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VRinSight Curriculum

Boosting Virtual Reality Learning
within Higher Business Management Education

Co-funded by the
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of the European Union

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Contents

List of abbreviations

VR: Virtual Reality

AR: Augmented Reality

IT: Information technology

HMD: Head-mounted display

3DoF: Three degrees of freedom

6DoF: Six degrees of freedom

PD: Pupillary distance

HE: Higher Education

HEI: Higher Education Institution

ROI: Return of investments

ERP: Enterprise resource planning

PLM: Product lifecycle management

Module A

An overview of VR technology and its potentials in European HEIs and SMEs

Erasmus+

1 An overview of VR technology and its potentials in European HEIs and SMEs – Module A

1.1 Overview of VR ecosystems

Four main hardware ecosystems exist for VR. These are *Oculus*, *HTC*, *Valve* and *Microsoft*. In addition, *Google* and Sony *PlayStation* both have a notable position in the global VR landscape. However, their current offering is either too low-end (*Google Cardboard* or *Google Daydream*) or their ecosystem is too closed (e.g. *Sony PSVR*) to be effective in the higher education context. Each of the three main ecosystems has main application distribution channels, which will dictate their success in the future. These are *Oculus Store*, *HTC's Viveport*, *Valve's Steam*, and *Microsoft Store*. As we are evaluating suitable tools and hardware to be used in higher education context, we will have to look at four key factors: a) Ease-of-use, b) Price point, c) Hardware availability, and d) Content.

To that end, we are left with four possible ecosystems – Oculus, HTC, Valve, and Microsoft. Original VIVE HMD was launched from collaboration between Valve and HTC. Today, HTC has their own Viveport content store and Valve focuses to develop their own platform Steam (previously known mainly from PC gaming). HTC has standalone (cordless, no PC needed) HMDs (such as VIVE Focus Plus), but their market focus seems to be mostly in Asia and USA. Valve does not offer any stand-alone HMDs. Instead, Valve is focusing on its own HMD Valve Index that is relatively expensive, complex to set-up, and thus it is aimed to high-end VR-markets. Therefore, Oculus ecosystem is our main candidate for a suitable solution at this point. Further analysis is presented below.

Oculus (Oculus Rift, Oculus Rift S, Oculus Go, and Oculus Quest): Oculus Guest is the potential HMD in context of VR adoption of European HEI institutions and SMEs. Other stand-alone devices have still performance issues in professional work (e.g. in virtual meetings). Oculus Rift/Rift S requires complex set-up and it is not ready for large-scale adoption (thus, it is mainly used by IT professionals or VR enthusiasts). However, one major advantage of Oculus Quest is an option to connect the headset to a PC via *Oculus Link* (USB-C cable that is sold separately), which enables the use of any application from Oculus Store. Therefore, Oculus Quest offers an advantage of standalone HMD, plus high-end performance when connected to a PC via Oculus Link.

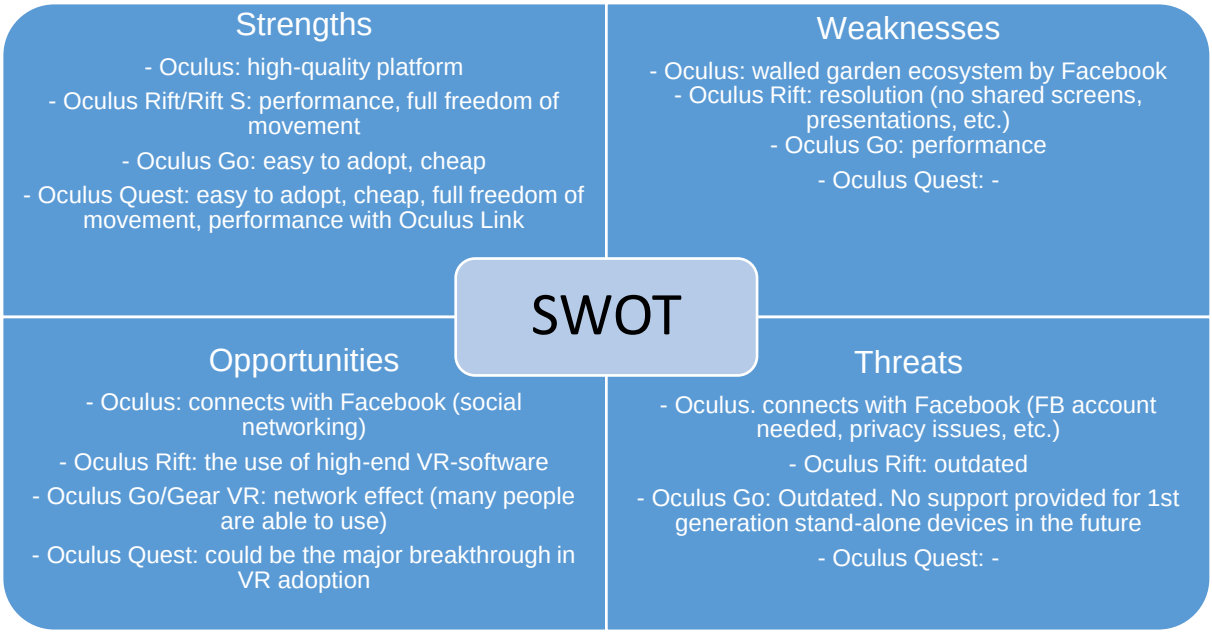

Fig. A1. SWOT analysis of Oculus platform

Today, HTC VIVE and Valve Corporation are the main competitors for Oculus. Valve's platform (Steam VR) runs on Windows. HTC has many different HMD's available: HTC Vive, HTC VIVE Pro, VIVE Focus Plus, VIVE Cosmos (not yet released), VIVE Pro Eye (not yet released). Stand-alone devices from VIVE (VIVE Focus Plus) will have their own platform for applications (i.e. they are not using Steam VR). Technically, these HMDs are not that different in relation to products from Oculus. The main difference is the platform: Steam VR is maybe more diverse VR ecosystem. There is a wide variety of both entertainment and business applications available, also from small developers. However, majority of the most used and widely adopted VR applications (especially for business purposes) are available for every major VR platform.

In our analysis, HMDs that require external PC are out of option when considering adoption of VR technology in HEIs. Due to different technological issues (updating hardware/software, setting up the devices, etc.), they are too expensive and hard to use. Oculus Quest is an end-to-end option that provides both flexibility and enough performance for high quality content and virtual meetings.

1.2 Current Status of VR in Higher Education and SMEs

1.2.1 Current status and examples of VR in Higher Education in the partner countries

In **Cyprus**, over the last years, there are many initiatives related to VR development and implementation, specifically in the Higher education field. Particularly, there are some research labs, which are focusing on VR technology. Those research labs are carrying out research related to the development, implementation, and promotion of VR solutions in education and in other fields. Some example of VR use includes scenarios in Science education, in foreign language teaching, in history (e.g. visit an archeological site/place/monument virtually). In addition, VR tools/devices is being combined with motion-based technologies in the context of embodied learning environments.

In **Finland,** there is a stream of academic research relating to the development of VR technology for organizations. In spite of this and the fact that Finland is known to be one of the world's leading

countries in the field of education, VR is not used that much in teaching. There seems to be lack of ready-made educational VR-applications that would be easy to use and able to deliver enough content to justify all of the expenses (hardware, software, licenses, staff training, adjusting physical spaces for VR use, etc.). However, there is interest towards implementing VR technology in education in the future, but that may require high quality social VR applications and high-quality educational content that would be, at least partly, scalable and user generated.

In **Belgium,** there are many examples in VR usage for education and other purposes. Some indicative examples are: VR application that measures recognition of dangerous situations in traffic by young cyclists, 3D microscopy in VR, pain reduction where patients with fire injuries not only get classic anaesthesia and pain relief during a surgical procedure. Furthermore, in the professional bachelor teacher training, Google Expeditions is used (with around 800 expeditions available). VR also allows to clarify abstract subject matters. There is an application to let students learn about proportions. In that application they virtually have to stand next to buildings to compare their own length with the height of a building. Also, at university of Ghent, they have tried to clarify Einstein's theory of relativity using VR. However, wider adoption of VR technology in HEIs does not exist yet in Belgium.

In **Spain**, VR is not used much in HEIs. In enterprises, the use of VR is mainly being driven by central and regional policies related to the implementation of RIS3 policies and Industry 4.0. For example, focusing on Basque Industry 4.0 is a move towards the incorporation of intelligent systems into production plants, the improved use of emerging capabilities and technologies in new products and processes, the integration of advanced materials into higher added-value solutions and improved processes, and the efficiency and sustainability.

The research into HE use of VR/AR has uncovered that there only a few institutes in **Germany** that are incorporating the technology into their institutes in a significant way. An example in University of applied Science, in Bielefeld, as well as Technical University Dresden having invested in CAVE technology (i.e. room-scale displays, not HMDs). There are also examples of HEI incorporating VR/AR technology into other disciplines, such as the Technical University Chemnitz with a large focus on process and manufacturing engineering. As well as the Technical University Berlin using AR in the Aerospace department for research in cockpit development and its practical use for aviation pilots. One of the key findings that was common amongst the HEI was that VR/AR was often introduced in learning and research to replace an alternative or more expensive technology (for example flight simulators), and the real potential benefit in future for Universities will be the financial aspect as the VR/AR technology becomes ever more inexpensive.

In **Austria,** VR has not established itself as teaching instrument in education and only few applications can be found. The medical university for example, has planned to implement virtual surgery in teaching this year. There are some examples of VR seminars and research projects in various fields of higher education. Like VR, e-commerce is an upcoming topic that is getting more and more attention. So, colleges and universities address this special field with their research.

1.2.2 Current status and examples of use of VR in SMEs with focus on the needs of HEIs

In **Cyprus,** there are VR technologies in business and training like the use of VR in promotion of a new product or service offering a realistic experience to clients. Also, in professional training and in management. One initiative in the business sector is the use of VR devices in architecture and real estate. With the use of VR, mainly PC-based devises like Oculus, clients can walk in the space and can see how their houses/offices/spaces look like. That opportunity gives a chance to the clients to make some strategic decisions before the actual implementation of the project.

Finnish VR industry has already developed to the point when there are solid business plans and ecosystems for the use of VR, but it has not yet reached its full potential. VR is still mainly focusing on "viewing 3D things in VR" (e.g. marketing, visualizing), and only recently there has been an attempt to implement more advanced VR solutions in a wider scale, with more complex interactions or communication processes in virtual space. The most potential use cases for VR were as follows: Collaboration/co-design (intuitive 3D interface, no physical boundaries in interaction), sells/marketing ("wow-effect"), operative work (e.g. visualizations that support it) and education/simulation.

In **Belgium,** some examples of the use of VR in SME field include: Nanopixel[1], In The Pocket[2], Yondr[3], OneBonsai[4], and game parks. DEME (previously 'Dredging International') invests in this technology because it will allow them to train their people for underwater operations and to prepare underwater operations in a dry and comfortable office where it is easy to communicate with each other. It also allows foreseeing safety issues and preparing safety measures.

Similarly, in **Spain** there are some VR initiatives for SMEs. Some examples are: VirtualTriage[5]: An innovative tool aimed at all emergency personnel who may intervene in multiple-victim situations (paramedics, ambulance workers, firefighters, armed forces, police, etc.). VirtualRet[6]*:* The first Virtual Reality platform aimed at all personnel involved in the Mental Health sector such as psychologists and psychiatrists. Tevrene[7]: Virtual reality intervention for Multiple Sclerosis rehabilitation. VR Spaceship App: Experience a journey through this 3D spaceship and an exciting environment with your mobile virtual reality headset for Google Cardboard, Daydream or any mobile virtual reality headset. Ludus VR[8]: Virtual training system for industry staff providing identification and decision-making processes related to occupational risk scenarios. Forklift VR Simulator[9]: The forklift simulator recreates different stages with didactic content to learn and improve the skills needed to drive and handle freights with the forklift.

The VR/AR trends being developed by the global companies can also be witnessed in **Germany**, with many market leaders offering hosting service and VR/AR app development (e.g. Amazon Sumerian). According to a study done by Deloitte in Germany, revenue in VR/AR was approx. €160 million, which will grow to €1 billion by 2020. The potential growth estimates in the German market for VR/AR vary

[1] Nanopixel: https://www.nanopixel3d.com/
[2] In The Pocket: https://inthepocket.com/
[3] Yondr: https://yondr.agency/
[4] OneBonsai: https://onebonsai.com/#virtual-reality-development
[5] Virtual Triage: (http://virtualtriage.info/
[6] VirtualRet: https://www.scribd.com/document/59430669/VirtualRET-Phobia-Treatment
[7] Tevrene: http://www.virtualwareco.com/news/virtual-reality-intervention-for-ms-rehabilitation/
[8] Ludus VR: https://www.ludus-vr.com/en/portfolio/risk-prevention/
[9] Forklift VR Simulator: https://www.ludus-vr.com/en/portfolio/forklift/

source to source, all agreed that the majority of the growth will come from content-production solutions. Some of the large global German industrial leading companies, enjoying sufficient capital have invested in VR/AR technology, across areas like marketing, new product launches, employee training (industrial, medical etc.), and integration with automobile navigation/displays, but this is limited and far from widespread and the potential opportunities have not quite yet been realised at this level, and certainly not at the SME level.

In **Austria,** bigger companies take advantage of the fact, that you can copy reality and re-enact scenes in a virtual environment. Most VR applications can be found in industry/manufacturing (e.g. automotive industry), architecture, health care/medical sector and tourism/art. Until now only very few SMEs already use VR at all. Even if their product is somehow VR related, they often do not use it for their own purposes. It was argued that the initial effort concerning time, money and staff is too high for small companies to use VR for business management purposes. Also, VR is a known tool for virtual meetings. Another possibility is to work collaboratively in a virtual environment. In case of one SME, both managing partners work from different locations. When creating, among other things, VR solutions they meet directly in the virtual scene and work there collaboratively. Moreover, one SME is presenting its product, a hydroelectric power plant, with VR. It was seen as only way to meet their needs, with an up-to-date solution.

1.3 Challenges, barriers, opportunities, and training needs in VR adoption for HEIs and SMEs

1.3.1 Challenges and barriers of VR adoption in Higher Education

As the participants mentioned, VR technology could bring dozens of benefits to almost any field, but it also has many barriers and important challenges in adoption and implementation. Some barriers or challenges, as mentioned by participants, include:

- Investment costs: The high cost of almost all VR technologies/devices
- Lack of proper physical space: VR implementation requires space to move around to make use of motion tracking
- Technical boundaries: VR is complicated to set up
- Lack of end-to-end products
- Psychological barriers: fear, discomfort, etc.
- Impractical in terms of portability
- Functionality issues
- Lack of flexibility
- Limited opportunities for collaboration
- Lack of digital skills
- The lack of knowledge about the real potential of VR
- The lack of operational dependently of VR technology in its current state.
- Availability of devices.

1.3.2 Opportunities in Higher Education

All participants argued that VR technologies provide plenty of opportunities in different sectors, including education. Students/learners also have a positive attitude towards using VR in their learning process. Furthermore, VR grabs and holds students' engagement, probably because it is exciting and challenging to interact, create, and manipulate objects in a virtual environment. According to the participants, virtual technologies promote a full student-cantered learning experience, given that students are main performers when experimenting and practicing with virtual objects. Today, as all participants claimed, it is not just about using virtual technologies in the classroom, but technological improvements allow various alternatives with different levels of interaction and immersion. More specifically:

- Provides outstanding visualizations that aren't possible in traditional classroom
- More interactive experiences - users can feel the experiences with their senses
- Promotes self-guided exploration and independent practice – autonomy learning
- It creates interest in learning
- VR increases students' engagement.
- Remote teaching (e.g. immersive 180-degree lecture videos)
- Collaborative learning (social VR)
- Learning by doing (skill-based learning, e.g. medicine, engineering)
- Expensive physical training can become cheaper with VR.
- VR makes unsafe training conditions safe. (e.g. crossing the road, fire extinction)
- VR may speed up communication and decision making (e.g. in real estate)
- VR has the potential to immerse people in a virtual but realistic environment in which they are confronted with a certain situation and a number of unexpected events. This creates a test environment in which a teacher can evaluate the reactions of the student and give him/her feedback afterwards.

1.3.3 Training needs for HE

VR technology opens up new, exciting possibilities for many different purposes. Being able to implement VR different scenarios from anywhere in the world is extremely powerful, as it allows each learner to practice their skills with no real-world consequences. As all participants explained, staff (in education and business management) needs a high-quality level of training in order to apply VR solutions effectively in their working environments. To sum up, based on participants' responses, some essential training needs are:

- Basic technical and digital skills
- Expertise in handling different type of technologies
- Adaptability
- Creativity
- Willingness to learn new things
- Openness: Teachers who aim for integrating VR in their teaching, should be open minded for this technology and all the possibilities it offers
- Knowledge about complex software (e.g. Unity or Unreal), is not relevant for teaching and, therefore, would take too much time for a teacher to learn it

- What teachers need most is help with implementing the scenario of their VR-idea.

1.3.4 Challenges – Barriers in SME

As the participants mentioned, VR technology could bring dozens of benefits to almost any field, but it also has many barriers and important challenges in adoption and implementation. However, many companies did saw potential of VR in the near future, but they were not able to scale the use of VR, or sell scalable VR products, quite just yet. There was also lack of end-to-end VR solutions (in which everything is "ready" and easy to use when you take the product out of the box) in the market. Companies need to have certain amount VR capabilities and understanding before using VR. Some barriers or challenges, as mentioned by participants, include:

- The high cost of almost all VR technologies/devices
- VR implementation requires space to move around to make use of motion tracking
- Complicated to set up
- Lack of end-to-end VR products
- It is not suitable for people who don't have some knowledge and experience with VR
- Lack of flexibility
- One of the boundaries for using VR companies are facing is the absence of 3D models of their current available infrastructure. They lack digital information of machines and installations currently in use
- The lack of a vision to transform to a digitalized company.

1.3.5 Opportunities in SME

However, it was clear that availability and usability of different VR solutions has improved significantly in past couple of years. For example, the upcoming product Oculus Quest could improve this user experience significantly, as it is able to provide six degrees of freedom (6DoF) and better performance in terms of resolution and computing power. VR is at its best when removing physical boundaries for interaction. VR could potentially substitute e.g. videoconferencing, especially in cases when interaction occurs around different 3D objects. Another important aspect of using VR was in visualising something that is 3D and/or otherwise complex.

- Less travels
- Advance services and training in dangerous environments.
- Better and fast competences acquisition. Better quality in the service.
- Show the company in detail in real time.
- Increase in the efficiency and agility in the design and start-up of productive facilities.
- More security for field staff.
- Predictive maintenance.
- Spatial sense: VR is a tool that solves the problem of spatial sense. For example, it is hard imagining proportions when looking at a 2D plan of a house.
- Marketing – unique selling point: VR is a trend topic and attracts customers.
- Immersion: It offers people a possibility to collect impressions and experience at a new level and to get better insights in processes

- Virtual testing: One strength of VR is that it gives you the possibility of trying and testing in a virtual environment, which would not be possible in real life
- Knowledge transfer: VR gives you the possibility to communicate special knowledge to other people in a seemingly real situation.

1.3.6 Training needs in SME field

Most of the technology companies that worked closely with the VR invest on the staff training because is a critical part of their work. Hiring individuals with proper VR competence is a crucial starting point in this sense as well. Companies need employees who are able to train other employees about VR. Training needs for SME's could be summarized into five parts: (1) what VR is and what it enables, (2) how to use VR (controls, hardware), (3) what VR software/platforms already exists, (4) how VR could potentially affect to the specific industry (e.g. construction, education), and (5) understanding other emerging technologies that could be potentially be utilized with VR (now and in the future). Particularly, in the training needs in SME field are also included:

- Basic technical and digital skills and expertise in handling different type of technologies
- Adaptability and creativity
- Willingness to learn new things
- Skills for content development by SMEs technical staff
- Social skill for the working environment and specific production operations.
- Improvement of VR receptivity in the company
- Adopt SIL-HIL technologies to be able to apply them in design phases, advising and helping our clients so they can implement them in their projects.

1.4 Conclusion

Based on the findings, VR will gain higher impact in the future and will be established as working technology. There is still not a clear vision of how to integrate these technologies in a stable way into an educational process. In this regard, there are many challenges and difficulties in the implementation and adoption of such new technologies. However, taking into consideration the quick evolution of mobile technologies like smartphones and tablets, the use of VR is more feasible and affordable for educational institutions and students than ever before. It will be possible to conduct immersive experiences by interacting with objects, concepts, or processes, as a regular learning workflow at any educational level, from primary school to higher education. As all participants agree, what makes VR so important is the fact that can promote knowledge and support learners to achieve something new. However, there are many things to be done.

To start experimenting with VR technology, the project needs stand-alone HMDs such as Oculus Quest or VIVE Focus Plus. These stand-alone devices remove many technological barriers that relate to VR technology adoption: they are cheap and easy to use. Before the implementation, people need to get familiar with this technology first, in order to understand all of the possibilities/barriers that relate to this technology. It is essential to understand first what VR is and what it enables, how to use VR and how VR could potentially affect to the specific industry (e.g. construction, education). Last, partners claim that one of the most important aspect in VR use is the accessibility and usability. Access to VR needs to be cheaper and easier. The devices need to be smaller, more lightweight, lose cables and external sensors.

Module B

Pedagogical aspects of VR learning

2 Pedagogical aspects of VR learning – Module B

2.1 Introduction

The purpose of this document is to provide an overview how VR can be used for pedagogical purposes. The document is targeted both at educators and policy makers. The contents of this document will be utilized in VRinSight-project as a guideline for the development the VR Curriculum Modules produced by the prohect. These modules are in the first instance, designed for lecturers and teachers of business management study programs in higher education institutes. As a wider audience, this module is aimed at lecturers and teachers of all disciplines, and more broadly aimed at the management of SMEs in Europe. This training program is enriched with many practical VR-cases/exercises/experiences. Therefore, while reading this text, you should use the accompanying VR Classroom provided by VRinSight. Although the VRinSight project deals with virtual reality, this document will also give an overview how virtual reality is different from augmented- and mixed reality, the two technologies that are tightly related with virtual reality.

2.2 Difference between VR, AR, and MR

Virtual reality (**VR**) is a simulated experience that can be similar to or completely different from the real world[10]. The key characteristics of VR can be summarized as follows:

1. Due to sensory immersion, ”brain treats it as real”
2. You can turn physics on and off. It is possible, just by selecting the right menu choices, to turn on/off gravity, to allow you to fly, to walk through walls, to lift heavy weights, etc.
3. You can become a different person (see The Proteus Effect).

At this moment, Virtual reality systems in education mostly use both headsets (head mounted displays, HMDs) to generate realistic images and sounds and handheld controllers to allow manipulation of virtual objects and to provide force feedback through haptic technology. The HMD allows the user to look around the virtual environment. The user can walk around in this virtual environment if the available physical space is large enough and freed from obstacles. As an alternative way to move to another location in the virtual environment, the user can move forward, backward, to the left or to the right with one controller and rotate clockwise or counter clockwise with the other controller. To virtually jump to another location, the user can be teleported using his/her handheld controllers. Other sensations like, for example, smells and tastes are not simulated yet in commercial VR systems.

Applications of virtual reality can include entertainment (e.g. gaming, painting, and sports), education (e.g. medical treatments, military operations, machine safety, attitude training, virtual expeditions, traffic courses), marketing (e.g. virtual tours, virtual product experiences) and communication (e.g. meeting people in a virtual room, presenting in front of a virtual audience).

Augmented reality (**AR**) is an experience of a real-world environment where the objects that reside in the real-world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities[11]. Information about the environment and its objects is overlaid on the

[10] Wikipedia 2019, *Virtual reality,* Viewed 20 September 2019, <https://en.wikipedia.org/wiki/Virtual_reality>
[11] Wikipedia 2019, *Augmented reality,* Viewed 20 September 2019, <https://en.wikipedia.org/wiki/Augmented_reality>

real world. The perceptual information is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment.

Applications of augmented reality include entertainment (e.g. games like Pokemon Go), education, production (e.g. maintenance support, interactive checklists), construction (e.g. architects, AR helmets for construction workers), medicine and communication.

Mixed reality (**MR**) is the merging of real and virtual worlds to produce new environments and visualizations where physical and virtual objects are integrated into a physical view. Contrary to AR, in MR interaction with the virtual objects is possible.

Applications of mixed reality include product design, surgical operations, communication (be virtually together in the same room), repair and maintenance instructions, entertainment (e.g. immersive video games, immersive sporting events)

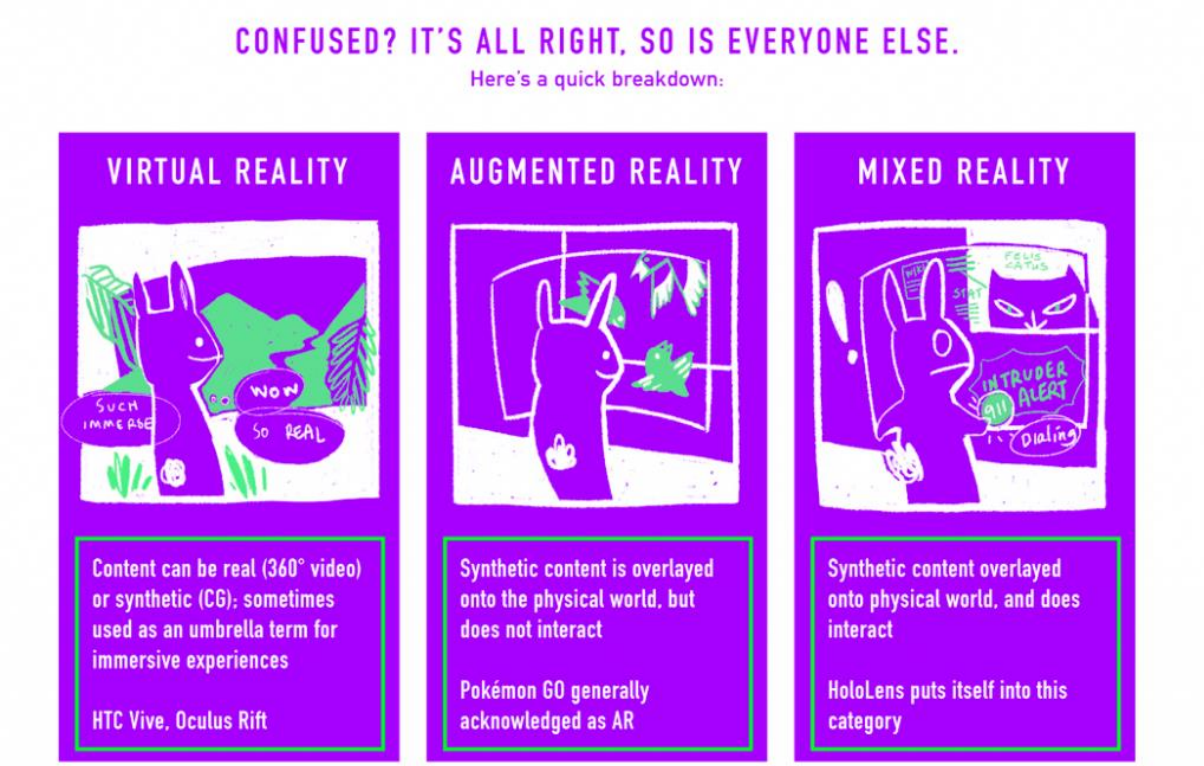

Fig. B1. VR should not be mixed with augmented reality (AR) or mixed reality (MR)[12]

2.3 Benefits of using VR in education

In general, studies have confirmed that VR can foster learning in at least three ways: by allowing participants to take *multiple perspectives* (Exocentric or Egocentric view), *situated learning* and *transfer*. Ability to take multiple perspectives helps individuals to understand complex phenomenon by shifting between exocentric and egocentric view[13]. Egocentric view provides, for example, embodied learning via avatars in different training scenarios (i.e. just like doing things physically in the

[12] Source: http://flipthemedia.com/2016/10/virtual-reality-in-enterprise-and-beyond/

[13] Dede, C. (2009). Immersive interfaces for engagement and learning. *science*, *323*(5910), 66-69.

real world), where exocentric view enables perspective taking that foster the learning of more abstract information, such as viewing a landscape in Google Earth.

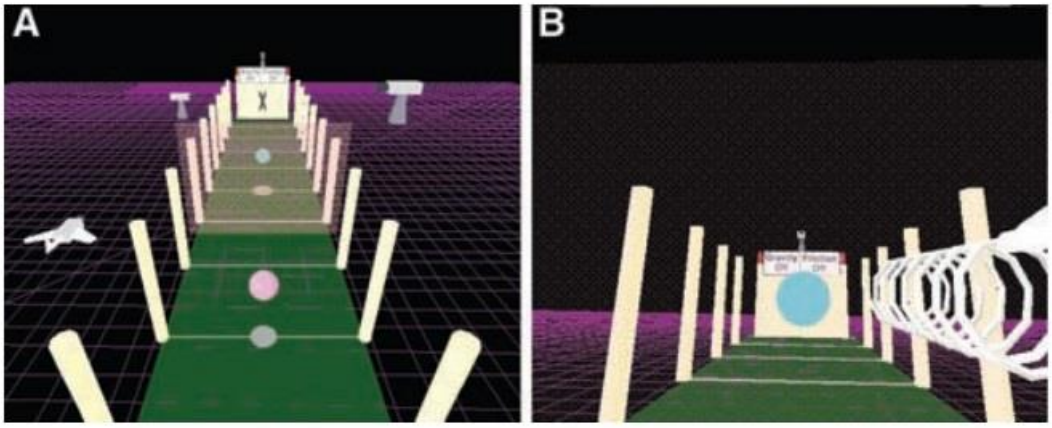

Fig B2. Demonstration of Exocentric view vs. Egocentric view in VR[13]

Situated learning emphasizes context dependent learning scenarios, in which learners participate in activities and deliver assessments that simulate scenarios from the real world. However, VR is not bound by laws of physics and, therefore, this form of learning can be leveraged in ways that are not physically possible otherwise (e.g., lack of gravity enables flying or lifting of heavy objects). In addition, situated learning can be coupled with real-time quidance or mentoring in a multi-user environment, which makes this form of learning even more efficient. Additionally, the of knowledge that is acquired via "learning by doing" is more easily transferred to another situation. Knowledge acquired via the use of VR is less abstract and more concrete.

Immersion in VR in usually understood as "sensory immersion" that enhances *presence* (i.e. participants feeling of "being somewhere else"). However, there are different forms of immersion that are important when elaborating the educational benefits of VR, especially motivation to learn within VR[14]:

- Sensory Immersion: Physical information that is acquired via senses. Usually means sensory stimuli that is provided via Head-Mounted Displays (visual information) or, for example, haptics.
- Actional Immersion: Ability to do something in a virtual space, interact with virtual objects, etc. Fosters participant's focus in the virtual environment and potential actions that it holds.
- Symbolic/Narrative Immersion: Delivered by content of interaction, such as a storyline. E.g. horror movies are frightening because of this form of immersion due to its ability to stimulate viewer's imagination.
- Social Immersion: Enhanced by communication in multi-user virtual environments (e.i. social virtual reality, SVR). Participant's feel each other's presence and togetherness via means of verbal and nonverbal communication.

[14] Dede, C. J., Jacobson, J., & Richards, J. (2017). Introduction: Virtual, augmented, and mixed realities in education. In *Virtual, augmented, and mixed realities in education* (pp. 1-16). Springer, Singapore.

- Psychological Immersion: A combination of any forms of presence mentioned above.

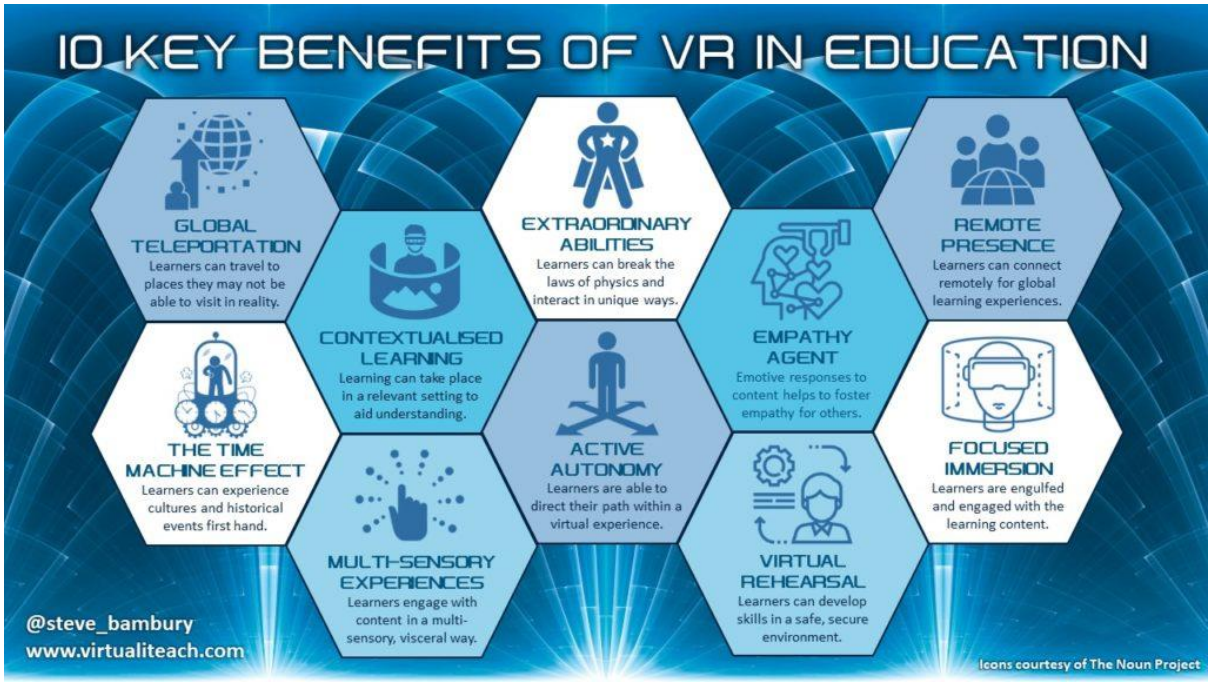

Fig B3. Ten key benefits of VR in education[15]

1. **Global Teleportation:** Have you ever visited the Seed Vault in Spitsbergen? Have you ever looked into an active crater? Have you ever enjoyed the aurora borealis in the very Nord of the continent? Have you been walking on the moon? It is so hard or even impossible to get there but VR allows us to visit these places virtually. With the app Google Earth VR, for example, people can traverse the entire planet.
2. **The Time Machine Effect:** Students can travel in time and experience the past. If today, you record with a 360° video camera an event like e.g. a lesson, a concert, a conference or a lecture of a guest speaker, students can attend that event afterwards as if they were there. They can virtually look around during the event. Since VR is a relatively new technology, no 360° video content has been recorded in e.g. the Middle Ages. Of course, such a scene can be recorded today while a scenario is played by actors in an authentic or reconstructed set. When the historic site still exists, 360° photo or video content can be used to let students virtually explore the site.
3. **Contextualised Learning:** VR can also show the context of the learning topic, compared to AR. AR can bring a Greek statue into the classroom and let pop up textual information about the statue. VR, moreover, allows to view the same statue in Ancient Greece.
4. **Multi-Sensory Experiences:** Students are able to move within a virtual space and engage with elements like never before. They can play tabletennis with a virtual ball, fly a zeppelin with a

[15] Bambury, S. 2019. VRFocus, viewed 3 December 2019, *10 Key Benefits of VR in Education*, <https://www.vrfocus.com/2019/03/10-key-benefits-of-vr-in-education/>

virtual remote controller, pick up and throw away virtual objects and a lot more amazing things. In all cases, VR delivers an immersive visual environment with accompanying surround sound and haptic feedback through the controllers. Aromas and flavors are not yet included in the multi-sensory experiences.

5. **Extraordinary Abilities:** VR allows us to break the laws of physics: e.g. lift a car, paint with fire, be teleported instantly to another place, look into a machine through its panels,… Maybe more interesting is the fact that a virtual accident, explosion or fall doesn't hurt. That characteristic makes VR an excellent tool to learn the right skills to handle dangerous conditions.
6. **Active Autonomy:** Students can choose where to look and where to go. Each time they are in a physical school trip, the teacher requires them to "stick with the group". VR, on the other hand, allows them to explore the virtual environment freely. Because of that, they can direct their own flow of information according to their own way of learning.
7. **Empathy Agent:** VR can be used to foster empathy. Stanford University researchers developed a new VR experience called "Becoming Homeless". In this VR app, the user lives out the experiences of people who were faced with homelessness after losing their job. In one scenario, the user has to decide which possessions he would sell in order to make his rent payments. In another scenario, the user has to protect his possessions from strangers. As a result of a study, users who underwent VR experience were more likely to feel lasting sympathy for the homeless than those who got to know the situation of homelessness through other media, such as by reading an article.
8. **Virtual Rehearsal:** Today, some VR apps exist that allow to practice and hone skills without fear of failure. This way of improving your skills is incredibly powerful. One of those apps, VirtualSpeech, is very useful to practice public speaking. A Frog Dissection app allows to develop skills in the Biology classroom, potentially saving a lot of money in the process!
9. **Focused Immersion:** Since VR is an experience played inside a headset, the user is less prone to distractions in his physical surroundings. For some students this type of learning may be very useful because they are prone to distraction, which leads to a loss of focus and ultimately a loss of learning efficiency. The immersive nature of VR means that students are inundated with learning topics, so this is a key factor in the retention of information.
10. **Remote Presence:** Students using VR can connect with other students as well as attend lectures and lessons delivered by educators across the globe using multi-user social VR platforms like Engage and AltspaceVR. In the near future, these platforms will become thriving hubs for educational content.

2.4 Benefits of VR for policy makers

For policy makers, creating jobs and increasing productivity in both industry and services are at the top of their agenda. The key to attain this goal is the development of skills of all managers and employees. However, the current workforce in most countries are not ready to meet the job market needs particularly in more competitive economic environments. In many countries, education systems are not providing young people with the basic skill sets both cognitive and behavioral[16]. Well, with VR technology, schools will have a powerful tool to train certain behaviors and to attain a significantly higher retention rate than traditional teaching. Now, it is up to our policy makers to actively promote and encourage the use of VR in education.

2.5 Pitfalls

1. Robin De Lange from Virtual Reality Learning Lab in the Netherlands: "We learned from experiments that young students are very enthusiast when their teacher proposes to use the VR headsets in the classroom. Afterwards, these students are convinced that they learned more compared with the traditional way of teaching. However, this is not always true. VR is not just an alternative way to teach. Teachers have to consider in advance, what they want to obtain with the use of VR. VR is only relevant in education if you use it to obtain a learning output you cannot accomplish in another way."[17]
2. Try to limit the duration of a VR session. Intensive use of a VR headset may result in following complaints[17]:
    - VR head mounted display isolates students from the physical environment which leads to disorientation,
    - VR apps may contain a plethora of stimuli, disturbing for hypersensitive people as for example autistic students; for other students, the fact that VR allows to look around 360°, makes it such an overwhelming experience that they miss the aspects to which they should pay attention.
    - When virtual movements do not match movements in the physical world, like in roller coaster VR videos, students may become dizzy
3. Some VR app developers have not enough feeling with education. Their apps are beautiful but are not adapted to the foreknowledge or vocabulary of the students for whom they are intended. If the VR app assumes a lot of foreknowledge and when it contains high-flown vocabulary, students may get knocked off. On the other hand, when an app is developed for a lower level in education, students may get bored.[17]

2.6 Barriers to VR adoption

It is difficult for educators, who know the educational potential of VR, to convince their management to start integrating VR in their schools or institutions. School leaders vetoing VR project proposals take decisions based on misconceptions, lack of understanding or fear of the unknown. Alternatively, they do not understand what virtual reality actually is or they have experienced 360° images or videos and

[16] World Bank Educational Overview 2018: http://documents.worldbank.org/curated/en/821801540479977693/World-Bank-Education-Overview

[17] Verweire, E. (2019), EOS Wetenschap, viewed 3 December 2019, *Virtual reality zonvol voor het onderwijs*, <https://www.eoswetenschap.eu/technologie/virtual-reality-zinvol-voor-het-onderwijs>

have the misconception that VR is limited to that kind of applications. What are the barriers they perceive?

1. A lack of understanding VR

To help them understand the power of VR, let them try it for themselves! Let them fly with Google Earth VR in no time from one touristic location to another, let them make 3D-paintings and walk through it with Tilt Brush or let them experience walking the plank from the top level of a skyscraper with the famous app 'The Plank VR'. They will feel that these applications really affect them and they will conclude that VR has a huge potential in education[18].

2. Cost and ROI:

Schools have tight budgets and these budgets have many pulls. That is why the school board considers it as a risk to invest in a new kind of technology. However, as a start, the investment can be limited. It is not necessary in a classroom, to have one headset for every student. There are many ways to integrate VR in a lesson. VR and spatial computing as a whole is the future of how we will interact with all digital content across every industry. The fact that VR represents a complete different way to interact with digital content makes this barrier even harder to overcome. When the iPad was introduced, it was broadly familiar with a laptop computer. The iPad was in fact a small computer with touch-screen functionality while VR totally changes the hardware interface as well as the very nature of the content it offers. 3D interface provided by VR will soon substitute or even replace conventional 2D screens. Schools have to start preparing our youth for this shift to immersive technologies now. An investment in VR makes an educational institution ready for the future. However, what about the ROI? Let us be critical: Is ROI the right criterion? Ultimately, we are talking about empowering students to be prepared for their jobs in the future. Achieving that goal is the highest ROI[18]

3. Rate of change

Martec's Law states that technology changes exponentially while organizations change much more slowly. That means that, even when an educational institution want to be an early adopter of new technologies, their decision process and implementation process are slower than the pace of technological evolution!

Schools have fear of "jumping too soon". Technology is constantly evolving and there will always be a newer/ bigger/ smaller/ faster/ quieter/ more powerful version coming next. If schools wait to invest in new technologies because there is something very promising in the pipeline, they will never adopt a new technology and, in the end, their students will lack the necessary job skills and competences to become an efficient and successful professional.

We have to be aware that most of our students are generally more technology-savvy than school staff since they are growing up with technology every day. They are used to services with the adjectives: 24/7, wireless, animated, interactive, visual, instant, intuitive, etc. To this list, VR can add a new and thrilling adjective: immersive![18]

4. Health and safety

[18] Bambury, S. 2019. Virtualiteach, viewed 15 October 2019, *5 Key Barriers to VR adoption*, <https://www.virtualiteach.com/single-post/2019/03/31/5-Key-Barriers-to-VR-Adoption>

Is VR safe for our children? Among hundreds of other concerns, parents also have concerns about their children using VR. Top concerns are[18]:

- Sexual content/porn/violent content: this concern is not related to VR only. When children use a smartphone, a tablet or a computer linked with the internet, they already have access to this kind of content.
- Too much time with VR: A lot of children and teens have the same problem with for example watching television, playing games with on-line opponents, or using a game console. The solution is parenting: set limits to this kind of entertainment, be consistent and talk to your child about their impressions. The advice from professionals is: 2-3 minute sessions for children <6 years old (and without using the head strap so that they don't feel trapped in any way) and 10-15 minute sessions for young people <13 years old.
- Social isolation: once you put on a headset, it is not possible anymore to have eye contact with other people in your physical environment, but maybe you are meeting new people in a virtual space like AltspaceVR where you can talk to each other live but where you can see the participants to the meeting (as avatars). Social isolation did not arise with VR. Young people excessively using their smartphone at home are also 'absent' for their family. Again, the solution is parenting.
- Health and safety concerns:
    - Since the user cannot see the physical environment, there is a risk to bump into something. To avoid this, modern VR systems oblige the user to mark a chaperone. This is the digital cage of boundary lines that the user can draw with his controllers to mark a cleared physical area in the room where he is using the system. When the application does not trigger the user to move around or to make gestures with his controllers, the user can just sit down for safety.
    - Dizziness with VR is generated by those apps in which the user moves virtually fast without feeling the expected G-forces. The equilibrium system feels fooled by for example roller coaster apps or apps like Google Earth VR. In professional flight simulators or F1 race simulators, G-forces are more or less generated by complex hydraulic actuators and so the immersive experience is even higher.
    - There is no evidence that the use of a VR head mounted display leads to eyestrain, especially if the duration of the VR session is moderated carefully. Of course, just like when you read a book, if you do not take a pause from time to time, you invoke eyestrain.

5. Benefits to learning

Some hesitating decision makers say: "There still hasn't been enough research into the benefits of learning with VR". OK, although research into the benefits of learning through VR is still quite in the start-up phase, the results observed by research institutes from all over the world are pointing to the same direction: VR raises engagement, it fosters concentration and ultimately it can increase the retention of information. It is a tool for leading students into a focused state of concentration where deeper learning is possible.

- VR fostered positive emotions in students and improved learning outcomes[19].
- VR was the preferred learning medium by a majority of students tested[20].
- EEG data shows that VR improves students' concentration by 6x[18].

2.7 Advice for teachers

- If you, as a teacher, have to recommend a VR set-up to your school board, first consider the most appropriate platform. If the application is developed for a head-mounted display connected to a computer, the virtual experience can be very powerful and fast but the physical wire connection with the computer will limit the student's elbowroom and these configurations are significantly more expensive. If, on the other hand, your application is developed for mobile systems based on iOS/Android/Windows Mobile/… the user has the freedom to move around in the physical room (as far as it is cleared). Mobile head mounted displays are less expensive, especially the ones in which you have to put your smartphone These VR systems are particularly useful for educational institutions with small budgets
- Take into account age recommendation ratings for VR equipment like headsets to ensure maximum comfort and safety for your students
- Look for the good stuff. Seek for unique educational experiences that enrich the knowledge and speed up the comprehension of your target user group
- Check reviews to find out if the application content is OK for your students
- Optimise safety: limit the duration of sessions to avoid dizziness, move furniture out of the way and make your student stay seated to prevent him/her from colliding with objects in the physical environment
- Have someone present who will give feedback about perceived emotions
- Monitor feelings like dizziness, anxiety or confusion and try to observe the non-verbal communication immediately after the VR session. They are signs to take a break.
- Talk about the VR experience. Ask the student to share his/her experiences with you.

3 Learning methods with high retention rate

The Learning Pyramid is a representation of the average retention rate for a range of different learning methods. Traditional learning methods, like ex-cathedra teaching, reading a text, watching a video and looking at a demonstration, have the lowest retention rate. Students stay very passive during these learning methods and their learning is based only on what they hear and see. The more a learning method is situated towards the bottom of the pyramid, the more the students are actively participating during learning. For those learning methods, like discussion groups, practice by doing and teaching each other, learning is based on a higher extent of reflection and a deeper cognitive processing. Teaching each other has the highest retention rate. In order to be able to explain something to another one must know the subject very well. The better the subject is known and understood, the better it can be explained.

[19] Allcoat, D., & von Mühlenen, A. (2018). Learning in virtual reality: Effects on performance, emotion and engagement. *Research in Learning Technology*, *26*.
[20] Madden, J. H., Won, A. S., Schuldt, J. P., Kim, B., Pandita, S., Sun, Y., ... & Holmes, N. G. (2018). Virtual Reality as a Teaching Tool for Moon Phases and Beyond. *arXiv preprint arXiv:1807.11179*.

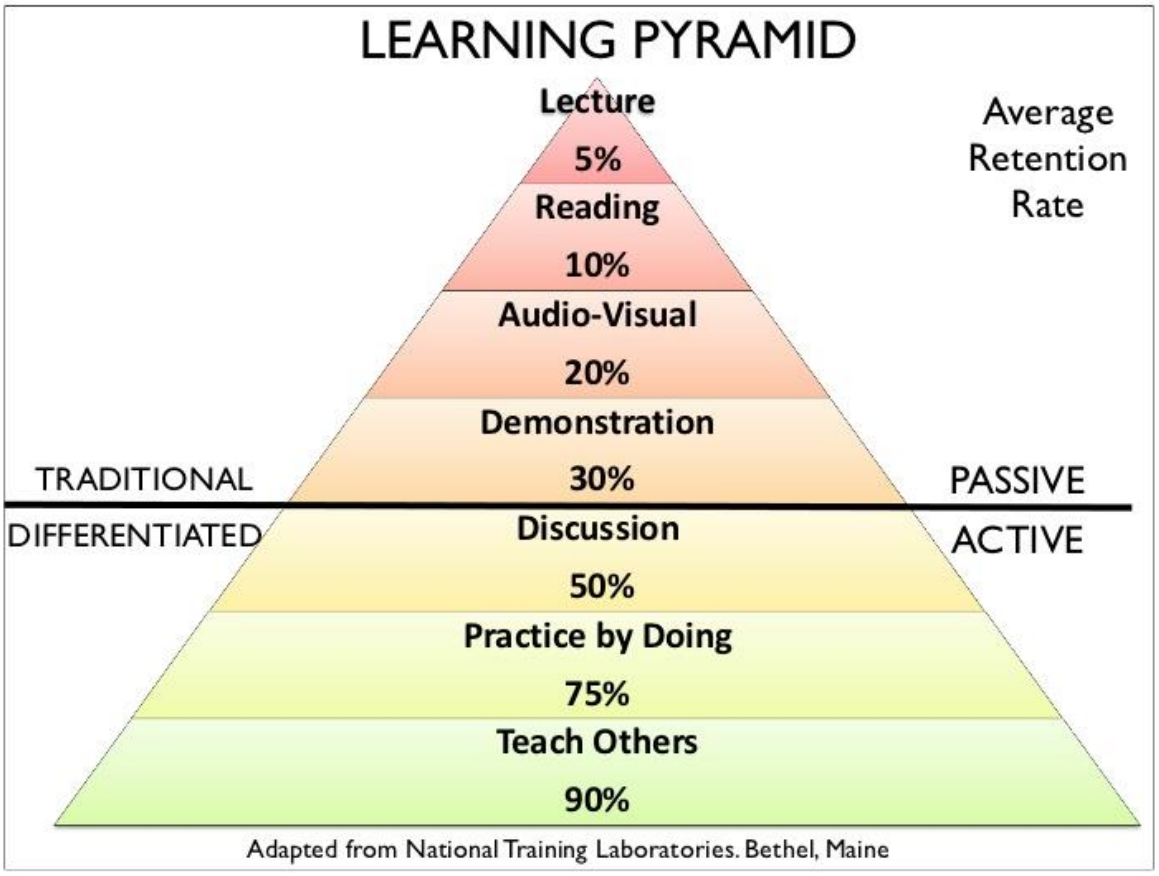

Fig. B4 Learning pyramid[21]

Physical multiplayer simulation games are popular in business management education (e.g. business games) and production management (e.g. lean games). In these games, participants have a double role: on one hand, they are workers in a process and on the other hand, they have to find and to discuss about improvement actions. These improvement actions can be implemented in the game and in a next round they can measure the results of their decisions. As with VR, wrong decisions do not lead to any harm. Instead, they are an additional and unforgettable experience.

Learning with VR belongs to the activating working methods. Users have to use their handheld controls to move, to communicate (non-verbally), to manipulate objects and to select menu options. The fact that a head mounted display prevents the user from being distracted, even further increases the retention rate of VR.

3.1 Social VR

Social virtual reality (SVR) allows people to meet other people at a virtual location using a VR headset and a social VR app. It is a tool that allows friends sitting in different parts of the world to feel like they are spending time in the same room. It has a potential to dramatically change how individuals interact

[21] Source: : https://sites.google.com/site/pedagogiayandragogia2016/the-learning-pyramid

online and is one of the killer apps for VR. Participants customise their own avatars and interact as if they are actually in the simulated environment.

3.1.1 Social VR tools and their features

In order to meet each other, all visitors of a virtual space have to create an avatar first. During the virtual meeting, they can manipulate virtual objects while talking to each other and making gestures using their handheld controls. Social VR tools include:

1. Virtual space

This is a virtual location (meeting room, loft, garden, park, sports field), accessible by several people (public or with limited access). Handheld controls allow to navigate all around the location as if you were a ghost. Spatial sound gives an even more immersive experience.

2. Avatars

An avatar in a virtual space is a personalised three-dimensional graphical representation of a computer user or his alter ego. Although people can extensively customise their avatar, according to many studies, the most important aspect of an avatar is it's realistic behaviour.

3. Virtual objects

More and more developers use 3D drawing software to design new products and parts. When these designs can be saved as a VR compatible format, the objects can easily be brought into a virtual space. Additionally, some kinds of manipulation are allowed in order to let the user do something useful with the objects.

4. Verbal communication

Avatars can speak with each other. You then hear the real voice of the person speaking. And, when you look at the avatar speaking, you see his mouth moving. Alternatively, in most social VR apps, also a chat functionality is available for text-based interaction.

5. Non-verbal communication

It is impossible not to communicate. Even when we prefer not to say anything, we still communicate non-verbally. This is also true in VR. Our avatar copies our head, lips (lip sync), eyes (blinking), hands and in the near future our finger movements. In a further future, the face of our avatar will be a scanned version of our own face. As an example, current VR technology enables non-verbal communication that consists of:

- Emoticons enable you to show others know how you feel
- Head movements (e.g. nodding yes or no, looking down, looking at the speaker, etc.)
- Posture (e.g. body position and orientation and ready-made gestures)
- Avatar customization
- Tone of voice
- Gaze tracking (e.g., gaze tracking is supported in the app Virtual Speech. This app checks whether or not you are looking at the whole audience during your speech or presentation).

3.1.2 The Proteus effect

As soon as people create and use an avatar to meet other people in a virtual space, the characteristics of the chosen avatar may have psychological and behavioral implications, changing the user's attitudes in real life. Studies revealed that:

- Research study result 1: Participants assigned taller avatars behaved more confidently in a negotiation task than participants assigned shorter avatars[22]
- Research study result 2: This effect persisted in subsequent face-to-face setting as well[23]
- Research study result 3: "The experimenters found that participants in attractive avatars walked closer and disclosed more personal information to their communication partner than participants in unattractive avatars[23]
- Research study result 4: Also these results (boost in self-confidence) lasted after the experiment in real world settings as well. It has been measured by the use of a dating app[23]
- A social experiment by Facebook reveals that introverts open up more in VR[24].

[22] Yee, N., & Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human communication research*, *33*(3), 271-290.
[23] Yee, N., Bailenson, J. N., & Ducheneaut, N. (2009). The Proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Communication Research*, *36*(2), 285-312.
[24] Business Insider (2017), viewed 15 October 2919, *Introverts open up more in VR*: <https://www.businessinsider.com/facebook-social-experiment-reveals-introverts-open-up-more-in-vr-2017-1?r=US&IR=T&IR=T>

Module C

VR developments across the globe

Erasmus+

4 VR developments across the globe– Module C

4.1 Module Objective

The objective of this article is to provide the read with an overview of the current developments across the globe in VR technology generally and in terms of the integration of virtual reality technology into education at all levels and in all forms but particularly at higher education level.

This article will analyses a group of four different regions, detailing the status que in the region generally in relation to VR technology and the individual technologies adopted for education, the accompanying government policy and investment, public acceptance of the technology in education and what future developments are to be expected. The countries selected for analyses are based on the country market share of VR technologies and where the most advances are being made. These include South Korea, USA, China & Japan.

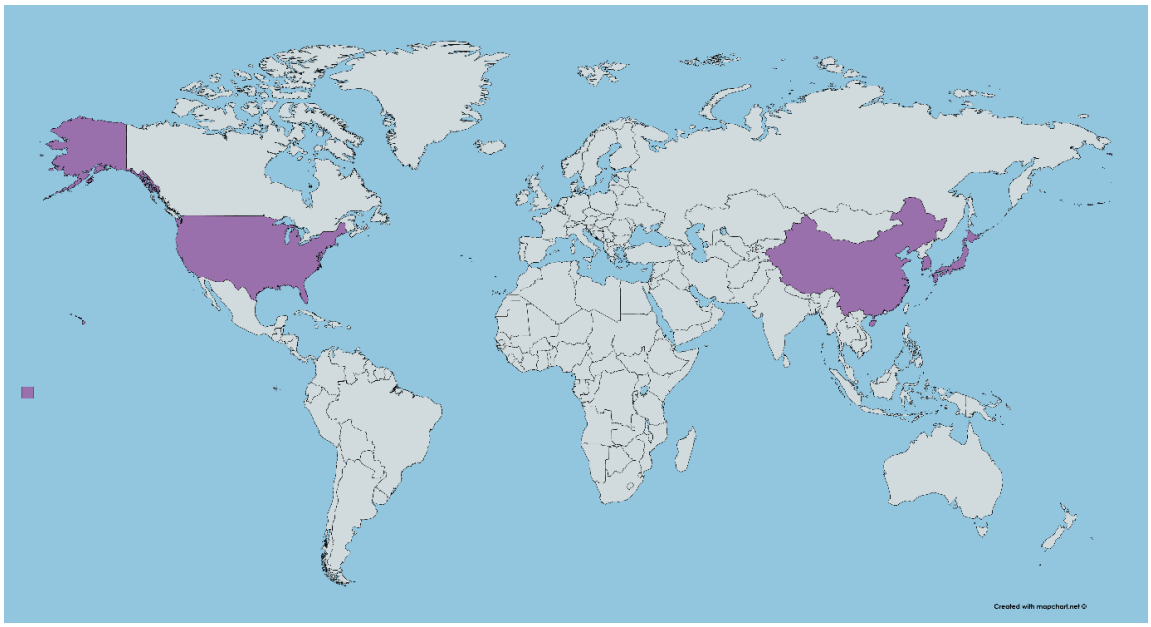

Fig. C1 Countries included in analysis: South Korea, USA, China, and Japan[25]

The article will finish by detailing the current situation in Europe and the VR developments that can be witnessed in these countries. The areas of VR integration into business will be detailed, as well as activities regarding education and government policy. The article will finish with a set of conclusions on how the situation in Europe compares with the other regions in the study and where the opportunities for Europe lie.

4.2 Global Status Quo

VR & AR technology is developing rapidly in various regions of the globe. The regions with some of the most significant developments are highlighted in this article, South Korea, USA, China & Japan. Although the USA as an economic power is the lead region in this innovative field, it can be argued

[25] Source: mapchart.net

that each region is a leader in specific area of VR technology and how it is being developed in different sectors such as business, education, gaming etc. Looking at the market share as it currently stands:

- *USA is the leading region in the technology in terms of spending, valued in 2018 at $6.4 billion*
- *Asia/Pacific (excluding Japan) is the next biggest spender with $5.1 billion estimated in 2018*[26]

However, this trend is shifting with spending growth in China alone set to overtake the USA in the next few years in market share. Both countries also feature heavily when considering VR within the business sector. Recent studies have highlighted the USA and China as leaders when it comes to implementing VR technology into the business operations of existing companies.

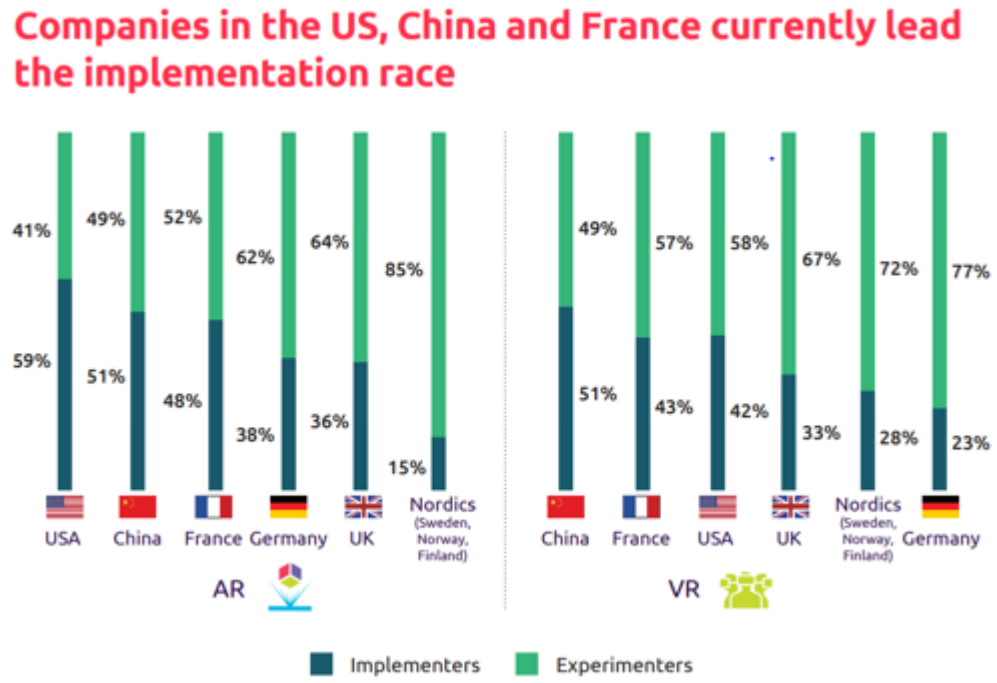

Fig C2. AR and VR survey[26]

In terms of entrepreneurship and technology development, as of 2019 there are over 2200 listed VR startup companies globally, increasing from 1800 in 2018. In the past, the biggest growth area regarding VR development has been gaming and most experts are convinced that this sector will continue to dominate VR development into the future[27].

[26] Capgemini 2018, *Augmented and Virtual Reality in Operations*, viewed 29 August 2019, https://www.capgemini.com/wp-content/uploads/2018/09/AR-VR-in-Operations1.pdf
[27] Petrov, C. 2019, *35 Virtual reality Statistics That Will Rock The Market In 2019, viewed 10 August 2019*, https://techjury.net/stats-about/virtual-reality/

4.3 South Korea

South Korea is widely recognized as one of the leading innovative countries internationally and is regularly ranked first-place in the annual Bloombergs Innovation Index. [28] The country is also in a leading in terms of VR development as the home to the global technology company Samsung who create a range of VR equipment and VR ecosystem. Through the development of Samsung VR ecosystem, the company has been at the forefront of mainstreaming VR technology, particularly with Samsung *Gear*, which can be used directly by connecting with a person's smartphone. Additionally, Samsung's *Odyssey* is a high-end Windows MR head-mounted display.

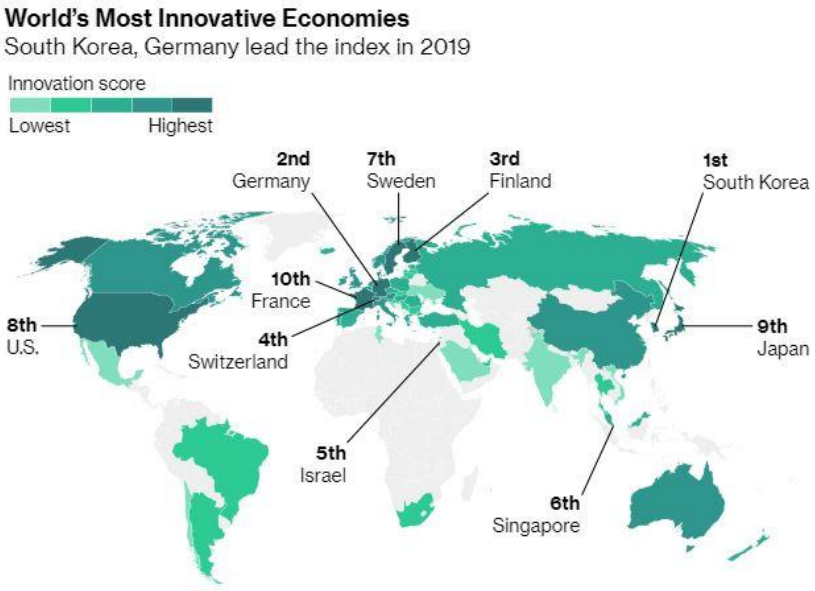

Fig C3. Innovation index map [29]

There is generally a widespread awareness of VR technology, which is evident in the establishment of countless VR arcades in the cities of South Korea. Culturally in South Korea there has developed a wider acceptance of technology and its advantages. Part of this acceptance has come about through government policy to promote IT skills through the Ministry of Science and the establishment of Korea's National IT Industry Promotion Agency.

For the purposes of VR, in major cities the government has opened new facilities to promote virtual reality in the shape of a VR campus complex to nurture VR and AR companies and research centers. The largest of these is named the KoVAC center in Seoul. The group of VR campuses across the country will in future be used to train and educate students in the latest VR technologies and VR practices, and house offices for start-ups and small-sized firms in this field.

[28] Source: https://www.bloomberg.com/news/articles/2019-01-22/germany-nearly-catches-korea-as-innovation-champ-u-s-rebounds
[29] Source: https://www.bloomberg.com/news/articles/2019-01-22/germany-nearly-catches-korea-as-innovation-champ-u-s-rebounds

Fig C4. VR/AR complex at Korea[30]

The complexes are part of the government's broader plan to invest more than $350 million until 2021 in developing new and indigenous VR and AR technologies [31]

Within the government's plan is the promotion of such skills within the education system at all levels. Part of this program includes the introduction of VR technology into the classroom. One such example of this involves D 'Carrick, a South Korean immersive digital content company, and a European company Immersive VR Education. In partnership with the South Korean education sector they are currently rolling out a VR education platform named ENGAGE[32] in a number of South Korean schools and together creating educational programs. This is one of many pioneering projects that have been recently introduced to the Korean education system, and illustrates the Korean governments' enthusiasm for embracing new technology throughout their society.

[30] Source http://koreabizwire.com/s-korea-to-open-2-more-vr-ar-complexes/88338
[31] Source http://koreabizwire.com/s-korea-to-open-2-more-vr-ar-complexes/88338)

[32] ENGAGE: https://engagevr.io/

4.4 USA

In terms of technology and innovation, the USA is undoubtedly at the forefront of VR development. Many of the global leaders in VR are based in the USA, including Oculus, Google and Microsoft. All are pioneering new technologies, and there are countless startups and SMEs across the USA involved in VR & AR. USA is also the region with the largest AR/VR spending globally and the spending valued was estimated in 2018 at $6.4 billion[33].

In terms of business integration the USA is advancing rapidly with integrating VR & AR technology into the daily business operation of companies. Examples of this integration include using the technology as part of employee training & induction, collaborative product design processes, remote equipment maintenance and repair.

A recent report has detailed that over 50 % of those companies (approx. 220 companies) that were surveyed across the USA are currently integrating VR/AR technology into their business operations. This is significant when compared to the European companies that were surveyed (Approx. 390 companies), of which 50% stated that they are currently only experimenting with VR/AR ideas.[34]

When compared to the Asian examples, in terms of educational policy in the USA there is limited development in VR/AR adoption generally. However various education authorities have made available funding for development of VR education programmes and projects, and these funding opportunities where highlighted by The White House Office of Science and Technology Policy at Virtual Research Data Center in 2016.[35]

There are numerous cases across the US of individual educational organizations taking the initiative and introducing VR/AR technology into their classrooms, and often in collaboration with private enterprise. At the level of higher education, the San Diego State University has been pioneering the implementation of VR/AR technology into its learning programmes. The university launched the Virtual Immersive Teaching and Learning (VITaL)[36] initiative in 2017, that introduces VR/AR technology to its lectures and educators. The Initiative demonstrates how VR/AR technology can be implemented into lectures of different subjects and disciplines in a meaningful sense that enhances the effectiveness of the teaching and enhances the students' capability to understand the subject matter. The Initiative makes available a collection of VR/AR Equipment and provides the skills and instruction for educators to use the equipment competently. The collection includes a range of VR & AR headsets, 360-degree cameras, Google expedition sets, and a venue to accommodate large groups.[37]

[33] Source https://techjury.net/stats-about/virtual-reality/)

[34] Capgemini 2018, *Augmented and Virtual Reality in Operations*, viewed 29 August 2019, https://www.capgemini.com/wp-content/uploads/2018/09/AR-VR-in-Operations1.pdf

[35] Source: https://www.gdcvault.com/play/1023933/The-White-House-Call-Virtual

[36] VITaL: https://its.sdsu.edu/vital/

[37] Source: (https://its.sdsu.edu/vital-the-future-of-immersive-learning-at-sdsu/)

Fig C5. Virtual Immersive Teaching and Learning (VITaL) initiative[38]

Since 2017, the academic staff have integrated the VR/AR Technology and it has become an established element of the college modules for a rage of academic disciplines on offer in the university. Including the following example courses and colleges within the university:

Mechanical Engineering – Introduction to Engineering Materials, College of Engineering

Management Information Systems Analysis –College of Business

Communications – Persuasion –College of Professional Studies and Fine Arts

Hospitality & Tourism Management – Commercial Recreation & Attractions Management, College of Professional Studies and Fine Arts

Religious Studies – Jainism, College of Arts and Letters

Teacher Education – Seminar in Science Education, College of Education

Astronomy – Principles of Astronomy, College of Sciences

Nursing – Nursing Care of the Acutely Ill Adult, College of Health and Human Services

This idea of using VR/AF technology is gaining much traction across the institutes of higher education in America, with many of the institutes experimenting with the concept. Gartner, a leading research and advisory firm based in the US suggests that by 2021, the number of higher education institutes using VR to "create simulations and put students into immersive environments" will be nearing 60%.[39]

There have been individual efforts too at the primary & secondary level. In 2017 a study of over 40 schools in North America introduced VR technology into the classroom to survey attitudes and acceptance of the technology. Foundry 10, this US educational research organization surveyed over 1300 students mostly of the ages between 12 to 14. The results showed that widespread acceptance

[38] Source: https://its.sdsu.edu/vital-the-future-of-immersive-learning-at-sdsu/
[39] Source: https://blogs.gartner.com/marty-resnick/virtual-reality-vr-in-higher-ed/

of the technology in terms of educational content consumption, but interestingly also in the creation of educational VR content. The student's survey also highlighted a higher interest in utilizing the technology is school subjects like Science and History rather than Math or Art.[40]

4.5 China

"Scientific and technological innovation holds the key to development … The new round of scientific and industrial revolution with Internet at its core is gathering momentum, and new technologies such as artificial intelligence and virtual reality are developing by leaps and bounds. The combination of the virtual economy and the real economy will bring revolutionary changes to our way of work and way of life …"

Xi Jinping, General Secretary of the Communist Party of China speaking at the B20 Summit in Hangzhou in 2016

China is home to some of the largest tech companies globally such as Huawei and HTC (in Taiwan). These companies are able to compete alongside the American corporations such as Microsoft and Google in terms of technology and especially in the VR/AR sector. Politically the indigenous companies in China have a clear advantage over their American competitors that produce VR technology, with access restrictions in China on both Facebook (Oculus) and Google for example. The restrictions inevitably will hinder the uptake of headsets and VR technologies produced by these firms. Globally sales of VR technology have not yet met expectations, whereas China in 2018 accounted for over 80% of global VR headsets purchases and the investment in AR technology has increased to almost 4 billion dollars in 2018.[41] This investment is spread across venture capital in new VR/AR companies and throughout the larger companies who are developing their in-house VR programs, as well as large Internet and telecommunication companies like Alibaba, Baidu, and Tencent. A recent report has detailed that over 50 % of those companies (approx. 100 companies) that were surveyed in China are currently integrating VR/AR technology into their business operations. These figures are very similar to the figures returned from the survey of US firms and highlights the uptake of the technology in both these economic powers.[42]

Outside of business, there is also a growing public acceptance of VR/AR technology in China. The presence of the technology across China has been assisted by the HTC company campaign to launch

[40] Source: https://www.roadtovr.com/1350-student-vr-education-study-measures-attitudes-interest-in-vr-learning-building/

[41] Source: https://foreignpolicy.com/2019/06/21/chinas-communist-party-is-making-its-own-virtual-reality/

[42] Capgemini 2018, *Augmented and Virtual Reality in Operations*, viewed 29 August 2019, https://www.capgemini.com/wp-content/uploads/2018/09/AR-VR-in-Operations1.pdf

almost 3000 VR arcades (VIVE VR Cafés,) in shopping centers and malls right across China.[43] This is heightening public awareness and allowing participation and access to VR technology for individuals who may not have the means to purchase a personal VR headset.

Overall, the Chinese state is aiming to position the country as a global leader in VR/AR technology not just in business but in many sector of society through government policy and often direct investment. Initiatives such as the China Virtual Reality industry alliance and other public/private associations support R&D and ensure best practice across the growing VR industry. By spreading the technology across the society and normalizing this technology, it hopes to create the necessary talent and tech skills to achieve its position as a global leader in this field.

As part of this effort, China has also begun to take the first steps in embracing VR technology within education. One the largest global tech giants is the Chinese based HTC, and as part of their VR technology drive, VIVE have developed a fully operational turnkey VR classroom solution. This solution is a full classroom management system, with each student headset integrated into a central system controlled by the teacher or tutor. The solution also includes a locker for each headset, which recharges and updates the stand-alone devices and hygienically cleans each individual headset before re-use. [44]

Fig C6. Headset locker for VIVE Focus[45]

[43] Source: https://www.forbes.com/sites/charliefink/2017/12/19/vrar-in-china-an-emerging-giant/#347ee2af7573
[44] Source: https://www.roadtovr.com/htcs-new-vive-focus-headset-locker-aims-put-vr-forefront-education-china/
[45] Source: https://www.roadtovr.com/htcs-new-vive-focus-headset-locker-aims-put-vr-forefront-education-china/

4.6 Japan

Japan has traditionally ranked highly in terms of innovations and technology and is ranked 9th in the Bloomberg Innovation Index of 2019. Japan has always played a very strong role in the electronics industry with some of the largest global companies originated in Japan, such as Sony, Toshiba & Fujitsu. With many of these large companies already producing VR and AR technologies. Sony have already released VR equipment (PSVR) under the Playstation brand focusing largely on the gaming sector of VR and this focus appears to be the trend amongst many Japanese companies. Interestingly the Japanese company Nintendo have chosen to focus much of their VR development in children's entertainment and a DIY (Do-it-yourself) approach for its VR headsets and devices that can be self-assembled and combined with other devices to create the VR effect. The best example being the *Labo* VR headset for children. This approach by Nintendo creates not only increased accessibility to VR technology but also reaches to a new target group.

The size of the VR/AR market in Japan is relatively restraint when compared with regions such as the USA, however the estimated growth rate is substantial. The VR/AR market was estimated at approx. 14 billion yen (€120million) in 2016, and is estimated to grow to 211.1 billion yen (€1.8 billion) into the year 2020.[46]

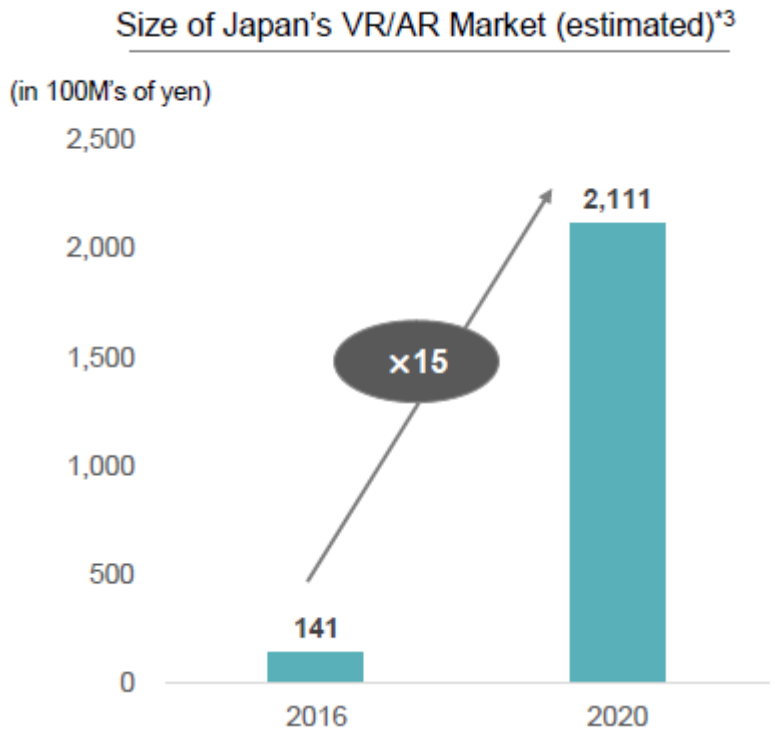

Fig C7. Estimation of the size of Japan's VR/AR Market [47]

[46] Source: *JETRO* Japan External Trade Organisation 2017 Market Report, VR/AR Industrial Solutions
[47] Source: *JETRO* Japan External Trade Organisation 2017 Market Report, VR/AR Industrial Solutions

Outside of the gaming sector, there have been significant developments in the application of VR in industry across Japanese companies. Examples of this kind of application include Toshiba who introduced a VR work training system to provide training for their employees in a number of areas ranging from design review, product introduction as well as safety and operations.

The developments in industry have been coupled with a range of government policy to support the development of VR technology with the introduction of subsidies and incentives by the Ministry of Economy, Trade and Industry. For example in 2017, the Ministry was supporting development projects up to approx. 10 million Yen (€850,000) [48] .This has been accompanied by the establishment of trade associations and consortium across the VR sector in japan in order to raise the profile of VR technology and promote research and cooperation.

Across the Japanese universities and research institutes there have been significant developments in VR with various applications of the technology across a wide variety of sectors. The Ritsumeikan University has developed VR technologies for application in medical surgery support and collaborative support. The company Holoeyes[49] has managed to create a medical surgery support tool that models patient anatomy using CT imaging data and gives surgeons the opportunity to simulate medical operations and view patent anatomy at a 360 degree perspective using HMDs.

At the education level, there has already been integration of VR technology into the Japanese education systems on trial basis. One such trial involved the American company Oculus who wished to observe how educators and students interact when VR technology is introduced as a learning tool, and integrate these analyzed results into the development of their devices and content. One of the clear applications of this technology was for distance learning programs so that educational opportunities can also be spread to the more remote regions of japan.

[48] Source: *JETRO* Japan External Trade Organisation 2017 Market Report, VR/AR Industrial Solutions

[49] Source: https://holoeyes.jp/

4.7 Europe

Compared to other regions in the world, Europe is not home to any of the major global leaders in VR technology and VR hardware development. Majors players like Google, Oculus, HTC all have a presence in Europe and in the European market but are based outside of Europe. When speaking about VR development in Europe, the focus tends to be on software, content development and online platforms & hardware components. Often these companies tend to be of SME scale or start-ups. There are approx. 700 registered Virtual reality companies in both hardware & software in the EU region, the majority dependent on venture capital, which often tends to stream from outside the EU from Asian and US accelerators and venture capital companies. European VR companies also tend to be dependent upon seed money or financing from national bodies or financing instruments of the European Union. The availability of capital and qualified resources, and clients in other regions like the US often attracts start-up companies out of Europe. Many VR applications employ the gaming engine Unity, a company originally founded in Denmark in 2004. This company has since rebranded, relocated and is now based out of Silicon Valley, USA.

Finnish company Varjo[50] provides "human eye resolution" HMD's for Enterprises. Varjo's VR technology (e.g. VR-2) is widely considered the most advanced that exists on the markets.[51]

[50]Source: https://www.varjo.com
[51]Source:https://www.crunchbase.com/hub/european-union-virtual-reality-companies#section-overview

Fig C8. Overview of the VR industry in Europe[52]

Due to the divergent nature of the Europe made of many different nations, markets and different national polices it could be viewed as problematic to compare Europe with regions such as China and the USA. The character of the European VR developments is a complex mix of cooperation and competition between its stakeholders that can drive innovation. This is often materialized in the cooperatives and associations across Europe's VR associations. Examples include pan European associations such as eurovr-association.org, EUVR.org and localised examples such as Finnish Virtual Reality Association (FIVR) or Virtual Reality Berlin Brandenburg (VRBB).

A look at the Bloomberg 2019 Innovation index paints a very positive picture for Europe with leading economies like Germany, Finland, Switzerland (non-EU) all in the top five ranking, and the remaining western European countries dominating the top 20 ranking.

[52] Source :https://ec.europa.eu/futurium/en/system/files/ged/vr_ecosystem_eu_report_0.pdf Bezegová, A., Ledgard, M. A., Molemaker, R-J., Oberč, B, P., and Vigkos, A. (2017). *Virtual reality and its potential for Europe*,

Bloomberg 2019 Innovation Index

2019 Rank	2018 Rank	YoY Change	Economy	Total Score	R&D Intensity	Manufacturing Value-added	Productivity	High-tech Density	Tertiary Efficiency	Researcher Concentration	Patent Activity
1	1	0	S. Korea	87.38	2	2	18	4	7	7	20
2	4	+2	Germany	87.30	7	3	24	3	14	11	7
3	7	+4	Finland	85.57	9	16	5	13	9	8	5
4	5	+1	Switzerland	85.49	3	4	7	8	13	3	27
5	10	+5	Israel	84.78	1	33	8	5	36	2	4
6	3	-3	Singapore	84.49	13	5	11	17	1	13	14
7	2	-5	Sweden	84.15	4	15	9	6	20	5	25
8	11	+3	U.S.	83.21	10	25	6	1	43	28	1
9	6	-3	Japan	81.96	5	7	22	10	39	18	10
10	9	-1	France	81.67	12	41	13	2	11	20	15
11	8	-3	Denmark	81.66	8	21	15	12	19	1	28
12	12	0	Austria	80.98	6	11	12	24	8	9	18
13	14	+1	Belgium	80.43	11	26	10	9	41	16	9
14	13	-1	Ireland	80.08	32	1	1	16	15	14	38
15	16	+1	Netherlands	79.54	16	29	21	7	42	12	12
16	19	+3	China	78.35	14	13	47	11	6	39	2
17	15	-2	Norway	77.79	17	49	23	15	17	10	11
18	17	-1	U.K.	75.87	20	45	26	14	5	21	19
19	18	-1	Australia	75.38	19	56	17	20	18	15	6
20	22	+2	Canada	73.65	22	39	27	22	31	19	8

Fig C9. Innovation Index 2019[53]

The VR hubs of europe are recognised as being in the UK, Germany and France, focused in the respective capitals, as well as throughout the nordic countries, and tisi s where most innovative ativiity is taking place. Much of the VR activity in Europe is funded through state structures, with one of the largest funds being the EU Research and Innovation programme (including Horizon 2020).

Since the early 1990s, EU research funds have supported more than 450 projects dedicated to VR and AR, with a total of over €1 billion. [54]

As previously stated, Europe is lacking in major global players in VR. One of the few global companies in Europe that have developed VR hardware is the Finnish telecommunications company Nokia. Nokia launched their *Ozo* virtual reality camera system for capturing 360 degree material. The product was discontinued in 2017 and the company cited "slower-than-expected development of the VR market" as the main reasons for abandoning the product. [55]

Smaller companies in Europe have ventured in VR hardware development, such as Waveoptics based in the UK. The company develop core optical components for augmented reality (AR) displays. At the moment they employ 80 people and have raised approx. $60 million in investments over the last five years. In the VRinsight Survey Cumulative Report there are use case examples detailed from SMEs from each participating project partner country (Finland, Germany, Belgium, Spain, Austria).

Across many of the larger companies in Europe who enjoy the benefits of vast resources and capital, there has been a significant investment in testing and adopting VR/AR technology. Use cases include the automotive and aerospace industry where VR is being used for collaborative design and presentation of CAD models. However many of these cases of adopting VR/AR technology tend to be isolated and often in the non-critical areas of business operations, these can include health and safety

[53] Source: https://www.bloomberg.com/news/articles/2019-01-22/germany-nearly-catches-korea-as-innovation-champ-u-s-rebounds

[54] Ecroyrs Consulting Firm, 2018, Report on Virtual Reality and its potential for Europe, Ecroyrs Report

[55] Source: https://www.theverge.com/2017/10/10/16452114/nokia-killing-off-ozo-virtual-reality-camera-310-jobs-lost)

training and other practical training programs for employees. For example, British Aerospace company Rolls Royce have begun using VR/AR technology as part of their engineers training programs in maintenance and repair.

"We're looking at creating holograms of an engine that we can use to teach in a classroom, or Augmented Reality that can be overlaid over a real engine to show technical information. Nothing will beat learning with an engine and this will never be replaced, but new technology is allowing us to be innovative with the ways we teach engineers." Steve Buckland, Customer and Product Training Manager Rolls-Royce[56]

This quotation highlights the current perspective and opinion on VR technology held by many in Industry, namely that VR has a lot of potential, but can only be adopted in controlled environments and acts as a valuable but not critical additional tool to a current operating process or procedure.

The marketing departments of companies have also embraced VR/AR technology for branding and product launches. This is particularly true in the automotive industry, where companies have at their disposal large marketing budgets.

The marketing function of VR has also led to adoption in architecture and construction sector particularly interior designers, property development where customers can experience different stages of the design and construction process.

In Europe, the adoption of VR within Education is sporadic, and often limited to funded research programs within the education sector. Yet there are widespread examples of VR being integrated independently at every level of education to accelerate immersive learning, for example at primary school level in Ireland [57] and secondary level in Mendel Grammar school, in the Czech Republic.[58]

The most significant uptake of VR and AR in education tends to be seen in vocational training where it allows realistic practical training for apprentices. This model has been taken up by many large European companies such as Rolls Royce, Heidelberg Printers and Festo.[59]

As previously mentioned a European company has made significant development in education by creating a online VR platform for use in the classroom. The European company Immersive VR Education have together with D 'Carrick, a South Korean immersive digital content company launched the ENGAGE platform. In partnership with the South Korean education sector they are currently rolling out in a VR education platform ENGAGE in a number of South Korean schools and creating educational programs. The company has also had projects with Oxford university hosting Emergency life saving training in which up to 30 people can be trained simultaneously on the platform in a classroom setting. The platform allows tutors to guide learners and give ongoing feedback in real-time.

[56] Source: https://techhq.com/2019/04/rolls-royce-is-training-aerospace-engineers-with-vr/
[57] Source: http://missionv.ie/
[58] Source: https://www.seriousgamemarket.com/2019/02/virtual-reality-accelerating-its-merger.html
[59] Source (https://holo.data-experts.de/news/cases/holographic-training-at-rolls-royce-germany-2/)

4.8 Conclusions

VR has reached a tipping point for large scale adoption, in particular thanks to the development of more comfortable and affordable hardware. Even though VR has been around for a while, initially it was not available for the wider audience. Headsets were either too clumsy and not allowing for smooth virtual experience, or they were too expensive and powered by large-scale computers. As a result, VR was mostly used by large companies in industrial design or by specialised research centres.[60]

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Wide scale adoption of VR technology would undoubtedly bring about a paradigm shift in the way people interact with one another and the potential of this technology being adopted in business, education and in all parts of society has been widely recognised by countries and their government around the globe. The most innovative of these countries have already taken steps to nurture this potential.

Due to their sheer economic strength, both the USA and China will understandably be very significant actors in the wide scale adoption of this technology. Wide-spread adoption of VR is dependent on the development of sophisticated and accessible hardware, however in the modern global market, it is becoming less important where a product is developed and rather more important where it is sold and to whom. In this context it therefore appears that South Korea is a leading region globally regarding VR technology, and it is in this country that widespread adoption of this technology is already truly on its way to becoming a reality. There appears to be a culture in South Korea, not only of an acceptance and embracing of technology but also a demand and curiosity for new and innovative technologies across huge strands of the population. This is witnessed across the business sector, education and wider society. Although this acceptance is replicated in other regions covered in this study, it appears to be at its most severe in South Korea.

For Europe, there are many lessons to be learned from these selected regions. For Europe it is important to keep in mind that although the new VR hardware that will facilitate widespread adoption is predominately being developed in other regions, it is the development of business & education friendly VR applications, software solutions and platforms that will be an essential factor in widespread adoption of VR. This will continue to be a key growth area, and as detailed, many European companies are already focusing upon it. To understand the challenges and the lessons that are now already being learnt in widespread adoption of VR technology it is also important that European companies and educational institutes interact with their counterparts in other regions, particularly South Korea, so they can benefit from the trials and pilots being conducted there.

It is often said that one of Europe's key advantage is its diversity. A key advantage of VR technology is its versatility and overwhelming potential to be adopted across a diverse range of educational scenarios, business settings, languages and different working cultures, as demonstrated in the countless examples detailed in this article and other articles of the VRinSight curriculum.

[60] Ecroyrs Consulting Firm , 2018, Report on Virtual Reality and its potential for Europe, Ecroyrs Report

Module D

VR solutions for Business and SME perspective

Erasmus+

5 VR solutions for Business and SME perspective – Module D

5.1 Module Objective

The objective of this article is to provide the read with an overview of the current business and SME perspective on VR technology and the solutions it can provide taking into account the feedback of European SMEs provided by a questionnaire. Practical examples and practical suggestions of VR integration in business will be detailed such as Manufacturing Solutions, Business Analysis & Process solutions, as well as Marketing & Promotion solutions. A major part of the article will be to give SMEs a clear overview of VR technology, and to dispel the perception of high cost, and high level of training required for VR integration. A clear return of investment perspective will help to educate SMEs on the potential of VR, this will be coupled with any available statistics and figures for VR business integration. One example from partner KULeuven included the ROI for Center parks, which increased profit by integrating virtual experiences in its marketing and website. Here too best practice examples from the VRinSight showcase will be referenced where appropriate.

5.2 Introduction

The sustainability of the business over time and how to enhance profitabiility of the company are usually the most critical issues addressed by SMEs managers. For that reason, an organization is always in search of new technologies which can achieve the desired results in minimum input and in short time period. Thus, companies must face in the context of the 4th Industrial Revolution characterised by the outbreak of new industrial technologies and communication technologies, that increase dramatically the level of connectivity between the components involved in the organization process.

The fourth Industrial Revolution has the potential to improve the flexibility and productivity of businesses and companies, but also brings risks for competitiveness, job markets and society. Since top management, support is essential to foster Industry 4.0, and management is the core process of a company, changes in management affects all the main processes of the company and all the business model components: value proposal, main activities, relationship with stakeholders, technology and innovation absorption capacity, organizational structure, corporate culture and even risk management. Industry 4.0, and especially key enabling technologies such as Virtual Reality, are becoming critical to face the company challenges and client needs.

Virtual Reality is defined as: “Create an interactive, completely digital environment that provides a fully enclosed, synthetic experience incorporating auditory and visual feedback, experienced often through the use of a head-mounted device”[61].

[61] Capgemini 2018, *Augmented and Virtual Reality in Operations*, viewed 29 August 2019, https://www.capgemini.com/wp-content/uploads/2018/09/AR-VR-in-Operations1.pdf

Fig D1. Industry 4.0[26]

Fig D2. Illustration of virtual manufacturing in an era of Industry 4.0[61]

5.3 Industrial perspective on VR

VR applications can be used for industrial purposes to improve product development processes, train staff and enhance communication. Driven by the needs of major European industries, VR applications are either developed in-house or are outsourced to VR dedicated companies. Early adopting companies that already use VR solutions come from: the automotive industry (Groupe PSA (FR), Renault (FR), Jaguar Land Rover (UK), BMW (DE), Volkswagen (DE)) the aeronautical industry (Dassault aviation (FR), Airbus (FR)) the transport sector in general (SNCF (FR), Alstom (FR)) the energy industry (EDF (FR)), and other industries where industrial design is expensive and elaborate (Bosch (DE), Siemens (DE)). The large list of companies that have integrated VR solutions in their design and production processes is continuously expanding as new companies want to benefit from this new technology, even SMEs.

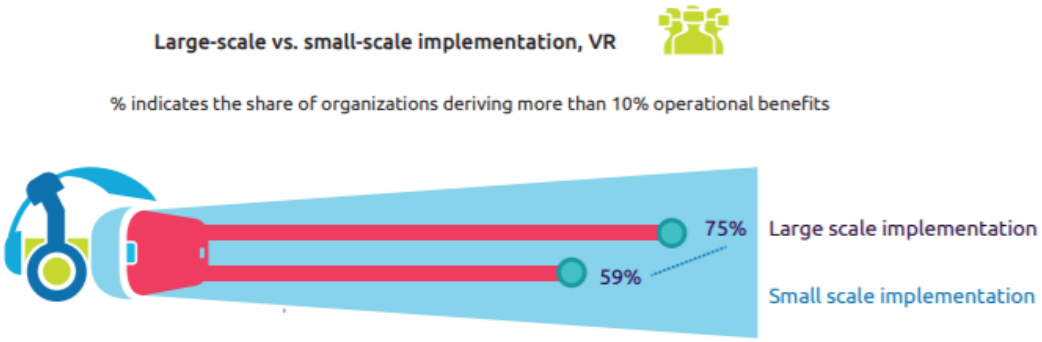

Fig D3. Share of companies expecting over 10 percent operational benefits from the use of VR[61]

The visualisation of 3D models, CADs and other content in VR applications give the possibility for different people to access them from any location, to analyse and interact with them in a virtual environment. This can improve the manufacturing process, firstly during the conception phase for the design, development and assembly of components or the final product, and secondly for the creation of prototypes and experimentation once the final product has been developed[62]. Both applications are radically reducing meeting costs and possible errors, as distant communication can be just as efficient as meetings in person.

Companies are already implementing VR across several parts of the value chain. For example, the use of real-time visualizations and information assist in completing a training of maintenance or repair task, advance marketing and promotion, etc.[61]

5.4 Main Hindrances to Use of Virtual Reality

Companies in manufacturing industry find out obstacles and challenges in VR technology adoption. These obstacles are inherent to the production activity and the work force profile of this kind of companies, but most of the obstacles are extensible to other sectors. In the following sections, there will be described obstacles and some recommendations and solutions.

5.4.1 Level of digitalization

Major challenge is the low level of digitalization in the companies. Company representatives required network to connect machines and devices but also the need for a large bandwidth are hurdles that need to be overcome. Therefore, sufficient data in adequate quality is missing and cannot be collected due to insufficient networks. In addition, connecting new machines might work well but there are many plants and machines out there that are 20 or 30 years old[63].

Less obvious but still important, companies perceive organizational requirements as problematic. It is still unknown to many organizations who would be responsible to maintain data so that it is always

[62] Engineering.com 2015, Viewed 27 September, *Can Virtual Reality Help Optimize Product Engineering, Manufacturing, and Operations?*, <https://www.engineering.com/PLMERP/ArticleID/9484/Can-Virtual-Reality-Help-Optimize-Product-Engineering-Manufacturing-and-Operations.aspx>

[63] Alleman, L. and Sattler M. 2017, *Obstacles for the Use of AR/VR in the Manufacturing Industry*, viewed 17 September 2019, <https://www.zuehlke.com/blog/en/obstacles-use-ar-vr-manufacturing-industry/>

up to date. As an example, maintaining VR work instructions might require more effort than maintaining the same content on paper. Also, while creating paper instructions is comparably easy, creating VR work instructions requires certain skills that not all workers have. Besides organizational requirements, also industrial requirements are seen as a complicating factor. In some industries, the lot sizes and the sheer amount of product variations make it difficult to create virtual assembly instructions. Other companies also fear security issues with VR applications for various reasons. Some fear that hacker attacks could tie up their whole production once everything is connected[63].

Fig D4. Illustration of VR user interface with hand tracking[64]

To increase the company opportunities for VR implementation could be recommended the following steps:

- Monitor I4.0 technologies and other business opportunities (e.g. market/user's needs, legislation requirements etc.) that could affect your business to face structural changes and continuous improvement.
- The company can contact VR experts in the region to contrast the strategic vision. The company can get in contact with experts in I4.0 informative meetings usually set up by public organizations, universities and professional associations.
- Study the current internal expertise and the company can consider the implementation of a VR team as a department for spreading the technology inside the company, and as a group of motivated people to develop new services and products. It would be interesting to formalize the VR team's activity for developing a smart product and services portfolio and learn how to do it.
- Invest in developing and maintaining an innovative company culture and Start involving more people within innovation processes[65].

5.4.2 Lack of expertise

The lack of knowledge, missing experiences and empirical values from VR make usage more difficult for companies to assess the effort required to build VR applications or piloting activities. Moreover, company representatives struggle with imagining what these new technologies can do. In addition,

[64] Source: http://www.mobileoutdoormagazine.com/247/derechos-digitales-para-los-cibernautas
[65] SMeART 2019, *SMeART – making Europe's SMEs smar*t, viewed 12 August 2019, <http://www.smeart.eu/>

people are absorbed by their daily business and that they will not be able to handle the additional effort that comes with the introduction of a VR application[61].

Some organizations, early achievers, that are advanced in terms of immersive technology implementation identified some key factor and they focused their efforts on the following steps[61]:

- Invest in upgrading talent and focused research initiatives to gear up for future adoption.

Because immersive technologies require new skillsets, early achievers are investing heavily in agile, in-house teams of experts. They avidly conduct specialized in-house training and recruit personnel with AR/VR expertise. Together with building internal capabilities, outsourcing subject matter experts with direct experience in immersive technology is an alternate way forward. For their part, organizations at early stages of adoption can choose to partner with specialized teams and institutions to leverage outside talent and technology.

Fig D5. Early achievers invest in R&D, upskill employees with training, partner with Academia and hire people with VR expertise[26]

- Put a centralized governance model in place and build AR/VR awareness.

Early achievers have dedicated, central teams or an innovation center that manage the organization's overall AR/VR activities. The governance structure must be established by a committed team to allow the technology to develop and flourish. Immersive technology key stakeholders may be operations managers, for example plant managers or process engineers, who are accountable for delivering on key operational metrics[26].

- Focus on identifying the right use case that provides lasting value and supports employees in this journey.

When focusing on a particular use case, organizations should encourage employees to apply it. VR tools pose a significant change to traditional ways of working and should be managed like any other technological change in order to overcome employee resistance. Similar to other technology changes, VR especially augments operational processes, making change management vital to overall acceptance. Organizations can gamify the VR experience to engage their workforce and reward them for making use of immersive tools. For instance, Light Guide Systems, an enterprise AR technology provider, turns a set of manufacturing tasks into a sequence of challenges where employees can score points and effectively track key metrics. This provides positive motivation and a competitive environment for completing those tasks. Accordingly, similar logic of task gamification could be applied in context of VR[26].

Digital Transformation Manager at Fortum, Panu Arvila, agrees that employees need to be part of the development and their feedback and development ideas should be heard. “You need to be able to demonstrate how the new technology can support the daily work and encourage them to adopt this new way of doing things,” he comments. Organizations must also make on-request training and support staff available to help employees clarify their doubts and concerns regarding the technology. Integrating VR to technology infrastructure requires following steps[26]:

- Ensure content availability. Organizations should have a repository of content and data available in the proper format for a well-functioning AR/VR system.
- Evaluate partnering with experienced vendors to minimize complexity. To minimize VR complexity in execution, organizations can collaborate with software providers, often times found in a start-up company ecosystem.
- Carefully consider connectivity requirements for your VR use cases. Not all use cases need a high availability of network and bandwidth. However, for those use cases that do, the absence of remote collaboration, or a lack of proper connectivity and bandwidth can be a deal breaker.
- Integrate VR solutions with existing technologies to reap full benefits. To yield higher benefits, consider VR as an important part of a larger digital journey. Part of this journey is the integration with the company’s various enterprise systems such as enterprise resource planning (ERP), product lifecycle management (PLM), etc.

5.4.3 The return of investment in VR

The missing resources are seen as a principal restraining force for all companies. The limited financial resources but also the lack of people with the right expertise to develop VR applications as a problem. In most of the industrial VR application cases, manufacturers could not justify the cost of using virtual reality. Yet, newer technologies, such as predictive analytics models, advanced data storage, and increased processing power from the cloud, are helping manufacturers save money across an enterprise, opening the door to virtual reality. Additionally, the cost of creating a virtual environment has grown cheaper as technologies and electronics have become less expensive.

Another restraint for adopting VR is the difficulty in measuring the ROI (return of investment), an important issue for investment decision making (Fig 6.).

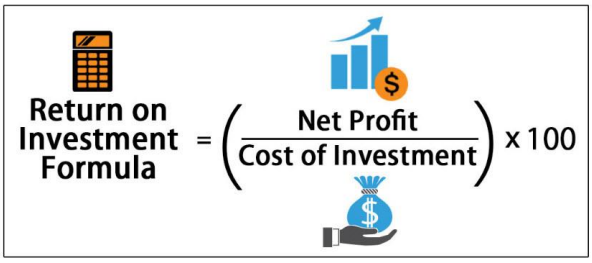

Fig D6. Return On Investment Formula[66]

The following are sample thought-starter questions for ROI calculations[67].

Virtual Prototyping

- What is the cost of one physical prototype, and how long does it take to build?
- What was the costs of rework on previous prototypes that were built?
- How could better access and ergonomics improve assembly tasks and production?

Reduced Design and Development Cycles

- What is the value of a designer's time?
- What is the opportunity cost if they cannot work on new projects?
- Have your designers/engineers expressed concern about working on complex designs on a desktop monitor?
- How much insight can be gained by collaborative viewing of complex, digital prototypes in 1:1 scale instead of on a desktop or wall monitor?
- How would cycle time reduction improve responsiveness to capitalize on new user demands and trends?

Collaboration

- What efficiencies could be realized if product teams work together in a comfortable workspace to evaluate the impact of design changes more quickly?
- What errors and costs could be avoided through improved collaboration?
- How could product assembly and servicing be assessed sooner and made more efficient?

Decisions-making

- How could virtual designs enable faster, better decisions at any stage of development?
- What product quality elements could be assessed before physical prototypes or production begins?
- How could more insightful reviews inform executives and reduce risk?
- If critical decisions are not made in a meeting, how long does it take to get stakeholders together again and what could that delay cost in time and lost opportunity?

Sales and Marketing

[66] Source: www.wallstreetmojo.com
[67] Improov 2018, Measuring the Benefits and ROI of VR, viewed 17 September 2019, <https://www.improovr.com/blog/measuring-the-benefits-and-roi-of-vr/>

- How could marketing use digital models to gather early user feedback on design to make improvements?
- What is the full opportunity cost of losing a deal because your development technology is not competitive?
- What is the value of taking advanced sales orders if utilizing digital prototypes?
- What is the value of a new client?

What to Consider Before Investing in VR

Before investing in any VR technology, thorough investigation into the use cases, capital, facility, and human resource requirements should be conducted. Consider all of the elements necessary for successful implementation to understand the total investment. This will be, at minimum, the return that is required. Larger-scale systems like wall-sized displays (Powerwalls) or surround-screen immersive displays (e.g., ARC) can require facility modifications to physical spaces, power, and air handling. Smaller-scale solutions like HMDs may not require significant changes in a facility, but allocation of time for dedicated testing may need to be captured as time invested. Consider ongoing staffing and maintenance as well.

Getting Started

If the investment required to realize needed gains is higher than expected, but the value is still perceived, consider a small-scale pilot run to provide evidence. A pilot run can take several forms[68]:

1. Start with a smaller-scale system like an HMD or small collaborative display. Consider the work that can be tested in such a system and how the results will apply to a larger roll-out.
2. Rent technology for a period of time to do a short-term proof of concept.
3. Partner with a university that has VR technology, and either rent time or create a student project.

Developing the ROI justification for a VR investment can seem like a mountainous task, but is worth the effort. Virtual reality is a proven technology. Some organizations realize ROI in one project or less than one year through multiple cost- and time-saving areas. Using the ideas outlined above will provide a framework to help your organization take the next step in applying this technology to your digital workflows. Look at past projects. Talk with people that would use VR to gather their insights on how VR will create efficiencies. If a third party may be valuable to gather more information from users, consider a consultant to perform interviews. While VR can add value, any investment decision should be fully informed.

5.4.4 Integration

Another major deterrent in the path towards virtual reality in manufacturing was integration. Even today's virtual reality systems cannot be easily integrated with manufacturer´s existing design systems. However, modern manufacturing is ready to create these integration tools, and many

[68] Mechdyne 2018, *Calculating ROI in Virtual Reality for Manufacturing*, viewed 17 September 2019, <https://www.mechdyne.com/article.aspx?id=429&name=Calculating+ROI+in+Virtual+Reality+for+Manufacturing>

manufacturers have already taken steps to do so. Furthermore, manufacturers are realizing some of the major benefits from the implementation of virtual reality programs as well. Some useful steps to follow a successful integration of VR[61].

Ensure content availability. Organizations should have a repository of content and data available in the proper format for a well-functioning VR system.

Evaluate partnering with experienced vendors to minimize complexity. To minimize VR complexity in execution, organizations can collaborate with software providers, often times found in a start-up company ecosystem.

Carefully consider connectivity requirements for your VR use cases. Not all use cases need a high availability of network and bandwidth. However, for those use cases that do, the absence of remote collaboration, or a lack of proper connectivity and bandwidth can be a deal breaker.

Integrate VR solutions with existing technologies to reap full benefits. To yield higher benefits, consider VR as an important part of a larger digital journey. Part of this journey is the integration with the company's various enterprise systems such as enterprise resource planning (ERP), product lifecycle management (PLM), etc.

5.5 How Does Virtual Reality Benefit SMEs

Virtual Reality (VR) is shaking things up across all industries, including manufacturing. While the technology is currently being employed mainly by large manufacturers, like additive manufacturing and the robots before it, growing acceptance of the technology is likely to cause prices to drop, allowing SMEs to take advantage of its powers as well. Along this section, we will describe some advantage that VR can bring and some examples adapted for SMEs[69].

[69] Robinson A n.d., *The 5 Benefits of Virtual Reality in Manufacturing*, viewed 19 October 2019, <https://cerasis.com/virtual-reality-in-manufacturing/>

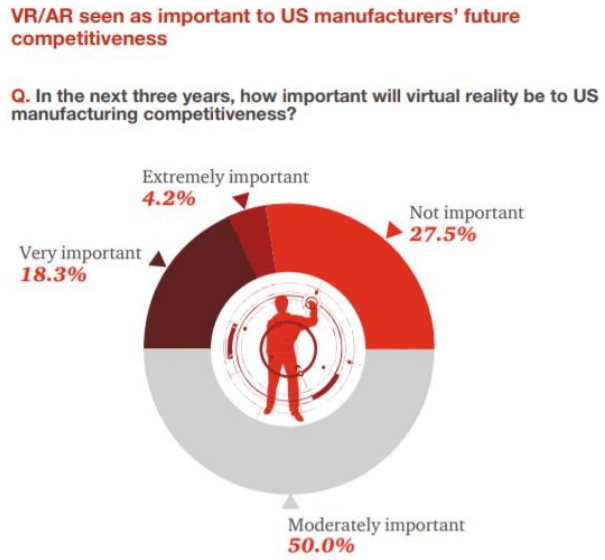

Fig D7. Most companies in the US see VR/AR as important to manufacturing competitiveness

5.5.1 Research and Design

Design processes start by reviewing a project's goals, plans, and materials. Once these factors have been determined, traditional manufacturing design teams would build a prototype, which was then reviewed for defects, errors, or other issues. Unfortunately, this represented a major cost to production, but virtual reality is allowing manufacturers to reach the review process without incurring any costs in creating the product[69].

Examples:

How McLaren Automotive uses virtual reality to design its sports cars and supercars[70]

Gravity Sketch VR - Oculus Rift Touch Controllers[71]

5.5.2 Floor planning

While floor planning is done in many industries, not only in manufacturing, here it may be somewhat more complicated and difficult. Planning the space for assembly lines or production workshops requires taking into account multiple factors – equipment dimensions, connections between different units, safety distances, power outlets, supply line inputs and many more.

It is so much easier to plan the factory floors in virtual reality. By recreating the actual areas in VR and placing the equipment models there, the manufacturers can verify that everything is placed and connected correctly. Companies can see in VR if all equipment is properly accessible, all safety distances are kept, and the production sequence is built in the correct order.

[70] McLaren: https://www.youtube.com/watch?v=mWaQfjEJIMQ
[71] Gravity Sketch: https://www.youtube.com/watch?v=XDCmDjs9z5I

By using virtual reality in manufacturing, companies can optimize their floor area before they start physically moving the equipment. Thus, virtual reality can help to save the costs of the works and reduce the risk of equipment damage or worker injury[69].

Example:

Orinox: VR for Process, Energy, Naval Industry[72]

5.5.3 Inspection and maintenance

If we consider the manufacturing equipment inspection, we will have to admit that virtual reality can literally reduce time and space to nothing. Today, machines are becoming too complex to be inspected by the regular factory personnel.

Often, for any routine or emergency inspection, companies need to invite experts of the plant that produced the equipment. Such inspection visits usually involve high costs and careful advance planning and scheduling.

Inspectors' time is often booked out for weeks, and it may be difficult to invite them when a machine suddenly malfunctions. Also, the travel and accommodation costs are often to be borne by the inviting side[69].

Example:

Virtual Remote Maintenance & Inspection[73]

Virtual Reality Motor Maintenance[74]

Machine Assembly in VR[75]

5.5.4 Review of Workflows and Benchmarking

As predictive analytics have become crucial to success, virtual reality is being used to review workflows and improve benchmarking processes. Manufacturers can see what is going on, review how workers' responsibilities could be changed, and determine if the changes would save the manufacturer money.

Certainly, the efficiency and productivity of many of our everyday workflows have improved through the application of technology over the years, and this will continue. But, it is important to pay attention to how to make many of our commonplace processes easier, and faster, especially for those who have to execute them every day as part of their work.

[72] Orinox: https://www.youtube.com/watch?v=Rx8zF8FRDF4
[73] Virtual Remote Maintenance & Inspection: https://www.youtube.com/watch?v=ymOefNdr7vY
[74] Virtual Reality Motor Maintenance: https://www.youtube.com/watch?v=dq2RSlslQcU
[75] Machine assembly in VR: https://www.youtube.com/watch?v=RPVE_muU4W4

Many organizations have moved from paper documents to digital documents, facilitating more effective accomplishment of workflows[76].

Example:

Virtual Production Process Planning in VR[77]

Mixed Reality Solutions in process automation[78]

5.5.5 Training Protocols

Trainings are yet another area where VR applications can support the engineering and manufacturing sectors by immersing staff in a simulation of a real-life situation. VR trainings are eco-friendly and cost saving, as no real resources are used, there are no safety hazards and they can be easily repeated. The benefits of VR trainings are bigger where expensive or specialised machinery is used in real-life or where there is an unnecessary exposure to danger. For example, according to EON Reality's department in France, the maintenance time of an energy plant's facilities which requires the interruption of production can be reduced by 50% with the help of VR trainings.

Maintaining compliance and visibility through training protocols are another way virtual reality is improving manufacturing. Workers can be trained in a digital environment, allowing for proactive training of what-if scenarios, which will reduce incidents, injuries, and delays in production. (Robinson n.d.)

Examples:

VR training for Dassault Falcon Aircraft Mechanics[79]

Weld VR Simulator[80]

VR Training for Industry[81]

Foundry 45 VR Training for Manufacturing[82]

Virtual Reality Headsets To Train Workers[83]

Plant Immersive Training Simulator, Safety Services[84]

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[76] Brandt S n.d., *Virtual Reality Workflows*, viewed 17 September 2019, <https://www.equorum.com/virtual-reality-workflows/>
[77] Virtual Production Process Planning in VR: https://www.youtube.com/watch?v=rtrFQPZcKzk
[78] Mixed Reality Solutions in process automation: https://www.youtube.com/watch?v=Hi-z4WKBOHQ
[79] VR training for Dassault Falcon Aircraft Mechanics: https://www.youtube.com/watch?v=Yb4-ASQX1AQ
[80] Weld VR Simulator: https://www.youtube.com/watch?v=w7jjcMCqFKk
[81] VR training for industry: https://www.youtube.com/watch?v=BkibHXgXnRM&t=59s
[82] Foundry 45 VR Training for Manufacturing: https://www.youtube.com/watch?v=gGH9wWre0eE
[83] VR Headset to train workers: https://www.youtube.com/watch?v=Rnk_akgSjqg
[84] Plant Immersive Training Simulator, Safety Services: https://www.youtube.com/watch?v=4On17hnQECw

5.5.6 Quality Assurance and Risk Management

Products may not always be correctly manufactured, and risks will always be present. However, virtual reality in manufacturing is being used to conduct a more comprehensive QA checks and manage risk by keeping all parties accountable. For example, QA applications of virtual reality may include periodic review of products as they're being created[69].

Example:

Machine Assembly In VR[85]

5.5.7 Control of Robotics

Virtual reality in manufacturing could also be used to eliminate the need for advanced control panels when robots are used. This could help enhance the precision guidance of robotics, enabling more cautious and detailed actions without actually putting stress on the employee.

As manufacturers move towards a more efficient supply chain, the use of virtual reality will increase. Virtual is reducing cost and helping manufacturers visualize products faster than ever before. For manufacturers like Ford, the applications of virtual reality in manufacturing are key towards growth in the 21st century, and all manufacturers should be actively working to embrace virtual reality today.

5.5.8 Disrupt traditional sales strategies

Automakers are looking to VR technologies to attract buyers, improve their time at dealerships and form a stronger emotional attachment to a product they helped create[86].

VR videos allow potential customers to explore the company´s product/service first before making a purchase. You can even incorporate a product/service app or an interactive 3D picture with your virtual reality video to pinpoint certain prodcut potentials or benefits to customers. This is a chance to showcase the product the company is promoting in a vivid and convincing way rather than just giving the customer a brochure. By presenting your services to potential customers in advance using a VR video, you will convey the message that the company is transparent and authentic[86].

[85] Machine Asssembly in VR: https://www.youtube.com/watch?v=RPVE_muU4W4
[86] Business.com 2018, *How can businesses reap the benefits of virtual reality?*, viewed 22 October 2019, <https://www.business.com/articles/virtual-reality-business-use-cases/>

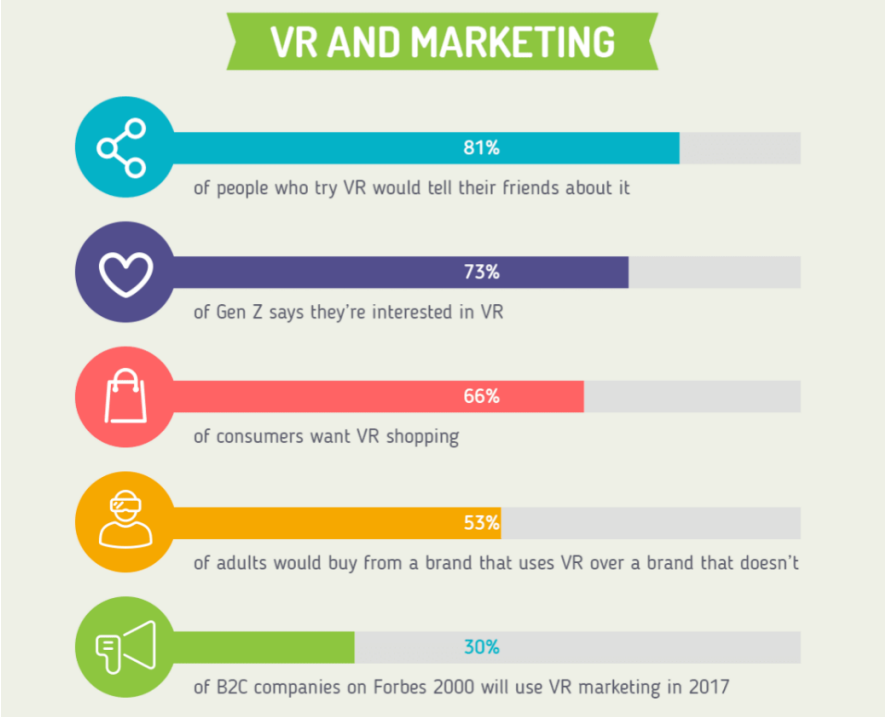

Fig D8. Why VR matters[87]

The Audi VR experience uses proprietary software and visualization technology from ZeroLight, a technology company based in Great Britain. Using a VR headset at the dealership, customers can configure their new Audi and experience their dream cars virtually, in real time. And, they have the opportunity to explore every detail of the vehicle as they choose options and accessories in the virtual setting of their choice — a lunar landscape, a tunnel, or the National Library in Paris.

Example:

VR for Industrial Marketing[88]

VR Plant[89]

5.6 Conclusions

The sustainability of the business over time and how to enhance profitabiility of the company are usually the most critical issues addressed by SMEs managers. For that reason, an organization is always in search of new technologies which can achieve the desired results in minimum input and in short time period.

Virtual Reality, despite being a technology usually related to gaming, is becoming an interesting resource with great potential in the manufacturing environment with an impact in many areas of the company such as research, design, planning, marketing, risk management, and maintenance.

[87] Source: https://www.webfx.com/blog/marketing/why-virtual-reality-matters-to-marketing-infographic/
[88] VR for Industrial Marketing: https://www.youtube.com/watch?v=quBuEqNmKF0
[89] VR Plant: https://www.youtube.com/watch?v=6a97u3tkFQo

Apart from the benefit and advantages, that are clear and most of the companies recognize, there are some barriers to overcome for an appropriate VR impementation, and they´re related mainly with the return of the investment, level of digitalization and lack of expertise.

Consider the implementation of a VR tech in a company is an important decision that requires a deep understanding of the current internal expertise and digitalization status of the company. What is more, a group of motivated and trained people is need to develop new products and services portfolio

This article could to be consider as the basis to be introduced in the benefits of VR implementation in business companies and a supporting material for the training modules developed in the scope of VRinSight project.

Module E

Step-by-Step guide to good VR practice

Erasmus+

6 Step-By-Step guide to good VR practice - Module E

6.1 Introduction

The purpose of this document is to provide readers with the basic knowledge they require to become accustomed with virtual reality hardware in a practical sense. It also the aim to guide the reader through the first steps of using VR hardware and through the challenges they may face.

These aims will all go to preparing the educator to present demostrations of VR technology and VR software to learning groups – for example other educators, academic staff who may wish to incorporate VR technology into their lectures and seminars.

Although the main target group of this Module is primarily educators at higher level, the practices taught in this module and the guideline on VR technology and VR demonstrations can easily be transferred to those in private enterprise who may wish their fellow employees to become acquainted with VR technology.

6.2 Technology introduction

Currently, there are a number of different types of devices available that can create a virtual reality setting, ranging in size and capability depending on the requirements and budget of the user. For the purposes of an educational setting involving multiple users and connectivity, the suitably of certain device types has been highlighted. The devices available range from virtual reality displays encompassing immersive environments such as VR caves (Fig E1.0.1 & Fig E1.0.2) and to head mounted display (HMD) (Fig E1.1) allow the user a fully immersive VR experience.

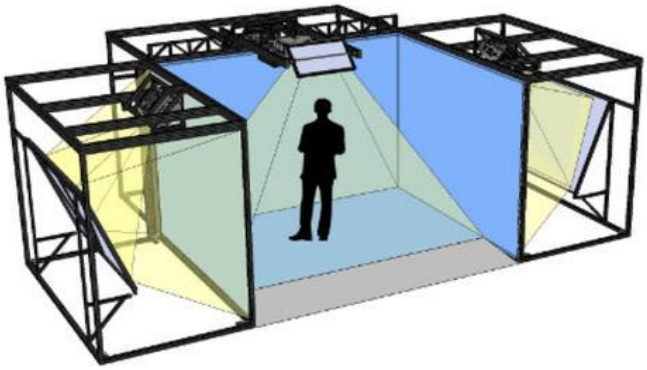

Fig E1.0.1 Cave[90] & Fig E1.0.2 Cave [91]

Fig E1.1 Head-mounted display (HMD) enables high sensory immersion[92]

Following extensive research into available technology within the VRinSight Survey - Cumulative Report, Standalone devices have been identified as the most appropriate devices available to educators. These devices can operate alone without being connected to a PC and are very suitable on a practical basis due to the absence of any cables allowing for freedom of movement and convenience for both educators and learners. In a classroom or tutorial setting with a tutor and numerous learners this is seen as a huge priority. These Standalone devices can also be suitable for modest budget holders and are relatively user friendly for novices as they often have a large range of apps available to stimulate learner interaction. Please refer to VRinSight Survey - Cumulative Report and accompanying SWOT analysis of individual headsets.

[90] Source https://www.wavin.ca/vr-cave.html
[91] Source: https://www.wavin.ca/vr-cave.html
[92] Source: Fachhochschule des Mittelstands, Berlin, 2019

Example of Standalone Device: Oculus Quest headset including controllers (Fig E1.2) and HTC VIVE (Fig E1.3)

Fig E1.2 Oculus Quest HMD and Oculus Touch controllers[93]

Fig. E1.3 HTC Vive Headset and controller[94]

6.3 Unboxing Guideline

Your first encounter with a VR headset can be quite overwhelming and this section has been written to give a guideline on how to handle the equipment and how to begin your first VR experience. Depending on the headset device you have chosen the first steps can differ but generally follow the same approach.

Standalone devices usually include the following equipment (Fig E1.4):

- Headset device
- Controllers Left and Right
- USB Cable and plug for charging Headset (via PC or Plug)
- Batteries for Controllers

[93] Source: https://www.pcgamer.com/oculus-quest-review/
[94] Source: https://www.vrfocus.com/2019/01/htc-vive-cosmos-is-the-latest-headset-to-feature-inside-out-tracking/

Fig E1.4 Oculus Quest unboxing[95]

6.3.1 Headset

The Headset is mounted facing outward (see Fig E1.7) with the straps around (and above) the head, and the headset sitting around the eyes and above the nose comfortably. The tightness of the headset strap can be adjusted to size. The straps of the device should be sufficient to carry weight of the device (Fig E1.5) and it should not be necessary to use your hands to support the device. The Oculus Quest for example weight is approximately 600gram. The straps can be adjusted to fit the user (Fig E1.6)

Fig E1.5 Oculus Quest head straps[96]

Fig E1.6 Adjusting head straps[97]

[95] Source: Fachhochschule des Mittelstands, Berlin, 2019
[96] Source: Fachhochschule des Mittelstands, Berlin, 2019
[97] Source: Fachhochschule des Mittelstands, Berlin, 2019

Fig E1.7 Head-mounted display (HMD)[98]

Many Standalone devices have the option to adjust the lens of the headset to the requirements of the user. To adjust the lens and the distance between the user pupils (pupillary distance, PD), there is often found either on the side or underside of the device adjusters to sharpen the VR image being seen by the user (see Fig E1.8 & E1.9). When purchasing HMD's for multiple users, it is strongly recommended that a headset includes an option to scale the pupillary distance as some of the users may otherwise be unable to use the system (due to blurry picture, motion sickness, etc.).

Fig E1.8 Pupillary distance adjustment in VIVE HMD[99]

Fig E1.9 Pupillary distance adjustment in Oculus Go could be found at the bottom of the HMD[100]

In the interior of the VR headset, there is a sensor above the lenses to detect if a person is currently wearing the device (Fig E2.0). Only when this sensor detects the user's forehead will the VR device

[98] Source: Fachhochschule des Mittelstands, Berlin, 2019
[99] Source: https://www.youtube.com/watch?v=dn6qEX3FNRw
[100] Source: Fachhochschule des Mittelstands, Berlin, 2019

remain activated. If the there is no presence detected the device will automatically switch to power saving mode.

Fig E2.0 Sensors detect if the user is wearing the headset or not (Oculus Go)[101]

In most cases, Standalone devices will have an embedded stereo sound speaker and microphone built into the device allowing the user to get a fully VR experience and allow for verbal/audio communication through the device. Many headset also accommodate the wearing glasses or spectacles by user. A glasses spacer (Fig E2.1 & Fig E2.3) is typically supplied when purchasing the device. The spacer should be inserted before using the device (Fig E2.2)

Fig E2.1 Glasses spacer for Oculus Go[102]

[101] Source: Fachhochschule des Mittelstands, Berlin, 2019
[102] Source: Fachhochschule des Mittelstands, Berlin, 2019

Fig E2.2 Glasses spacer insertion[103]

Fig E2.3 Glasses spacer [104]

Many VR headsets are now equipped with external sensors to measure the physical space in the immediate area around the user. Sensors and small cameras measure the area and allow the user to view the space in their proximity. (Fig E2.4)

Fig E2.4 Camera location at Oculus Quest [105]

[103] Source: https://www.androidcentral.com/how-adjust-focus-your-oculus-go)
[104] Source: Fachhochschule des Mittelstands, Berlin, 2019
[105] Source: Fachhochschule des Mittelstands, Berlin, 2019

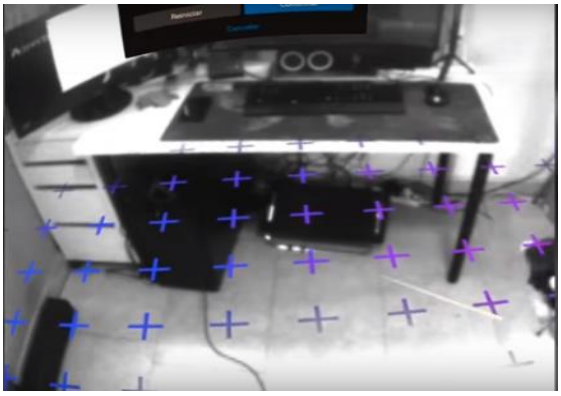

Fig E2.5 Sensors scanning the physical environment for inside-out tracking (no external sensors required)[106]

The Oculus Quest for example also allows the user to view the area around them through the VR device in a feature known as “pass through” and allowing the user to orient themselves in the physical space. (Fig E2.5)

6.3.2 Power supply

Standalone devices such as the Oculus Quest are provided with USB-C cable (Fig E2.6) allowing connection to PC or electric wall socket to allow charging and recharging of the devices power supply. The charging indictor light will turn green once it is fully charged. It is recommended to charge the headset fully before using the device for the first time.

In the case of Standalone devices, handheld controllers will require separate power supply (Fig E2.7). This takes the form of standard cell cylindrical batteries (typically AA standard) that are often supplied together with the device.

Fig E2.6 USB-C cable (Oculus Quest)[107]

[106] Source: https://www.youtube.com/watch?v=O-vwSrhLXUk
[107] Source: Fachhochschule des Mittelstands, Berlin, 2019

Fig E2.7 AA batteries required for handheld controllers (Oculus Quest)[108]

6.3.3 Register

On Standalone devices, such as the Oculus Quest, it is often also necessary to download the official Oculus app in order to register your device. The app must be downloaded on to an iPhone or Android phone, or tablet in order to register the device and connect it with your Wi-Fi network.

A code in the form of a 4 or 5-digit code will appear once when you look through the lenses of the headset, as in the case of the Oculus Quest. This code will be used to register the device with the downloaded app. Follow the on-screen instructions to connect your phone to your headset and your headset to your Wi-Fi network (see, Oculus Quest Basics Tutorial).

6.3.4 Device system Updates

VR devices will require regular system updates. In stand-alone devices, user receive an automatic system update message via the VR headset or through device used to download the app. System update message are usually followed with clear step-by-step instructions that can be undertaken by the user.

Stand-alone devices are end-to-end solutions, meaning that all system, software and hardware updates are being taken care of by HMD system provider. Majority of updates happen nearly automatically, and applications are always ready to use (or ready to use after a quick update, as described above). When using a HMD that is connected to a PC, system/hardware/software updates require more detailed technological knowledge. With this technology, it is recommended that an organization has strong IT support. Using a HMD that is connected to a PC requires far more time and effort to use, especially if there are multiple devices that need to be systematically updated so that they work properly when needed.

6.3.5 Handheld Controllers

Handheld controllers will be included with the VR device and these are essential to navigate through any VR apps or software. The controllers may differ from product to product but typically follow a similar arrangement. Each controller will be marked for each intended hand left and right (Fig E2.8). Each controller will have a range of buttons, typically including the following pattern:

- Trigger button (index finger)
- Thumb buttons (Thumb)

[108] Source: Fachhochschule des Mittelstands, Berlin, 2019

- Thumb joystick (Thumb)
- Grip button (Middle finger)

Fig 2.8 Left and Right handheld controller (Oculus Quest)[109]

In the case of the Oculus Quest, you can follow the on-screen instructions to pair your Oculus Touch controllers with your headset.

6.3.6 VR device *Walk Through*

Once you have fully charged the headset and added batteries to the handheld controllers, you will be ready to begin. You can power up your headset by pressing and holding the power button on the headset (Fig E2.9).

Fig E2.9 Power button at Oculus Quest[110]

In almost all VR headset, the first step you will be required to take is after powering up your headset is to designate a safe "Play Area", this is the physical space around you in which you intend to move whilst wearing the headset. You can either stand or sit whilst using the VR device. If you choose to stand and move around, it is important that any objects that inhibit movement such as furniture are cleared out of the way to allow for safe movement, typically outside of a 2 meter radius. The VR headset device will prompt you to mark out this "Play Area" around you using the handheld controller (Fig E3.0 & Fig E3.1). This process is also known as "Calibration" and allows for positional tracking to detect the precise position of the head-mounted display and the handheld controllers.

[109] Source: Fachhochschule des Mittelstands, Berlin, 2019
[110] Source: Fachhochschule des Mittelstands, Berlin, 2019

Fig E3.0 Setting up the play area with Oculus Quest[111]

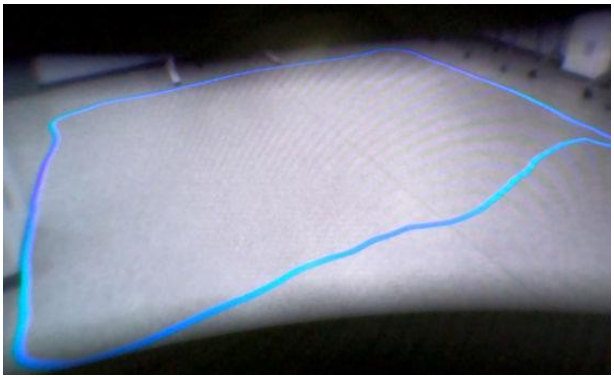

Fig E3.1 Play area in the physical environment (Oculus Quest)[112]

The chosen "play area " will then appear for confirmation by the user, typically in the form of a vertical grid boundary (Fig E3.2). If the user steps too close to the perimeter of the designated "play area when using the headset, the grid boundary will appear along with a warning. Once you step outside the "play area", you can view the grid boundary. Once you step back into the grid boundary the VR space imagery will return.

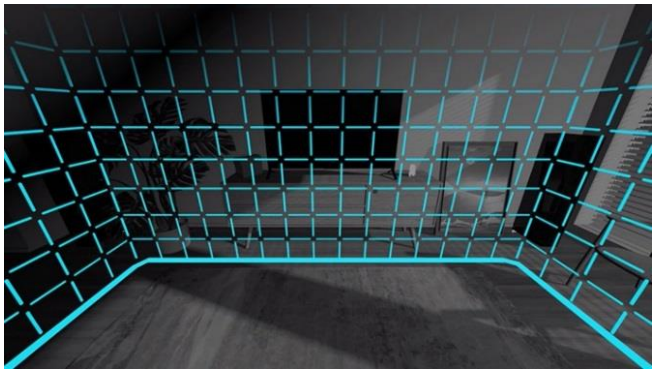

Fig E3.2 Grid boundary makes sure that VR user do not stumble outside play area[113]

[111] Source: Fachhochschule des Mittelstands, Berlin, 2019
[112] Source: https://uploadvr.com/quest-october-update/
[113] Source: https://www.androidcentral.com/how-many-vr-rooms-can-you-save-oculus-quest)

6.3.7 Basic movements and interactions

Depending on the design and capability of the device you purchase, the controls and how a user operates within the VR space will differ. The range of movement and capabilities differs with each headset, the Oculus Go for example uses only one handheld controller (Fig E3.4) and offers all the necessary control but only basic movement when using avatars. Sex degrees of freedom (6DoF) enables free movement in three-dimensional space (e.g. HTC Vive, Oculus Rift, Oculus Quest). Three degrees of freedom (e.g. Oculus Go) enable only movement in three dimensions (pitch, yaw, and roll movement, but not leaning forward in 3D space, etc.). These degrees of freedom include the freedom of both the headset and controllers [114]. (Wikipedia, 2019)

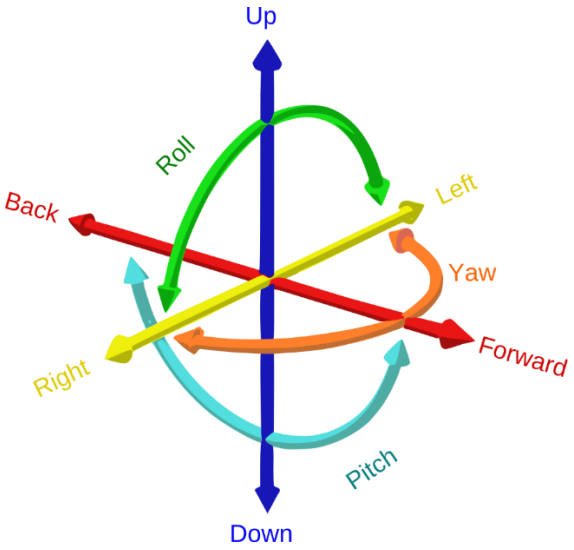

Fig E3.2 Six Degrees of freedom (6DoF)

Fig E3.4 Oculus Go controller enables 3DoF

More sophisticated devices provide handheld controllers for both hands with multiple controls and functions to track hand movements (6 degrees-of-freedom). Further examples include devices that provide virtual reality gloves that track not only hand movements, but the movement of each finger. Likewise part and full VR body suits are also available for an even more intensive VR user interaction. (Fig E3.5 & E3.6)

[114] Wikipedia 2019, *Six degrees of Freedom*, https://en.wikipedia.org/wiki/Six_degrees_of_freedom

Fig E3.5 VR gloves [115]

Fig E3.6 VR suit [116]

Although the handheld controllers can differ form one prodcut to another, the controllers typically follow a certain similar format. Instructions for Movements:

- To make selection in menus: hover the pointer (Fig E3.7)

Fig E3.7 Thumb joystick (Oculus Quest) [117]

[115] Source: https://www.ecumenicalnews.com/article/manus-vr-gloves-now-track-movements-of-the-entire-arm-when-used-with-the-htc-vive/44090.htm
[116] Source: https://www.blessthisstuff.com/stuff/technology/gaming/hardlight-vr-suit/
[117] Source: Fachhochschule des Mittelstands, Berlin, 2019

- Return to main menu: press home button and hold (Fig E3.8)

Fig E3.8[118]

Use pointing finger to push virtual buttons (Fig E3.9)

Fig E3.9 Pointing finger is the main interaction button in many VR user interfaces [119]

- To make a fist Squeeze the grip button (middle finger) (Fig E4.0)

Fig E4.0 Grip button (Oculus Quest)[120]

[118] Source: Fachhochschule des Mittelstands, Berlin, 2019
[119] Source: Fachhochschule des Mittelstands, Berlin, 2019
[120] Source: Fachhochschule des Mittelstands, Berlin, 2019

- to point squeeze the grip button (middle finger) and lift index finger (Fig E4.1)

Fig E4.1 Pointing with a finger [121]

- To pick up an object squeeze and hold grip button (Fig E4.2)

Fig E4.2[122]

- To drop objects release the grip button (middle finger) (fig E4.3)

Fig E4.3 Objects are often grabbed and released via the grip button[123]

[121] Source: Fachhochschule des Mittelstands, Berlin, 2019
[122] Source:https://tahium.com/news/tearing-down-the-oculus-rift-touch-controller/)
[123] Source: Fachhochschule des Mittelstands, Berlin, 2019

6.3.8 Applications & Software

In order to begin the first virtual reality experience, you will require virtual applications and software to be downloaded onto your headset. Typically, the headset producer that allow for a first VR user experience provides a number of pre-downloaded recommended applications.

Devices such as the Oculus Quest offer a range of VR applications that can be downloaded directly onto the headset through the Oculus Store and accompanying Oculus App on your mobile device or tablet. The VRinSight project partnership has selected a list of 25 applications that are suitable for Educators in business management and education in general. The 25 chosen apps are detailed in the *VRinSight Showcase,* with a user guideline, user review and links on each app available in Module F.

6.3.9 Sideloading

Sideloading is when you manually install apps without using the Oculus Store: You download APK files on the web, transfer them to the Oculus Quest, install them, then launch the app without using the Oculus Library. In other words, sideloading is a way to play many more games (and apps) that would not be accessible otherwise (e.g. apps that are at beta phase).

6.4 Introducing VR to other learners and hosting demonstrations

6.4.1 Preparation

When introducing VR to a group of learners the key to a successful session is the preparation. Good preparation will avoid any unforeseen technical difficulties that will delay the learning session resulting in lack of interest and impatience on the part of the learners. The following steps need to be completed in order to prepare successfully for group demonstration.

Review the workflow of this

i) Ensure that all software is updated and functioning.

ii) Ensure all cables are functioning correctly.

iii) Ensure that all headsets are fully charged.

iv) Standalone HMDs such as Oculus Quest have a battery life of approximately 2 to 2 and a half hours once fully charged. The battery life expectancy can vary depending on the intensity of usage and what software is being used. Plan the learning session within this limited 2-hour timeframe.

v) The battery life can also be effected by the device overheating. Prior to a learning session, make sure the device is stored away from direct sunlight or storage areas with an above average room temperature.

vi) Ensure that the handheld controllers have sufficient battery life and replacement AA batteries are at hand.

vii) Ensure all devices have a suitable power supply:

- USB cable for VR headset
- USB cable for Mobile device or tablet for Casting
- Monitors and PCs

viii) Ensure there are the necessary amounts of electrical sockets to supply all electrical devices.

ix) Ensure all cables and power supplies for each electronic devices have the necessary length to facilitate movement of users, learners and educators.

x) Ensure all devices (VR headset, tablet mobile device, Chromecast/Firestick, etc.) have a strong Wi-Fi connection available for the period of the learning session and are connected prior to beginning the session.

xi) Ensure a steady station (table or stand) is available for the tablet or mobile device being used to cast the VR content (see Streaming section), and that it is viewable for the learning group.

xii) It is advisable to open and load all applications and software that you intend to use during the demonstration prior to beginning the learning session. This allows time for loading and logins, which can be time consuming during a learning session and can lead to learner disinterest.

6.4.2 Streaming

When introducing VR technology to a group it is advantageous to allow all learners to experience the content being displayed within the headset. However, individual VR Headsets are designed to fully emerge only one user at a time into a virtual reality. There is, however, the possibility to simultaneously display the content being shown in the headset and display the content to a separate screen or monitor. This technique is known as casting. This is not only useful for the entire group but also useful for showing content to the user prior to wearing the VR device. This can help alleviate any apprehensions or uneasiness some user may have before actually wearing the VR device. Casting is very useful because it allows the teacher to display and explain the content to the group and also allows the teacher to guide the VR user through the virtual content and give instruction to the user on how to navigate the virtual reality.

For HMD such as the Samsung VIVE, this technique can be easily enabled because the headset is connected directly to a PC. However, for stand alone devices such as the Oculus Quest, the option to cast is facilitated through the accompanying Oculus App. The App allows the content to be cast onto the mobile device or tablet in which the Oculus app has been downloaded.

Fig E5.0 Streaming VR content to external display [124]

The content being cast can then be displayed to a larger PC monitor, Smart TV or any other device that is compatible with the mobile device/tablet via devices such as Chromecast or Firestick. The process of casting is not flawless and is not entirely reliable. Casting is dependent on capability of the mobile device or tablet being used and which software or application is in use while casting. Not all applications can be cast in this manner. Thus far, casting of audio to the Oculus app from the VR device is not possible, and therefore the fully immersive experience is not faithfully replicated by the casting feature. However alternatives for connected the audio to an external source are available.

In order to create the illusion of VR immersion and maintaining the learning group attention, the educator could consider playing background music from a different source or device. This should be at a suitable volume and should not interfere with the teacher ability to communicate with the VR user or the rest of the learning group.

[124] Source: https://holoeyes.jp/en/

The following video illustrates how the casting process works for Oculus Quest: Oculus Quest Basics Tutorial - How To Cast

6.4.3 Content

When teaching in the context with a learning group it is advised to begin any VR experience with a general content such as a interactive video or animation, rather than beginning immediately with individual VR users. An interactive video or animation cast to a monitor will capture the attention of all learners in the group and act as a colorful introduction to the possibilities of VR.

Suggestions include many of the free content available on the Oculus Quest such as videos from:

- Oculus TV App

- Samsung VR Videos

- Next VR

At that point, the educator can begin with volunteers from the group to wear the VR headset. Before the learners wear the VR headset, it is advisable to have the chosen app or software loaded and logged in prior to beginning, this will mean the user is fully immersed in the VR software experience once they put on the headset. It is advised to begin such sessions with the use of an avatar in order to introduce the basics of the handheld controllers and introduce the basic movements of the avatars, before moving on to more complicated actions. Suitable applications for such sessions have been choosen and are described in the VRinSight showcase. Suitable applications in the showcase include:

- Altspace VR App
- ENGAGE learning Platform
- Wakeone XR Platform

6.4.4 Instruction

a) Menu selection – In order to navigate in VR you must use the handheld controllers how to operate the Menu selection and basic navigation is illustrated in the following video: Oculus Quest Basics Tutorial Part 04: Navigating in VR.

b) Avatar Customization

There is the option in Oculus Quest to customize your avatar as it appears in VR. The following video illustrates how the customization process is completed: Oculus Quest Basics Tutorial – How to Create an Avatar

c) Communication between avatars

In many applications, using avatars there is the possibility to communicate between avatars. This can also be setup centrally through the Oculus Quest menu. Please view the following video to understand how this can be achieved: Oculus Quest Basics Tutorial – How to Voice Chat

6.4.5 Anxiety and comfort

It is not unusual that some learner are apprehensive or uneasy before using a VR headset. This uneasiness is often caused by fear of unknown technology. This uneasiness is also caused by wearing

the VR headset in front of a group, and fear of looking foolish or being cut-off from communication from the rest of the group. This often leads to hesitation when the teachers ask for a first volunteer from the learning group to wear the VR headset. Subsequently it could be considered advantageous for the teacher to be the first person to wear the VR headset in order to put the learners at ease and dispel any apprehensions they may have. However this isolates the teacher and isolates the learning group by removing the connection between them, and can lead to the teacher losing the attention of the learners. Therefore, it is recommended that the teacher have an assistant teacher present with them to be the first to wear the VR headset allowing the teacher to act as an intermediary to explain the process to the learning group and guide the VR user. This need not be an assistant teacher but also someone in the learning group who has experienced VR previously.

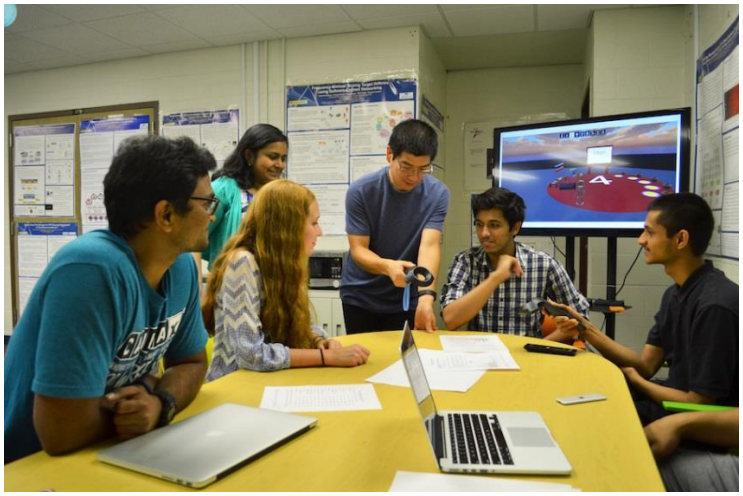

Fig E5.1 Participants in a meeting getting familiar with VR[125]

A further step in dispelling learner apprehensions is the ability to cast content from the VR device to a monitor to allow the group to experience what content is being shown in the VR Headset device. This can help alleviate any apprehensions or uneasiness some user may have before actually wearing the VR device.

6.4.6 Multi-user

In order for the learning group to become engaged with the VR technology it is encouraged to use VR applications that facilitate multi-user activity. This means that more than one user from the learning group can be in the virtual environment at one time and the users can interact with one another as well as with the virtual content in the virtual space. This leads a a whole dynamic for the learning group, not only increasing the acceptance of the technology but also increasing the and the learning effect through group interaction.

In order to facilitate multi-user interaction, you will have to provide at least two VR headsets t the learning group. You will have to ensure that both headsets are compatible with the app you intend to use and that both have been registered with usernames and passwords etc. You will also have to consider, which of the devices you intend to use for casting to your monitor or mobile device so that the rest of the group can view the interaction, and ensure that both user avatars are captured in the casting. You will have to also ensure that the app you are using can facilitate multi-users. In the

[125] Source: https://its.sdsu.edu/vital-the-future-of-immersive-learning-at-sdsu/

VRinSight Showcase there are a number of apps with multi-user capability that have been selected for their suitability for learning groups. The following applications:

- Altspace VR

- ENGAGE VR Learning Platform

6.4.7 Troubleshooting and common challenges

Many of the common issues you will faces when giving a demonstration to a learning group have already been covered in the 5.1 Preparation section. There are a few troubleshooting errors that can occur that cannot be foreseen.

6.4.7.1 Overheating

Depending on the capability of the VR headset you intend to use, it can often occur that a headset can become overheated. This is particularly after prolonged use and in an environment above average room temperature. This occurs more frequently in the lesser sophisticated VR headsets such as the Oculus Go. If this should occur, you will receive an error message in the headset warning of overheating. The device will have to be powered off and left unused until it cools down. This however means that the device probably not be used for the remainder of your demonstration. Store the device in a room of average room temperature away from direct sunlight allowing it to cool down.

6.4.7.2 Stalling

It is often the case that certain applications can stall when being opened or if the app is loading. This tends to happen on applications with high functionality rate, and particularly in conjunction with VR headsets that are not of high performance. In the example of Oculus devices, often in these instances the upload stall will lead to upload failure and the user will be returned to the main menu. The app can then be accessed again from the main menu. However in some instances it can lead to a failure in the VR headset and the unit will have to be powered off altogether. The device can then be restarted and the chosen app can be accessed again.

6.4.7.3 Casting failure

In the case of Oculus devices, the option to cast to monitor/tablet or mobile device via the oculus app is extremely convenient. Casting works well when navigating the main menu and for many of the listed apps. However for many of the more high performance applications the cast option will not function. His will not effect the user interaction with the high performance app on the VR headset, only those viewing the content via the oculus casting app on the monitor/tablet or mobile device.

Upon opening the application an error message will appear in the oculus app on your monitor or mobile device letting you know that the content will not be cast. Often this error message will not appear and the oculus casting app on your monitor will simply show no content. Once the user has finished using the high performance app and returned to the main menu, the casting to the tablet or mobile device will continue as before. However, often it is the case that failure to cast a high performance app can also often be followed by a failure in connection between the oculus app on your mobile device and the VR headset. In order to restore the connection, the VR headset user will have to access the casting option in the main menu of the VR headset

6.5 Assessment

Once the learning group has come to grips with the basics of movement and control with user Avatars in a VR space, it will not be long before the educator will wish to assess how much the learning group have actually learned and how competent the learners are to perform on their own.

The VRinSight VR Classroom includes a range of features that assess the competence of a VR user.

This assessment consists of multiple challenges. To test the movement and control the user can be given set of tasks to perform ranging in difficulty to complete independently. This may vary depending on the VR app/software being used, but they may include:

i) Avatar teleporting from one VR space to another specific location

ii) Importing a specific list of 3D objects from an objects library and arranging them in a particular pattern.

iii) Customizing a user avatar and/or customizing a virtual space

iv) Importing documents or video material for presentation

Assessing technical competence of the earning group can be assessed by presenting the group with certain scenarios of common troubleshooting and asking for solutions. These challenges, depending on the VR app/Software used and the device, could include the following;

i) Uploading/installation of new apps

ii) Battery power failure

iii) Failure in VR headset casting to Monitor

Module F

Introduction to VRinSight Showcase

7 Introduction to VRinSight Showcase - Module F

VRinSight Showcase provides best practice examples of VR applications in context of business management HE. This document provides a quick overview of these applications and their possibilities in leveraging VR related skills and competences in this field. Each application in VRinSight Showcase were evaluated via extensive testing (mainly focusing on Oculus Quest ecosystem) or online desk research. This document provides 1) a brief overview of VRinSight Showcase applications, and 2) a description of how these applications were evaluated. Only the most suitable applications were selected, mainly based on their perceived benefits to business management HE and European SMEs.

7.1 Best Practice Examples

This section provides an overview of each app selected and evaluated.

1. **Altspace VR**

Freely available Social VR (SVR) application. Altspace VR includes the use of Avatar in a multi-user environment (i.e., embodied communication (verbal and nonverbal) with other Avatars). Altspace VR is supported by most major VR ecosystems. The application is highly suitable for HEI as an introductory practice example because it is easy to get started as a user. Due to multi-user interaction, a tutor can accompany the learner in the VR space. The group interaction also demonstrates much of the communication dynamics, interaction and pedagogical considerations of VR environments. Altspace VR is aimed for consumer use more than enterprises, although it could be used for meetings, discussions, etc. as a substitute for videoconferencing or other online/physical meetings. Customized virtual spaces are also available. Browser sharing feature enables the use of existing 2D content in a virtual meeting.

Come to visit us at *VRinSight't Home* (friend request needed, search for a user "VRinSight")!

Target group: the general public, virtual teams (meetings, informal grouping).

2. **AVR Platform**

AVR Platform offers one of the largest immersive learning library available, and has a number of application dedicated solely to education. AVR platform is dedicated to Education and to help educators enhance the learning experience. The application has a library of ready-made interactive lessons for educators to use in the classroom. The AVR platform consists of 3 apps used for training and education:

- Creator AVR
- Virtual Trainer
- AR Assist

Target group: educators, trainers at all levels of education.

3. **CalcFlow**

CalcFlow "makes calculus less monotonous and more marvelous". Is is aimed at advanced mathematicians or anybody else dealing professionally with selected field of mathematics. CalcFlow enables mathematical modeling, manipulating 3D graphs, and real-time parameter editing. Pedagogically, CalcFlow fosters focused learning (no distractions in VR). High immersion

may enhance participant's motivation to learn. Real time 3D visualizations foster sense-making of mathematical models.

Target group: mathematicians, math students.

4. ClassVR

ClassVR is is designed for teachers and for the classroom (content is mainly aimed for elementary schools). ClassVR is not compatible with other VR ecosystems such as Oculus, Steam, or VIVE: both HMDs and the content comes from the technology provider Avantis. ClassVR content is based on 180/360 videos, or build in 3DoF 3D scenarios. ClassVR does not enable navigation in VR, or any complex interactions, because there are no controllers included in the system.

ClassVR is easy to use and cheap low-end VR solution for schools. Pedagogically, ClassVR focuses on enhancing student's sense-making via VR (taking multiple perspectives, and "being somewhere else"). However, lack of interactions may diminish situated learning and transfer. 3DoF also reduces actional and sensory immersion.

Target group: teachers and students, classroom learning.

5. Engage

ENGAGE is a social VR platforms for education, training, meetings and events. Participant's may use existing virtual locations (21+) and virtual objects (1200+), or download their own content. ENGAGE offers many built-in features such as media streaming, quizzes and session scheduling.

Target group: educators, trainers and corporate virtual teams.

6. Edorble

Edorble is a social VR (i.e. multi-user) platform that is specifically aimed at education, training, meetings and events. Edorble 3D design tools enable virtual world creation and customization.

Redommendation: educators, trainers and virtual teams.

7. Firefox Reality

Firefox Reality brings the web content of the well-known Mozilla Firefox browser to Virtual Reality headsets. Firefox Reality is a "browser for VR".

Target group: mostly suitable for educators, trainers, students, general public.

8. Google Expeditions

Google Expeditions is an immersive education app that allows teachers and students to explore the world through over 1000 virtual-reality (VR) and 100 augmented-reality (AR) tours. You can swim with sharks, visit outer space, and more without leaving the classroom.

Target group: teachers and students.

9. Prospect

Prospect is a one click solution for displaying designs in Virtual reality. The application is primarily designed to display 3D architecture models in VR setting and allow for multi-user meetings. These models are first generated in standard CAD and /or BIM software and then transferred into the Prospect VR platform.

Target group**:** designers and managers from construction industry, engineering, architecture, HE educators & students.

10. Job Simulator

Job Simulator is a fun and engaging game that illustrates the capabilities of "more serious" VR training as well. One need some time to get through all the activities! There are a large number of different activities and instructions that are very fun to implement. You can also learn a lot about the professions and the different areas of activity. The app has received many awards, which also speaks for its quality.

Target group: the general public, persons/students/pupils interested in the professions of convenience store clerk, office worker, gourmet chef and auto mechanic.

11. Labster

Labster provides a set of science laboratories (STEM, chemistry, biology, etc.) for educators, also for higher education. Currently, Labster does not have all of its assets available in VR. Labster has a great promise when it comes to laboratory related VR training, but some question marks remain relating to VR technology support. At the moment, Labster supports only Lenovo Mirage Solo and Google Daydream devices. However, Google has dropped its support for Daydream devices, and next VR ecosystem for Labster is still pending.

Target group: educators (e.g. chemistry, biology).

12. MakeVR Pro

MakeVR Pro is a 3D content creation experience with a natural style of interaction that lets anyone, regardless of age or experience level, step into a professional CAD engine and start building 3D objects and worlds on Day One.

Target group: 3D designers, the general public.

13. Mozilla Hubs

Mozilla Hubs is free to use open source platform. Aimed at general use. Hubs could also be used in enterprises as well (such as downloading and interacting with different 3D-models). The biggest strength of Mozilla Hubs is easy of use, scalability and flexibility (can be used almost via any device). Mozilla Hubs allows high amount of different features and integration possibilities. As a trade off, Hubs does not have that high immersion. Highly informal.

Target group: the general public, virtual team.

14. Nanome

Nanome is aimed at students, professional researchers and scientists in the fields of chemistry, molecular biology and related areas. The focus is on molecular design and exploration. Nanome has multi-user interactions that enable real-time tutoring, mentoring and collaboration. VR workspaces may also be customized and saved for future presenting or collaboration.

Target group: chemistry and molecular biology.

15. Oculus Rooms

Oculus Rooms is a social VR platform for entertainment, education and virtual meetings. However, Oculus Rooms is able to deliver content only via Oculus/Facebook. Social interaction is highlighted due to lack of interactions and features. However, Oculus Rooms have different games for, e.g. informal grouping sessions. Facebook Horizon will most likely replace Oculus Rooms in early 2020.

Target group: entertainment, educators, trainers and virtual teams.

16. Presentation Simulator

Presentation simulator is aimed at business people, students, teachers, politicians, leaders, or anyone who from time to time has to give a speech or a lecture, and wants to get over his nerves before. Presentation Simulator is the simplest of the alternatives for VirtualSpeech. It only offers public speaking simulation. There is no feedback, no courses for instruction and only a few venues to choose from.

Target group: anyone who wants to practice public speaking and presentations

17. Samsung VR videos

Samsung VR videos is a platform for 180 and 360 videos with “fresh” daily content. Users are also allowed to stream their own video content via the platform.

Target group: the general public. Also for educators, trainers, students.

18. SAVI

SAVI is a gamified VR platform for the training of professionals through virtual experiences in industrial environments that enables monitoring and evaluation of trainees. SAVE includes multiple different training scenarios, such as Crane Simulator, welding tasks, safety training for working in high places, truck driving simulator, etc. Multi-user interactions are also available. Tools for participant activity monitoring and evaluation are also provided.

Target group: industry, marketing, sales.

19. ViLeArn

ViLeArn develops and explores situated virtual learning environments based on presence and social interaction. The goal is the promotion of competences and the increase of learning success with special consideration of availability, participation and inclusion. Teachers and learners interact live.

Target group: teachers and learners.

20. VirtualSpeech

VirtualSpeech offers different training scenarios for taking speeches. VirtualSpeech offers ready-made scenarios and courses, such as public speaking, sales pitch and closing, train the trainer, and learning english for business. VirtualSpeech is used via standalone devices, such as Oculus Go, and no advanced technological knowledge is required. VirtualSpeech enables admin controls (e.g. monitoring learning progression). Integrations with other Learning Management Systems (LMSs) are also provided.

Target group: public speakers, sales persons, trainers, language learners.

21. VRChat

VRChat is a free-to-play massively multiplayer online virtual reality social platform. High amount of community created virtual worlds available (more than 50.000 worlds, build with Unity SDK). Full 6DoF with spatial sound.

Target group: the general public. Also suitable for students, educators, trainers, and virtual teams to some extent (VRChat is engaging, but highly informal).

22. 365 Dynamics Layout

Microsoft 365 Dynamics Layout is SaaS (software as a service) aimed for enterprise use. The purpose of the application is to streamline conceptual design and remote collaboration processes that includes the use of different 3D-models.

Target group: STEM professionals.

23. Nvidia Holodeck

Nvidia Holodeck is a high-end collaborative design software for STEM professionals. Holodeck provides photorealistic simulations for designs. It is currently at beta phase and used only by certain selected customers such as Nasa and Toyota. Nvidia Holodeck unveils the potential of collaborative VR.

Target group: STEM professionals and designers

24. Google Earth

Google Earth combines satellite images and location-based data to create 3D presentation of the Earth. Google Earth provides many featured locations that highly accurate rendering. Flight mode (birds eye perspective) and street-view mode supported. Mars and Moon modes are also available.

Target group: educators, students, general public

25. Wake XR Platform

Wake XR Platform provides immersive internet (AR/VR) solutions for enterprises: product marketing, learning and coaching environments, and customized business process gamifications. Wake XR supports also multi-user environments (avatar-based interaction) and 360-video integrations.

Target group: enterprises, industry.

7.2 Selection and evaluation of VRinSight Showcase Applications

The primary focus of VRinSight Showcase was in business management education, secondary focus was in higher education in general. Applications were evaluated based on six factors that were considered as important in case of developing VR related skills and competences HEIs:

1) Applications technical framework
2) Purpose and target group
3) Basic features
4) Prior knowledge needed
5) Learning outcomes
6) HEI added value

Additionally,

- learning content and practical work content/activities were summarized from each application
- SWOT-analysis (strengths, weaknesses, opportunities, and threads) was made from each application
- Concrete recommendations for use were delivered

- Possible further readings and online sources for applications were provided

Technical framework and key data

The information about what VR platforms (Windows MR, Oculus, HTC, etc.) and HMDs the application supports. Possible multiplatform (Desktop: PC/Mac) or mobile (iOS, Android) support is also mentioned. The support for standalone devices, such as Oculus Quest, was highlighted due to lower costs and increased usability.

Purpose and target group

A brief description of the applications purpose (main use cases, such as some specific simulations, virtual meetings, etc.) and main target group (such as educators, trainers, or virtual teams).

Basic features

The description of applications basic features (i.e. what specific actions the application enables). These could include features such as multi-user environment, avatar creation and customization, a possibility to download 3D content, support for 2D presentations/media streaming/session scheduling/etc., or specific simulations and visualizations. Some applications are intended for a specific use case (e.g. Presentation Simulator), and others have many different features for different means of use (e.g. ENGAGE that consists both customized content and interactions, and tools for user generated content creation).

Prior knowledge

The description of a prior knowledge that is essential when using the application. In some cases, the basic use of an application was relatively simple and required only little or no prior knowledge of VR. However, some actions in some applications require knowledge that is more advanced and expertise of VR technology. These include actions such as hosting events in VR, creating customized virtual worlds, or downloading/creating 3D content, to name a few.

Learning outcomes (knowledge, skills, and competences)

Concrete list of learning outcomes that could be achieved when using the application. These include some basic actions such as creating an avatar, customizing an avatar, navigating in a virtual space and interacting with virtual objects, and an advanced learning outcomes, such as importing or creating 3D content or scheduling/hosting an event in VR. Some learning outcomes can be less concrete, such as improved communication skills (Presentation Simulator, or Social Virtual Reality (SVR) applications) or very specific, such as geography (Google Earth).

HEI added value

A description of factors that are considered beneficial in context of HE and business management. For example, SVR applications could be valuable due to high amounts of engagement and social immersion with geographically dispersed stakeholders. Therefore, SVR could be valuable in terms of, for example, User-Centered Design or other forms of remote collaboration. Additionally, avatar-based interaction may improve shared focus and enhance problem-solving capabilities in online group activities. Content creation tools may provide value for HE institutions in terms of being able to

customize their very own learning content. Desktop sharing enables the use and distribution of existing 2D material, and so on.

Learning content and practical work content

A summary of learning content and practical activities (e.g. the most important features, such as importing content from a library or how to record and stream an event in SVR) that could be done with the application.

SWOT-analysis and recommendations for use

A brief description of strengths, weaknesses, opportunities and (possible) threads that are related to the use and adoption of each application.

Recommendations for use

Recommendations for how the application could be used in the context of HE learning and teaching.

Further reading and sources

Recommendations for further reading into the subject. Links to application website or other interesting sources.

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VRinSight Curriculum

2019

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DISCLAIMER

This report has been created in the framework of the project VRinSight funded by the European Commission.

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