolio/virtual-reality-industrial-planner/
TECHNOLOGY PROVIDERS	• https://upskill.io/ • https://eonreality.com/

VR USE CASES

	MAINTENANCE - WORKER
DESCRIPTION	**Maintenance Training On Equipment And Machinery.**
USE CASES	• Working together in one VR Training environment, up to dozens of trainees or users can communicate, interact, and collaborate in the same virtual environment from multiple global endpoints — anywhere, anytime. • VR offers a low-cost alternative to traditional methods of training by offering interactive and immersive 3-D simulation environments to train critical skills. Immersive training will result in better learning outcomes for training a procedural task than traditional computer-based training.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• By incorporating user interaction with the environment and content thanks to VR technology, companies can achieve three goals: train more people within a shorter period cost-effectively and interactively; enable people to learn about their workplace environment and machines without jeopardizing their life and safety; and help those very workers master using expensive machines before they try them out directly.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.

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REAL WORLD EXAMPLES	• https://www.youtube.com/watch?v=APYz8n2H9RY • https://eonreality.com/portfolio/vr-maintenance-training/
TECHNOLOGY PROVIDERS	• https://pale.blue/ • https://eonreality.com/

ASSEMBLY

DESCRIPTION	**Assembly And Installation Of Complex Parts.**
USE CASES	• Interactive virtual learning program to train its assembly line workers while increasing worker motivation and attention. Using the HTC Vive, employees are immersed in their realistic virtual assembly line environment. Work equipment such as containers and other components are illustrated as 3D objects, which can be grabbed and moved using the controllers. During the training session, the employee goes through various step-by-step assembly processes. Hereby, employees learn required hand movements while getting familiar with the corresponding IT systems. They are going through several levels of difficulty which also require an increasing degree of independence and information retention.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Boost of self-confidence. • Fun, motivational. • Provide personalized training based on the skills or knowledge of the worker. • Intuitive learning, with instructions, instant feedback, and error support. • Different language versions. • The reduced need for space, and physical equipment. • Control of learning objectives. • Show the consequence of errors. • Increase training efficiency.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios.

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	• Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://eonreality.com/portfolio/engine-explorer/
TECHNOLOGY PROVIDERS	• https://eonreality.com

	SALES - WORKER
DESCRIPTION	**Sales Conversion Tool. Salesperson Launches VR Models In Front Of Customers On An Enterprise-Only App.**
USE CASES	If you have an upcoming sales pitch, how would you prepare for it? You might practice with a friend, colleague, or even in front of a mirror. None of these methods fully prepares you for being at the actual pitch, in an unfamiliar office with an unknown audience. VR changes this. Virtual reality allows you to practice different sales techniques and strategies in a safe, realistic environment. You can practice high-stakes situations, such as selling to directors or at a trade show, as often as you like until you are confident with your approach. Practising in this way also allows you to receive feedback on your performance. Through speech recognition and motion detection software, you can receive feedback on eye contact, number of hesitation words used, pace of your voice and other metrics.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Load your presentation slides into the virtual room to practice with instant feedback on your sales pitch. • Eye contact feedback to help you engage with the clients. • Prepare with realistic environments and audience. • Practice high-stakes situations as often as you like. • Identify keywords you are saying and how often.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. Users' resistance to change. Wearing cumbersome headwear for long periods.

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	Battery life of the hardware. Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://makereal.co.uk/work/severn-trent-coaching/ • https://makereal.co.uk/work/lloyds-personal-vitality/ • https://takeleap.com/services/virtual-reality/porsche/
TECHNOLOGY PROVIDERS	• https://makereal.co.uk/ • https://takeleap.com/ • https://bodyswaps.co/

	CUSTOMER OR CLIENT INTERACTION TRAINING - WORKER
DESCRIPTION	**Better Understanding Of Customer Needs.**
USE CASES	In a popular 2015 TED Talk, VR executive Chris Milk labelled the technology “the ultimate empathy machine.” Virtual Reality can assuredly be used to help workers better interact with customers and clients. The simulation of human interaction can facilitate many things — learning how to deal with specific situations, becoming more relaxed during interactions through repetition, and a better understanding of where the client/customer is coming from. By simulating high-stress and high-pressure environments in VR before the actual day, employees can be more prepared and relaxed for the actual day itself. The combination of simulation and repetition is extremely valuable in the training world.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Using VR-generated apps on how to avoid distractions and focus on the task at hand. • The theory is that by recognizing these potential auditory and visual distractions in VR simulations, the user will be more prepared and focused when interacting with scenarios.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing of cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.

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REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	• https://engagevr.io/use-cases/training/

MARKETING AND ADVERTISING

DESCRIPTION	**Better Marketing Through Interactive Brochures, Real-Time Demos And Product Visualisations.**
USE CASES	• Brands are increasingly using VR- and AR-powered campaigns to immerse customers in their product lines and interact with their audiences in unique ways. • E.g. creating a virtual reality experience that can take people "flying" on a journey through a virtual showroom. • As consumer adoption of headsets increases, VR/AR will evolve to become less of a promotional novelty and more of a standard channel for experiential marketing and advertising.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Better customer engagement.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

EMERGENCY PROCEDURES AND HEALTH AND SAFETY

DESCRIPTION	**Emergency Procedures Training Tool Using VR Systems Including VR Headsets Or VR CAVE System.**
USE CASES	• Fire extinguisher training. • Correct lifting procedures.

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	• Slips, trips, and falls. • First aid training.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Increased confidence and efficiency. • Can be placed in any number of scenarios and environments. • Real word visualisation and better engagement.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

MACHINERY OPERATION - WORKER

DESCRIPTION	**Training Employees On Machinery Operation.**
USE CASES	• Training employees on new or complex machinery for manufacturing etc.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Increased confidence. • No chance of breaking the physical model until confident in operation. • Cost and timesaving. • Better retention and engagement.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware.

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	• Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

MACHINERY OPERATION - CUSTOMER

DESCRIPTION	**Training Customers On Machinery Operation.**
USE CASES	• Training customers on new equipment e.g. service, maintenance, operation etc.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or VR CAVE System.
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Increased confidence. • No chance of breaking the physical model until confident in operation. • Cost and timesaving. • Better retention and engagement.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

INDUCTION & ONBOARDING

DESCRIPTION	**Employee Induction And Onboarding.**
USE CASES	• Virtual induction of new employees including tour, meet the team, emergency exists, SOP, etc. • Likely the most popular VR for Training use case is new employee onboarding. Closely correlated, particularly in our world of fluid job functions, is employee cross-training. Both activities are geared towards educating

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	workers on something they are not likely terribly familiar with. • VR allows you to immerse a new employee in an environment and teach them (using features such as hotspots). This helps the new employee become familiar and comfortable with the environment before being thrust into it. The knowledge transfer potential is tremendous. As discussed above, recall is much better than say traditional 2D limited-width views. • Employee onboarding through VR is a great first touch point for many workers. It helps to calm the nerves and build confidence. Particularly in high-stress jobs, or ones that involve immediate client interaction, using virtual reality is a nice entry point for learning a job.
TECHNOLOGY USED	Mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Increased confidence and engagement. • Reduced stress levels. • Inclusion. • Create consistency. • Standing out. • Dramatically cut costs in training new employees at field offices. • Cut the technology budget for training by 80%. • No need to have to fly trainers to the field office, but also reduce travel for new employees. • As the content is evergreen, they're able to re-use the training for each subsequent recruiting class.
CONS	•
REAL WORLD EXAMPLES	• https://virsabi.com/onboarding-and-training-with-vr/ • https://virsabi.com/ikea-is-using-virtual-reality-for-onboarding-and-training/
TECHNOLOGY PROVIDERS	•

STANDARD OPERATING PROCEDURES (SOP)

DESCRIPTION	**Digitising Standard Operating Procedures.**

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USE CASES	• Using VR Headsets, SOPs can be digitised and accessible by workers. This can apply to all situations where complex tasks need to be performed, and the working environment allows for it. • These can include machine start-up/shutdown procedures, safety precautions, emergency stop procedures, fire training etc.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Increased efficiency and reduced downtime. • Increased worker confidence. • Increased level of support.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

	DRIVER TRAINING
DESCRIPTION	**Advanced Driver Training For Field Operatives.**
USE CASES	• Training drivers. Objective testing, using advanced data collection, means you can train and test a driver's skill sets BEFORE they ever sit behind the wheel of an expensive vehicle.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar).
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Retention rates up to 70% better than traditional methods have been proven in academic studies.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios.

	• Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://makereal.co.uk/work/vodafone-drive-safe/
TECHNOLOGY PROVIDERS	•

	CROSS-TRAINING
DESCRIPTION	**Cross Training Of Employees Between Different Departments And Skillsets.**
USE CASES	• Using VR scenarios, employees can be cross trained between departments using recyclable content. • Employees do not need to be physically present at the station for training.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Dramatically cut costs in cross-training employees. • Cut the technology budget for training by 80%. • No need to have to fly trainers to the field office, but also reduce travel for new employees. • As the content is evergreen, they can re-use the training for each subsequent recruiting class.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	• https://eonreality.com/

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TEST DRIVE - CUSTOMER

DESCRIPTION	**Allow Customers To Test Drive Equipment Before Purchase.**
USE CASES	• If users are in the market for a piece of machinery, VR technologies can enable them to test drive a piece of machinery before they take it home. • A VR app that allows the user to drive a piece of machinery through any chosen terrain. • More than just a marketing tactic, it is both a game and a point of reference for consumers.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Simulate real-world and relatable environments. • Conversion tool. • Better engagement. • Allow remote customers access to equipment that can't be physically transported.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://www.youtube.com/watch?v=HEkGRUkqjTA&feature=emb_logo
TECHNOLOGY PROVIDERS	•

DESIGN AND DEVELOPMENT

DESCRIPTION	**Helping Designers Visualise Designs In Real-Time And 3D.**
USE CASES	• VR tools that will allow designers to not only sketch in 3D but also immerse themselves inside their sketches, streamlining the design process. • Streamlining the otherwise lengthy design process by allowing designers to skip hand-drawn designs and jump right into working on a 3D model.

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	• This cuts the process down from a few weeks to eight hours and enables them to anchor a driver at the centre of the 3D model and rotate the design to view from any angle. • This means faster design and innovation, and a more thorough experience.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Quicker workflows. • Better understanding of physical size. • Better design and maintenance.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

	MANUFACTURING
DESCRIPTION	**Enhancing The Manufacturing Process Through Good Design.**
USE CASES	• Using VR to enhance the design of equipment. • Before virtual reality, companies had to build physical samples of equipment to determine how they could adjust the design to improve functionality. Thanks to this new technology, however, companies can now make real-time adjustments using virtual representations of their equipment, and “try out” the adjustments as if they were using them before manufacturing even begins. • The ability to develop virtual prototypes has had a major positive impact on the manufacturing industry. Instead of investing exorbitant amounts of money and countless hours creating physical prototypes, designers and

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	manufacturers can now develop virtual examples and make any necessary adjustments to those examples.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Increased manufacturing times and efficiencies. • Troubleshooting before physical production.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

	EXHIBITIONS, TRADE SHOWS, EVENTS & CONFERENCES
DESCRIPTION	**Remote EVENTS AND CONFERENCES WITH SALES CAPABILITIES.**
USE CASES	• Since VR enables individuals to be placed virtually, it provides an avenue for organizers to welcome more individuals into in-person events. • VR can be used in a similar way to enable virtual conference attendance, but event-industry stakeholders are also using it to drive collective experiences among in-person audiences.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Less travel costs and expenses. • No travel restrictions. • Time and energy savings.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change.

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	• Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

MEETINGS & COLLABORATIONS

DESCRIPTION	**Remote Meetings And Collaborations Between Geographically Dispersed Teams.**
USE CASES	• Virtual reality (VR) has great potential to help users who are physically at a long distance. From the business perspective, it is particularly true in the enterprise and business world where information needs to be quickly and accurately shared. • Therefore, VR is optimized accordingly with the need to offer a tool to help the user in every aspect. Using the best and most accurate information along physical scale models gives the best impression of the final product. VR Meetings allow experts to use virtual space to jointly review models. This is an advantage in today's world where colleagues can be continents apart, the subtleties of this information can be hard to convey using a flat monitor screen and a voice on a telephone or Skype connection. • We can say the VR tools have tried to make the process easier providing an increasingly cost-effective option. The benefit of using VR is to create a shared meeting space seems to be accomplished. Areas such as design, engineering, construction, and architecture are taking advantage of VR. • It is a product that is to be believed will greatly improve the quality of meetings. The feature of VR Meetings is that they have integrated collaborative mark-ups, voice-over IP and synchronized cloud models to allow for easier sharing of information in a joint space. Apart from those meetings becoming a free-for-all where one person becomes designated as the Presenter among all. All participants can view the model. To move

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	participants to a specific location in the model, control the model scale and orientation and even mute others the control is given to the presenter. And if the presenter needs to direct the other's attention to a specific location it can be done easily.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Less travel costs and expenses. • No travel restrictions. • Time and energy savings.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

	VIRTUAL SHOWROOMS
DESCRIPTION	**3D VR View Of Products In Your Personal Space.**
USE CASES	• Sales conversion tool - end users launch VR models in their locations. • In today's physical retail environment, shoppers are using their smartphones more than ever to compare prices or look up additional information on products they are browsing. • Companies can develop a VR app that customers can use at home to launch and view products. Users can also customize it using the app to see which colours and features they might like.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.

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COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Allows customers to see all products - no matter how large they are. • Customers anywhere in the world can view products. • Better immersion and engagement. • Callouts on product details
CONS	• Does not provide the same experience as seeing and touching physical equipment.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

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CASE STUDY

3D visualisation and interactive experiences

Audi creates a new dealership experience with Audi City

Audi is hoping its technologically equipped 'Audi City' stores will redefine the way customers shop for new cars, providing an exciting and engaging dealership experience. The stores focus on giving the consumer the ability to digitally explore and personalise Audi's line of vehicles. It is a new take on the conventional dealership, with virtual touchpoints able to present Audi's entire model range, while enabling millions of different possible configurations of the vehicles.

Audi has teamed up with ZeroLight to provide the real-time 3D visualisations. Multi-touch tables present a 3D virtual car to the consumer, which can be fully customised. The models that have been configured on these tables can then be viewed on a 'Powerwall', which presents a life-size scale of the car in large-format and 4K resolution, which can be explored inside and out. A member of the sales team is on hand to assist with the customer experience and journey throughout.

The level of personalisation that the technology allows for, creates a truly customer-centric experience, where the power is in the customer's hands to choose the right model, features and add-ons to match their tastes and needs, and help them create their dream Audi vehicle.

Without the need to stock Audi City stores with actual cars, the dealerships can be placed in key cosmopolitan locations, such as within shopping centres or airports. Current locations include Beijing, Berlin, London, Moscow, and Paris. In this instance, technology allows the customer to get the full Audi service experience and explore the complete spectrum of options, without needing to

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HAPTICS

DESCRIPTION	**Interacting With Digital Objects In A Physical Environment.**
USE CASES	• Interaction with objects (using gloves), viewing and scaling from different angles.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or VR CAVE System.
COST	Low. Only requires mobile devices (phones or tablets) with VR holders (Google cardboard or similar).
PROS	• Adds an element of realism to certain scenarios e.g. fire extinguisher training.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	• https://www.kat-vr.com/ •

PRODUCT TESTING

DESCRIPTION	**Testing Products For Defects Or Usability Before Expensive Production.**
USE CASES	• Using VR, users can test product designs for a wide range of metrics e.g. usability, size, colour, maintenance etc.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Detailed product testing before production to eliminate faults and usability issues.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware.

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	• Responsiveness of hardware.
REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

SCANNING & MONITORING

DESCRIPTION	**Scanning And Monitoring Large Geographical Areas.**
USE CASES	• VR have the potential to help farmers visualize the troves of crop data now available to them. • Commercially available aerial drones built with inertial sensors, GPS, powerful processors, and imaging sensors can give farmers and data scientists a look at what is happening in their fields. These drones, outfitted with 360-degree video capability, allow for virtual crop scouting, where farmers don VR headsets to scan through the field and assess crop response and damages. By caring for crops at the granular level VR and crop data allow for, farmers can increase yields, decrease disease, and improve costs. • Using a system of sensors, lights, and cameras that measure details of crop health., a solution can use AI to understand what each plant needs for the best growth. That data is wirelessly transmitted to a set of AR goggles, which farmers use to see what each plant should be getting, like more water, light, or fertilizers.
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System or Drones.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Better data utilisation and visualisation. • AI integration assists.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios. • Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.

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REAL WORLD EXAMPLES	•
TECHNOLOGY PROVIDERS	•

HEALTH & SAFETY

DESCRIPTION	**Emergency Procedures Training Tool.**
USE CASES	• Where to locate emergency stops on machinery using Model Marker solutions. AR is showing promise in solving both pieces of the public safety puzzle. First responders wearing AR glasses can be alerted to dangerous areas and show in real-time individuals that need assistance while enabling them to still be aware of their surroundings. For those in need, geolocation-enabled AR can show them directions, and the best route to, safe zones and areas with firefighters or medics. • At the Safety and Health Expo Lloyds Register demonstrated their VR "Safety Simulator and gaming experience", developed with Polar Media. The user is placed in a virtual oil rig environment, where they are challenged to identify and fix safety breaches. The impact of failing to fix the problems is illustrated with crash-test dummies stumbling, falling from height, or being crushed. • For less hazardous environments, Walmart is using VR to train staff to deal with situations that would be difficult or dangerous to recreate in the workplace – like spills in the aisles or managing the Black Friday hoards!
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar) or mobile devices (phones or tablets) with VR holders (Google cardboard or similar) or VR CAVE System.
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	• Increased confidence and efficiency. • Can be placed in any number of scenarios and environments. • Real word visualisation and better engagement.
CONS	• Cost of hardware (HTC VIVE Pro or similar) and cost of developing scenarios.

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	• Users' resistance to change. • Wearing cumbersome headwear for long periods. • Battery life of hardware. • Responsiveness of hardware.
REAL WORLD EXAMPLES	• https://www.shponline.co.uk/safety-training-and-development/immersive-factory-launches-its-ehs-training-exercises-on-virtual-reality-standalone-headsets/
TECHNOLOGY PROVIDERS	• https://polarmedia.wistia.com/medias/beeljipet3 • https://immersivefactory.com/

RECRUITMENT

DESCRIPTION	**Recruitment Based On VR Performance.**
USE CASES	• The advantage of introducing VR to a candidate assessment programme is that "seeing people in action is a better indicator of their potential".
TECHNOLOGY USED	VR Headsets (e.g. HTC VIVE Pro or similar).
COST	High. Development of software. Purchase of hardware (HTC VIVE Pro or similar).
PROS	•
CONS	•
REAL WORLD EXAMPLES	• https://www.irishtimes.com/business/work/how-virtual-reality-can-help-real-life-recruitment-1.4269791 • https://vervoe.com/virtual-reality-recruitment/ • https://www.stereoscape.com/blog/2019/06/25/vr-in-recruitment-and-onboarding/
TECHNOLOGY PROVIDERS	• https://www.stereoscape.com/

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