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

VRinSight Survey - Cumulative Report

University of Nicosia, Charalambos Vrasidas

April 2019

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

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Contents

List of abbreviations

VR: Virtual Reality

AR: Augmented Reality

SME: Small and Medium-Sized Enterprise

HE: Higher Education

HEI: Higher Education Institution

IO: Intellectual Output

DE: Germany

CY: Cyprus

FI: Finland

BE: Belgium

CEO: Chief Executive Officer

UNIC: University of Nicosia

HCI: Human Computer Interaction

CNC: Computer Numerical Control

1. VRinSight project Overview

Virtual Reality (VR; 2D/3D computer-generated immersive environments) is expected to have a major impact in education, training, business and industry. This will also have a strong direct impact not only on SMEs but also on HE business management and related studies. HE managers and teachers themselves need in-depth education and training concerning what VR is about, what kind of VR skills and competence industry requires from graduates and how their own pedagogical approaches and classes can be boosted by using VR applications. The overall aim of the project in the long run is to boost the use of VR applications within HE business management and related studies and to contribute to reaching the digitalisation goals set by the European Commission.

As part of the project the following main outputs will be generated:

- IO1 - "VRinSight 3 in 1 survey" with HE managers, tutors and higher education experts as well as with SME managers and VR developers to get a clear picture about the state of the art in the field of VR developments as well as about frameworks, demands, needs, experiences, attitudes and mindsets within HEs and SMEs with regards to applying VR solutions.
- IO2 - "VRinSight Curriculum" about relevant key data and background information, pedagogic considerations and recommendations about applying VR at the HE level, global developments in the field and a compilation of a virtual learning materials library for HE managers and teachers with a specific focus on business management and related studies; the so-called "VRinSight Showcase" is a collection of 25 open source VR applications most suited to **HE business management studies**
- IO3 - "VRinSight Training Programme" which enables HE managers and teachers to acquire knowledge, skills and competences to apply VR independently in their own classes; it will also be open to SME managers (and their R&D and HRD experts) so both sides can learn together about the potential of VR teaching and learning and its possibilities for HE and industry. The heart of programme is the "VRinSight Classroom", a VR environment specially created for the project. The whole programme will be tested by 52 target group representatives in DE, CY, BE and FI.

This report summarizes the findings from the 3 surveys in all partner countries.

2. Deliverable - The 3 Surveys

VR is now being used in healthcare, education, entertainment (including movies and games), real estate, marketing, architecture, product design, Cultural Heritage, corporate training and so on. Over ta last years, there are many initiatives related to VR development and implementation, specifically in Higher education field. As part of the project we have conducted interviews with Higher Education managers- teachers as well as some interviews with SME managers and education experts.

The purpose of the surveys is to help us to get a clear picture about the state of the art in the field of VR developments as well as about frameworks, demands, needs, experiences, attitudes and mindsets within HEIs and SMEs with regards to applying VR solutions. Also, the overall objective of the surveys is to gain a better insight into the three fields, technical – HE – SME, relevant to a successful project implementation and finally to develop the curriculum and training program, based on the findings of brief surveys. Our focus is to the following three fields:

a) Technical field: before starting with development work, it is important to gain a basic overview of what is available on the market and what are the advantages, disadvantages, strengths and weaknesses of the different systems with specific reference to teaching and learning environments. There is a mass of information available on the internet however this is partly more confusing than supportive. Each of the different hardware providers has already developed an incalculable number of applications but they have not yet been evaluated as to which of them are best suited for HE teaching and learning. Very often information is influenced by huge companies and therefore it is more advertising than information. Another weakness is that the information is mostly focused on the technical side of the devices and their suitability to HE teaching and learning in business management. In any case, such an overview is not only helpful to the partnership but also to HE teachers and management.

b) Higher Education field: the project group also needs a more detailed insight into the situation, frameworks, requirements, needs and demands of HEIs' state of the art and future planning with regards to applying VR in teaching and learning. Of course, data technical infrastructure and the financial/human/time resources available play a crucial role within this context. However, other comparable studies show that the general awareness of teachers towards digital learning methods and instruments, their personal skills, competences, attitudes and mindsets as well as the general teaching and learning culture within educational institutions are of the same importance.

c) SME field: last but not least, the SMEs' perspectives must impact upon the VRinSight outcomes. HEIs need to learn to customise their education and study programmes better to the needs and demands of the economy. Therefore, the partnership needs to involve SMEs at this early stage of the project to ensure that the methods, tools and content of the VRinSight Curriculum and the Training Programme are tailor made to the SMEs' requirements. Finally, the VRinSight Training Programme will also be open to SME managers as well as to learning and development experts.

To provide the partnership with data and information from all three field, three short surveys will be implemented during the project's first work packages (IO1). All three of them will have a strong impact upon the whole project development:

- They allow for the first time to obtain a holistic overview of the state of the art of VR developments as well as their potential for business management teaching and learning
- The research and analyses of software applications will allow for the identification of those which are most suited for being applied within HE teaching in **business management and related fields**
- On basis of the results, the partnership will decide which of the currently existing hardware solutions are best suited to the project purposes and should be purchased for the pilots
- Frameworks and teaching traditions at HEIs, the managements' future planning for increasing digitalisation into their studies and their teachers' knowhow, skills, competences, attitudes and mindset towards digital teaching in general and VR teaching in particular will directly influence the set-up of project's outcomes.
- With better knowledge about the SMEs' situations and strategic planning for applying VR solution within daily businesses (R&D, production, logistics, promotion, customer relationship etc.) the partnership can design and develop a VR training programme which allows HE teachers to perfectly educate business management students for the requirements of SMEs

The results of the survey are not only of relevance to **HE managers and teachers of business management or SMEs from engineering industries but are also helpful for HE and business in general.** The impact of VR and AR solutions is increasing greatly and soon all levels of life, including education and the economy, will be influenced. Therefore, the survey results are applicable to many other teaching and learning backgrounds. Additionally, they are helpful to policy makers and stakeholders for taking appropriate decisions at the strategic and policy levels.

2.1. Technical field

2.1.1. An overview of VR tools

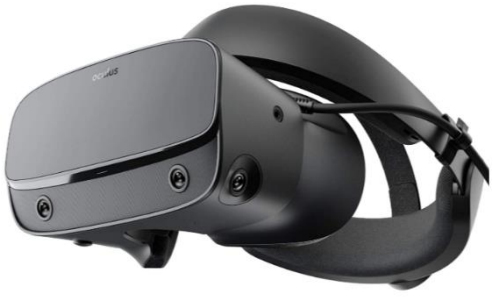
Three main hardware ecosystems exist for VR. These are Oculus, HTC/Valve and Microsoft. In addition, Google and Sony Playstation both have a notable position in the global VR landscape. However, their current offering is either too low-end (Google) or their ecosystem is too closed (Sony) to be effective in our higher education context at the moment. Each of the three main ecosystems have main application distribution channels, which will dictate their success in the future. These are Oculus Store, Valve's Steam and HTC's Viveport and Microsoft Store.

As we're evaluating suitable tools and hardware to be used in higher education context, we will have to look at four key factors:

- Ease-of-use
- Price point
- Hardware availability
- Content

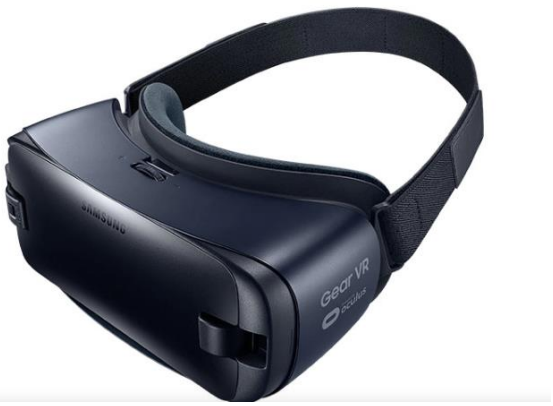
Most of the users will be non-technical and their financial resources are restricted, which means we will have to put emphasis on ease-of-use and price point. Thus, high-end PC VR solutions must be ruled out because of their technical complexity and plus 1500 EUR price point per system. Even though they enable the best available VR experiences, they don't enable sufficient scaling at this point.

At this point, we're left with two possible ecosystems – Oculus and Valve/HTC. As the situation with Valve's and HTC's collaboration seems unclear (HTC has launched their own Viveport content store and Valve seems to be launching their own next generation headset). From afar it seems that their paths might be diverging which naturally raises questions as to how much support will be available. Also, availability of new HTC standalone headsets has been a challenge as their market focus seems to be mostly in Asia and USA. Thus, Oculus and Valve/HTC ecosystems are our main candidates for a suitable solution at this point. Further analysis is presented below.

OCULUS VR ECOSYSTEM	Oculus (Oculus Rift, Oculus Go, Oculus Quest, Gear VR by Samsung)	
URL:	www.oculus.com	
Provider:	Oculus VR, LLC (Owned by Facebook)	
Short description (technical set-up and features, background of development):	**Oculus Rift:** The headset that started "The Second Wave of VR". Its Kickstarter campaign at 2012 was immediate success. Nowadays this Head-Mounted-Display (HMD) may be little bit outdated (released at 22/06/2016). High-end PC is needed to run Oculus Rift (1000€+). Six degrees of freedom (6DoF) is possible (movements that are tracked: forward/back, up/down, left/right, yaw, pitch, roll). Technical set-up and features: - Price: about 400€ - Cordless: no (1000€+ PC needed, OS Win 8.1 or newer, quite good Graphic Card and CPU as well) - Controllers: Oculus Touch (fully tracked) - Movements: 6DoF (head tracking, positional tracking (about 2 x 2 meters)) - Resolution: 1080 x 1200 - Refresh rate: 90Hz - Weight 460g  Currently a new version, Rift S, has been launched. New headset will feature inside-out tracking which will enable getting rid of the external trackers and, thus, help with the ease-of-use of the setup.	

Gear VR:

Samsung Gear VR is powered by user's mobile phone. Therefore, it is a low-cost option, with some major performance trade-offs. However, Samsung VR has increased availability of VR experiences in consumer markets significantly. It is an end-to-end solution: no complex set-up needed. No six-degrees-of-freedom (6DoF) available. This means that moving in VR is not possible by physical movement, only some of the user's head movements are tracked (i.e. three degrees of freedom (3DoF)). This reduces the user experience (immersion, presence, "feeling of being there") significantly.

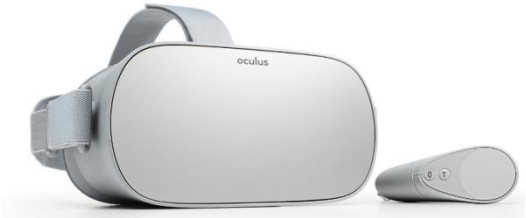


Its software ecosystem is also provided by Oculus. Gear VR is mainly used for entertainment purposes, not that much by industry or processionals. However, some VR applications are also available for professional use (e.g. IrisVR).

Technical set-up and features:

- Price: about 100€
- Cordless: yes
- Controllers: Gear VR controller (simple to use, not fully tracked)
- Movements: head tracking (3DoF)
- Resulution: 1280 x 1440 per eye (theoretical: depending on the mobile phone used)
- Refresh rate: 60Hz
- 64GB onboard storage and MicroHE slot
- Weight 345g

Oculus Go



Oculus Go is a stand-alone Head-Mounted-Display (HMD). This means that there are no PC or mobile phone needed to get into VR. Oculus Go is relatively low-cost (about 280€), but it is still able to provide quite good performance in e.g. terms of refresh rate (75Hz) and resolution (2560 x 1440, meaning 1280 x 1440 per eye). However, there is not 6DoF available, so that movements in VR are still quite limited. Mainly used for entertainment purposes, but there are also some professional apps available, like InsiteVR in architecture and engineering. Outperforms a resolution in Gear VR, and that enables e.g. text-based communication and the use of shared documents and presentations.

Technical set-up and features:

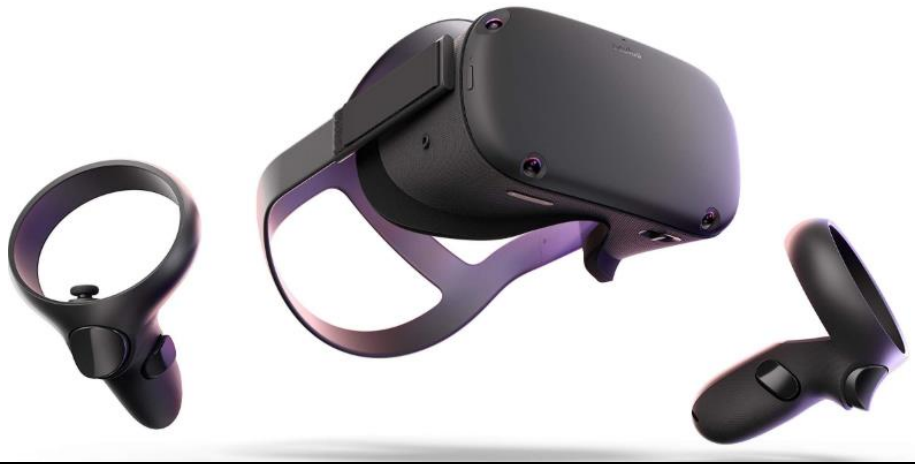
- Price: about 280€
- Cordless: yes
- Controllers: Oculus Go controller (simple to use, not fully tracked)
- Movements: head tracking
- Resulution: 1280 x 1440 per eye
- Refresh rate: 75Hz
- 64GB onboard storage
- Weight 467g

Oculus Quest:

Oculus Quest will (probably) be released during Q2 of 2019. Its tracking (head and positional tracking) is quite similar than Rift's (6DoF) and controllers are also fully tracked. It has better resolution than Oculus Go. It has far better resolution than Oculus Rift, but as it is not backed up by a powerful PC, it is not able to run every software. However, we are expecting this HMD to be an excellent trade-off between usability, price and performance, something that fits between Oculus Rift and Oculus Go.

Technical set-up and features:

- Price: about 400€
- Cordless: yes
- Controllers: Oculus Quest controller (fully tracked)
- Movement space: 6DoF
- Resolution: 1600 x 1440
- Refresh rate: 72Hz (not confirmed)



Main target sector/group for which developed:	Oculus Rift was developed for both entertainment and business purposes. Samsung Gear VR and Oculus Go is targeted mainly for consumer markets (entertainment, cheap, easy to adopt). As a high-quality technological trade-off, Oculus Quest could potentially be a stand-alone headset that is be able to penetrate both consumer and business markets.

SWOT

Strengths

- Oculus: high-quality platform
- Oculus Rift: performance
- Oculus Go/Gear VR: easy to adopt, cheap
- Oculus Quest: performance (?), easy to adopt, cheap

Weaknesses

- Oculus: "walled garden" ecosystem
- Oculus Rift: resolution (no shared screens, presentations, etc.)
- Oculus Go/Gear VR: performance
- Oculus Quest: performance (?)

Opportunities

- Oculus: connects with Facebook (social networking)
- Oculus Rift: the use of high-end VR-software
- Oculus Go/Gear VR: network effect (many people are able to use)
- Oculus Quest: could be the major breakthrough in VR adoption

Threads

- Oculus. connects with Facebook (FB account needed, privacy issues, etc.)
- Oculus Rift: outdated
- Oculus Go/Gear VR: no support provided for 1st gen stand-alone devices in the future (e.g. IrisVR does not have Go support)
- Oculus Quest: is not able to provide what is expected

Summary and evaluation of SWOT with special relevance to the project topic:	Oculus Guest is the most potential HMD for our purposes. Other stand-alone devices (cordless, no PC needed) 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 (mainly used by IT professionals or enthusiasts).
Average purchase costs (status quo 04/2019)	400€
Purchase recommendation: 1=no way; 10= go for it	1 – 2 – 3 – 4 – 5 – 6 – 7 – **8** – 9 – 10 (Oculus Quest) If Leonidas is able to run its software in Oculus Quest, purchase recommendation is 10.
Justification of recommendation:	Oculus Quest is cheap and probably well-performing stand-alone headset that is easy to use.

VIVE	HTC VIVE	
URL:	https://www.vive.com/	
Provider:	HTC and Valve Corporation	
Short description (technical set-up and features, background of development):	HTC VIVE and Valve Corporation runs a platform that is a main competitor for Oculus. The platform (SteamVR) runs on Windows (meaning that PC is most likely required with every HMD that Vive offers in the near future). Even though running via Windows, Vive's headsets are not compatible with Windows MR platform (just like Oculus). (However, Windows MR headsets, like Samsung Odyssey, are able to use SteamVR, but that requires a little bit of work from a user). HTC Vive has many different HMD's available: HTC VIVE, HTC VIVE Pro, Vive Focus Plus (not yet released), 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 SteamVR). Technically, these HMD's are not that different from products from Oculus. The main difference is the platform: SteamVR is maybe more diverse VR ecosystem. There is a wide variety of both entertainment and business applications available, also from indie developers. However, majority of the most used and widely adopted VR applications (especially for business purposes) are available for both platforms (Oculus and Vive).	
Main target sector/group for which developed:	High-end HMD's that require PC: (HTC VIVE, HTC VIVE pro, Vive Pro Eye, Vive Cosmos): business and consumers (VR enthusiasts). Stand-alone HMD's (like Vive Focus Plus): probably for both consumers and business, depending on performance issues	
Summary and evaluation of SWOT with special relevance to the project topic:	The same SWOT-analysis applies here than in case of Oculus: **HMDs that require external PC are out of option**. Due to different technological issues (updating hardware/software, setting up the devices, etc.), they are too expensive and hard to use. Upcoming stand-alone devices are an excellent end-to-end option if they are able to provide enough performance for high quality content and virtual meetings. Vive Focus Plus may be more expensive than Oculus Quest (800€ vs. 500€). However, HTC Vive is not connected to Facebook. This may e.g. increase user trust when it comes to privacy issues.	

Average purchase costs (status quo 01/2019)	800€
Purchase recommendation: 1=no way; 10= go for it	1 – 2 – 3 – 4 – 5 – **6** – 7 – 8 – 9 – 10 (Vive Focus Plus)

3. Methodology of interview section

The aim of this report is to provide a better insight of VR development, use and implementation into the following fields: HE field and SME field.

More particularly, this report aims to:

1. to offer a holistic overview of the state of the art of VR developments as well as their potential for Higher Education and business management teaching and learning, and
2. summarize the most significant and best practices of VR usage in order to propose an innovative curriculum development

3.1. Data Collection

In order to prepare the report, the lead partner prepared a set of tools and templates, which all partners implemented in their country. Interviews help us to get a clear picture about state of the art in the field of VR developments as well as about frameworks, demands, needs, experiences, attitudes and mindsets within HEIs and SMEs with regards to applying VR solutions. All the interviews were conducted after the permission of the participants. All the interviews have been recorded and transcribed. In all the interviews, the consortium followed the guidelines and the interview protocol with the list of questions. The needs analysis was conducted in each of the countries as follows:

1. **Cyprus**
   The Cyprus team has conducted three interviews with HE managers - teachers and five interviews with SME managers and education experts. Specifically, in the interview process were involved three people from the HE field, two professors and one post-doctoral researcher. All three participants (male) have extensive experience in VR research with publications in high impact journals and have experience in teaching VR in the HE field. In SME interviews were involved five people (three female, two male, age group: 28 – 35). Two participants with a background in Computer Science are working in the Higher education field as Post-doctoral researchers. Two participants with a background in Education are working as managers and consultants in educational organizations related to teachers' professional development. One participant with a background in Architecture and Business Management works as a manager in Architecture Company. All five participants use VR tools/applications/devices in their organizations for training and management. Each interview lasted on average no longer than 25 minutes in total.

2. **Finland**
   The finish team interviewed 13 persons in total (3 experts for Survey 1, 3 HE staff for Survey 2, 7 SME/large company staff for Survey 3). Nine of these interviews occurred at Tampere, two of them were at Helsinki. The duration of interviews were approximately 30-40 minutes. The interviews were also tape recorded to help with the analysis. All of the interviews were held in Finnish.

3. **Belgium**

   In Belgium have been interviewed 11 people in total. Three VR experts for Survey 1 (VR application development company and Marketing Manager Business Development), three HE staff for Survey 2 and five SME staff for Survey 3 (one internship student, one Marketing Manager, two Business Developer Managers and one Marketing Manager Business Development. The duration of interviews varies starting from 20 minutes to 60 minutes.

4. **Spain**

   Federación Vizcaína de Empresas del Metal, under the scope of VRinSight project, conducted a questionnaire to manufacturing SMEs in the Metal Sector. CEOs, owners, RH and training managers, production managers and other professional profiles were reached in the Spanish region of Biscay with the aim to know the status, barriers, opportunities and needs of Virtual Reality technology in the manufacturing sector: Metallurgical industries and first transformation, metallic products, machinery and equipment, electronic and electric materials, transport materials, commerce services and metal installations, die industries.

   The general objective as well is to understand the participants who were selected, with anonymous info on their background and working context. 26 SMEs, 3 HEIs and 1 VR experts were interviewed trough an online questionnaire.

5. **Germany**

   Germany has conducted eight interviews, three interviews in HE field and five interviews in SME field. To start with, in HE field were involved one scientific researcher, one VR Professor and one Industrial Engineering Professor. The first interviewed professor is heavily involved in research to integrate VR/AR technology into this area. The second interviewee leads a university course in VR-technology and has extensive experience in training VR/AR in a university setting and with private businesses. The final interviewee is a researcher and lecturer in the aerospace technology department of a large university, doing extensive work on how AR can be integrated into the display units of Airplane Cockpits and how pilots can be trained adequality to use the technology. In SME field, were involved two CEO of research consultancy company, two people from AR/VR Start-up and one Software Engineer Data.

   Amongst the interview partners were all largely companies who are beginning to look at VR/AR as a possible tool to expand their business and have begun their first ventures into the area. All SME participants were able to give us key insights into how both large and small firms will be offered such services in the near future, as the companies to trying to understand and meet the needs of SMEs all over Europe.

6. **Austria**

   In Austria were involved 11 people in the interview process. Particularly, the Austrian team has conducted three interviews with VR experts for survey 1, three interviews with HE staff for survey 2 and five interviews with SME staff (all interview partner are manager/managing partner of small SMEs) for survey 3. All interviews were performed on telephone, with an average duration of 30 minutes, varying between 15 and 60 minutes. Five SME staff and three HE staff were interviewed, contacted with request for interview way more. Many people who were contacted for interviews refused to participate, because they had nothing to do with VR and only an abstract understanding of this technology.

3.2. Data Analysis

Each partner (Cyprus - Finland - Belgium – Spain - Germany - Austria) analyzed and prepared a report. Then UNIC- Cyprus took all reports and prepared the cumulative one. The aim was to identify key common themes, as well as possible major differences.

As all the partners agree, there are many VR cases in HE teaching and research, mainly a lot of research labs under Higher Education institutions focusing on academic research and highlighting the benefits of using VR in educational field. On the other hand, there are several companies focused on VR/AR technology, specifically start-ups working on the development of VR solutions as well as several VR Centers focusing on gaming and entertainment. Most VR applications can be found in industry/manufacturing (health care, real estate, architecture, tourism, business, etc.). Also, the key technologies in the area of VR are Oculus Rift, Oculus Go, Google Expeditions, Cave, Lenovo Explorer, Google glasses, Cardboards and some other standalone VR devices.

According to the partners' reports, VR creates new paths for teaching and learning but it has not established itself as teaching instrument so far. However, VR is developed intensively in HE institutions, is being used in Professional training because it increases staff engagement, in e-commerce, in virtual meetings and conferences, in experiencing big things and new products as it creates an immersive and interactive experiences. Moreover, many companies and organizations already have a virtual company tour, as VR gives a full and detailed view of the place (spatial sense). Despite the growth of VR usage in business and education, all agree that more work has to be done in terms of accessibility of VR/AR.

Below we present the findings of each country regarding the HE and SME field.

4. Findings

The findings are classified under 2 main categories: Findings regarding 1) Higher Education and 2) findings as they relate to SMEs, per country. Also, in each main category per country the findings are divided as follows:

- Current status and examples of use,
- Challenges and barriers,
- Opportunities,
- Training needs

4.1. Higher Education

4.1.1. Current status and examples of use

Cyprus

Over the last years, there are many initiatives related to VR development and implementation, specifically in the Higher education field. Particularly, in Cyprus, 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.

Over the last decades, VR solutions and applications have been implemented effectively in educational settings. Based on the results, the Virtual technologies have the potential of making students feeling more committed and motivated, and argued that these technologies open new paths for teaching and learning. In the same way, students also have a positive attitude towards using VR in their learning process.

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). Also VR tools/devices is being combined with motion-based technologies in the context of embodied learning environments.

Finland

There is a stream of academic research highlighting the benefits of using VR in education. 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. However, there is interest towards implementing VR technology in education in the future, but that may require high quality social VR applications and/or high-quality educational content that would be, at least partly, scalable and user generated. Maybe the most promising way to combine VR and higher education (HE) could be, for example, the field of construction /architecture or engineering, as there is already existing 3D content that could be used in VR. Otherwise, HE institutions could have a significant impact on raising general awareness of VR technology, and by this it would surely help to remove some toughest barriers in VR adoption such as the knowledge of what VR is and

how it could be implemented to solve different problems in a world that is getting more and more complex.

Belgium

In Belgium there are a lot of 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, look around inside the body of a little fish,
- Pain reduction: patients with fire injuries not only get classic anaesthesia and pain relief during a surgical procedure. If they wish, they also get a VR headset with images that distract them from the pain and discomfort. Patients testify that it really helps them.

Furthermore, in the professional bachelor Teacher training, Google expeditions is used (with around 800 expeditions available). They also have made a 360-video recording of a demo lesson for which they used a 360 camera for the first time. 360 video allows to confront students during teacher training classes with virtual annoying situations/events/problems in a classroom and is an easy tool to learn to react on such situations. 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. VR can also have a sensitizing property: a student who annoys other students would experience in a virtual plague scenario how it feels to be annoyed. This may have a positive impact on his own future behaviour. VR can also be used to explain how an autistic person thinks. There are other examples related to social interactions such as speaking in front of a virtual audience, red cross helpers pass for a first aid course but in a panic situation they forget almost everything they have learned. A critical bloody situation can be simulated with VR.

Last, PlayItSafe (https://playitsafe.eu) created an online game-based learning platform for autonomous learning about following topics: fire prevention, first aid, ergonomics, general safety, psycho social and hygiene. People can perform the training anywhere in the world, at any time and on multiple devices (smartphone, tablet, computer).

Spain

The use of Virtual Reality in Spain is being driven by central and regional policies related to the implementation of RIS3 policies and Industry 4.0. Below we provide examples:

- Spain (Country): Spanish Ministry of Industry, commerce and tourism – INDUSTRIA CONECTADA 4.0.
- Catalunya (Regional): ACCIÓ - Agència per la Competitivitat de l' Empresa. - Indústria 4.0.
- Madrid (Regional): Comunidad de Madrid – Industria 4.0
- Basque Country (Regional): SPRI - Sociedad para la Transformación Competitiva – Basque Industria 4.0

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 advanced manufacturing strategy is a priority area of the Smart Specialization Strategy RIS3 Euskadi. Its implementation is carried out through public-private cooperation led by the Steering Group. Integration of KETs - to promote multi-disciplinary and technological convergence in a structured way so as to develop best-in-class manufacturing capacities and solutions while optimizing existing resources.

Technological priorities for the region: The commitment to technological development in advanced manufacturing is crucial to maintain the competitiveness of the industry and to ensure positioning in market niches with greater added value. In this case, apart from other priorities - Digital Connected Factories:

- Virtual Factory (Virtual Reality)
- Predictive maintenance systems
- Integrated inspection' measurement
- Unitary level traceability
- Real-time data services

Germany

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. This usually takes the form of dedicated departmental teams with a particular focus on VR/AR technology development. A VR/AR lab is common place, where all hardware is available for research purposes but all for courses being provided to students. An example in University of applied Science, in Bielefeld, as well as Technical University Dresden having invested in CAVE technology. 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.

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. VR applications at academic institutions are, aside from research and development, not known to the interview partner from HEIs. Although one was not sure about the use of VR at medical colleges, like midwife education. Their excitement for using VR in teaching was diverse. While one has a strong interest in using VR in teaching, another couldn't think of a possible application in education beside virtual meetings in the near future.

Like VR, e-commerce is an upcoming topic, that's getting more and more attention. So, colleges and universities address this special field with their research. One interview partner is involved in

performing experimental studies about VR in product presentation in e-commerce, especially how companies should advertise their products in VR shops.

4.1.2. Challenges – Barriers

Cyprus

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:

- The high cost of almost all VR technologies/devices
- VR implementation requires space to move around to make use of motion tracking
- It is complicated to set up
- It is not suitable for people who don't have some knowledge and experience with VR
- Feeling of worthlessness
- Impractical in terms of portability
- Functionality issues
- Lack of flexibility
- It provides limited opportunities for collaboration
- Lack of digital skills

Finland

Interviews revealed that barriers to adopting VR technology related to both technological and human factors. VR technology has not been fully matured yet: too big, too expensive, too difficult to use. University staff and faculty do not have the capabilities to use VR: they do not know how to use it, or why to use it.

VR is a tool for many different use cases, but content creation was still a serious bottleneck. There is not much content available to justify all of the expenses that relate to investing in VR hardware (that is still quite clumsy and difficult to use). HE institutions did not have a way to scale up content creation by themselves. Therefore, scaling up the use of VR was seen difficult at this point. Interviewees did not see any shortcuts to tackle the problems that relate to human factors. It was seen essential that HE staff and faculty simply start to use VR and experiment with it. At this point, VR was seen to be used as a part of online learning / courses, especially in context when there are existing 3D-models available that could be used as content (engineering, architecture, etc.).

Belgium

Based on the results, some barriers include:

- There is a need for a computer with a very performant graphic processor (computer + head mounted display: around €2500).
- It would be fantastic if it would be possible to generate component drawings from a 3D surface point model (generated with a Leika laser scanner) with limited input from an engineer.
- Management have to be aware of the possibilities and restrictions of VR at this moment. They have to know something about the process of making different VR applications just to have an impression of the amount of work and the associated costs. They should also follow the evolutions in VR technology and software in order to predict that some new VR applications will become affordable in the near future.
- In the future, it will be possible to display additional information not on the screen of AR glasses but directly on an implanted lens. Recently, some Chinese and South-Korean companies obtained patents concerning this concept.
- A VR application in which the teacher can determine the scenario in real time and in which he/she can generate events.

Spain

According to the responses in the online survey, the barriers in VR adoption are:

- The lack of knowledge about the real potential of VR
- The high investment and content costs
- Clients before SMEs implementation

Germany

The great challenge currently sited by the HEIs, was the lack of operational dependently of VR/AR technology in its current state. When beginning with this technology it is often easy to integrate it initially into a classroom setting and give students an overview of the possibilities. However as soon as the complexity level of what is being demonstrated increasing, then the operational stability can begin to decrease. Often there are technical problems (for example overheating of hardware), that cannot be quickly or easily solved, and in a classroom situation this is often disastrous for a teacher trying to maintain participating attention and motivation.

Austria

Austrian participants claim that the barriers/ challenges are:

- Technical boundaries: Technical aspects were often mentioned as boundaries for VR application, but most of them won't be a problem in the near future. Either products missing those negative aspects are released soon, or companies are developing solutions at the moment. The actual technical barriers named were weight of glasses, cables and extra sensors needed, computing power necessary, immobility 2, data transfer/bandwidth.
- Investment costs: When it comes to VR, the costs are the sticking point. It was either the main obstacle to overcome in the decision making process or hindrance in even considering a VR solution.
- Personal boundaries: Some people (one estimated 2%) have a very deep aversion towards VR and won't put on VR glasses, no matter what. Some refuse because of fear, others would feel embarrassed when they see how others move with the VR glasses on, some have a general reservation towards VR and quite a few claim they will feel dizzy, although studies show, that that's not going to happen.
- Availability of devices: To use VR in teaching, students and teachers also need to fulfil the technical requirements and have VR devices at hand. They feel certain to use VR in teaching, as soon as it becomes state of the art in teaching and is widely-used from students.
- Know-how: People, including students and teachers, lack the know-how necessary, to understand why VR is important and which opportunities it can bring. Actual examples of use in education, which are missing until now, could enhance the interest in VR, while also showing the possibilities of VR.

4.1.3. Opportunities

Cyprus

All participants, HEs and SMEs, 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:

- Users can immerse in an unknown world
- VR gives a full and detailed view of the place
- VR tools allow widest range of application

- 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.
- Learning gains

Finland

However, each of our interviewees saw the potential of VR, for example, in context of:

- Remote teaching (e.g. immersive 180-degree lecture videos)
- Collaborative learning (social VR)
- Learning by doing (skill-based learning, e.g. medicine, engineering)
- Simulations (machinery, physics, etc.)
- Demonstrations, visualisations
- Gamification (e.g. World War II at Tampere University)

Belgium

In Belgium, the VR trends and solutions are developed by many global companies and by many HE institutions, offering a lot of opportunities for VR usage in many sectors.

- 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 is at this moment the only technology that creates a immersive experience and so it leads to applications to overcome fear of height, fear of bees, claustrophobia,… and applications to create awareness about driving a bike while being drunk, about living in a family with domestic violence,…
- A virtual company tour allows to disapprove the prejudice that your company belongs to a sector with old and dirty plants.
- Instead of inviting clients to the company and organizing a guided tour on the (noisy, dusty, slippery, fumy, foggy,…) factory floor, you can bring the company to the clients with a 360 photo or video and, in the long run, you save a lot of time and money.
- VR allows to communicate efficiently about installation issues and to measure distances without having to go out and climb onto the installation.
- 3D model of brains allows the surgeon to prepare the surgery process virtually in order to reduce the duration of the physical process.
- VR has the potential to immerse people in a virtual but realistic environment in which they are confronted with an 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.

Spain

In Spain, there are some initiatives and opportunities regarding the use of VR, mainly focus on the following sectors:

- VR for training purposes
- Maintenance
- Production
- Sales/ marketing

Germany

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.

There was also commonality amongst the interviewees that more work has to be done in terms of accessibility of VR/AR, particularly for HEI Staff who have a limited technical experience and "not so good" programmers with better user interfaces. Only when easy to use, and user-friendly applications are developed and marketed, will the potential of VR/AR be realised and its acceptance be widespread. Although it was sited that programming is not absolutely necessary as a gateway to integrating VR/AR into a HEI setting, it is very helpful if one wants to understand what is and what is not possible with the technology. Far more important, was sited, an openness to technology and a necessity to abandon previous impressions of VR/AR technology in order for the person to really benefit from the full extent of the technology and how it can be integrated into education. This was sighted as a typical stumbling block, as it often let to an imaginative blockage on the practical implementation and application of the technology when original expectations and impressions of the technology were not initially realised.

The Technical University in Chemnitz currently use VR /AR technology in the process of new product development and the virtual analysis of product evaluation. Although this virtual method is less comprehensive then product evaluation, it is less cost intense and has the potential to deliver quick and often in-depth analysis.

Austria

At the same line, Austria has invested a lot on VR usage promoting the advantages of virtual opportunities in many aspects of life.

- Walkable architectural models
- Showing big products at exhibitions (e.g. wind turbine) to "walk through time" in museums
- Simulations of maintenance jobs in industry or training for jobs in dangerous environment
- All types of training scenarios
- Virtual conversational partner when AI develops further

- Training for repetitive task (assembly-line work) so new employee starts at line when his training is finished and doesn't slow down production
- VR in planning (construction industry): mixed reality at the construction site. Building site is overlaid by further information (e.g. where the pipes, electrical installation etc.)
- Indoor navigation for new staff
- Car assembly where QM list in glasses is ticked off with hand gestures.

Also, based on the findings in Austria, there are further potential future applications:

- Virtual meetings/conferences: Meeting other people such as co-workers, professors, co-operation partner, experts, students, in a virtual environment gives several opportunities. Beside meetings, lecture given from a virtual visiting experts/professors in own lecture hall trough AR glasses, visiting companies and examining processes in companies are imaginable.
- E-commerce: VR has already been successfully tested in e-commerce and research is focused on this promising application. There is still a lot to investigate, to use all the potential there. VR could give the possibility to test interpersonal behaviour, especially the distinct conscious and unconscious behaviour of different nationalities in e-commerce.
- Humanized VR: One interview partner wished for VR to become more humanized, not only attending industrial and economical needs, but also social needs. He would like to see someone like the deceased "Stephan Hawking leaving his wheelchair and flying around". Making it possible for immobile persons to move, interact and experience again trough VR.
- Plug-and-Play-VR: Easy alteration of the VR content, and direct transformation from computer screen to virtual scene.

4.1.4. Training needs

Cyprus

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

Finland

In the future, VR was seen as a unique computing platform, both in terms of social interaction and human-computer interaction (HCI). HCI with multiple senses and input methods (touch, smell, speech, etc.) was already studied intensively at Tampere University. When technology develops further, it becomes also possible to use it for a longer period, with more people, more casually and routinely as a part of a daily work. However, VR does not suit for everything and, therefore it is critical to study it more. The effects that relate to using VR technology are often underestimated (immersion, etc.). Accordingly, there may be some psychological barriers as well, which we do not yet know much about. However, at first, faculty/staff/students of HE institutions need to learn the basics of VR technology.

Belgium

In Belgium, findings indicate that the training needs regarding VR usage for users in educational sector and also in companies are:

- Knowledge about complex software like Unity or Unreal is not relevant for teaching and would take too much time for a teacher to learn it. If they only have to use VR applications, no specific VR-related skills and competences are needed. The use of a VR application is as easy as reading a book. If training is necessary, it will be limited to an explanation how to use the technology, how to launch the application and how to stop it.
- What teachers need most, is help with the scenario of their VR-idea. Afterwards, the technical implementation is mainly a job for VR developers.

Spain

From HEIs side, there is an economic boundary for using VR, however, they implemented some trainings for using industrial machinery due to for some applications it´s affordable instead of buying the real equipment (CNC machines, welding etc.). The respondents consider that teachers would need to integrate some transversal skills/attitudes for the integration of VR in their teaching as openminded to new technology and new ways of teaching through ITCs, desire to change, be restless….and they have no plans to implement VR solutions in the sort term. The respondent would like to know what short of tools, methodologies, materials and program languages the market offers for training. What is more, when VR develops further, respondents would be interested in standardised industrial knowledge sharing libraries for training and virtual classrooms where pupils and teacher can interact.

Germany

There was also commonality amongst the interviewees that more work has to be done in terms of accessibility of VR/AR, particularly for HEI Staff who have a limited technical experience and "not so good" programmers with better user interfaces. Only when easy to use, and user-friendly applications are developed and marketed, will the potential of VR/AR be realised and its acceptance be widespread. Although it was sited that programming is not absolutely necessary as a gateway to integrating VR/AR into a HEI setting, it is very helpful if one wants to understand what is and what is not possible with the technology. Far more important, was sited, an openness to technology and a necessity to abandon previous impressions of VR/AR technology in order for the person to really benefit from the full extent of the technology and how it can be integrated into education. This was cited as a typical stumbling block, as it often let to an imaginative blockage on the practical implementation and application of the technology when original expectations and impressions of the technology were not initially realised.

On the side of HEI course participants, the survey suggested that no real previous VR/AR experience is required on their part, in order for the participation to be successful. There are on the other skills that are very helpful such as psychological skills. The practical use of the VR/AR technology in often demands that participants must surrender a certain amount of self-control and allow themselves to immerse in the technology (particularly in VR cases), as this technology demands a lot of physical interaction. The practical use often occurs in group settings, so a certain amount of group trust has to be developed, as well as trust in the course teacher to guide the participants through a VR setting. Furthermore, there is the necessity to reduce the complexity of the tools used in VR/AR, particularly on the headsets. A complete streamlining of the headsets, including reduction in weight and improved usability will need to be focused upon if VR/AR technology is to be widely accepted an integrated in to the work of HEI staff and in learning situations.

Austria

All interview partners agree upon a few things when it comes to training needs:

- In general, they expect training needs for applying VR very high and intensive, due to unique applications.
- In such a fast-moving sector like VR, continuous education is of importance, to avoid being outdated and miss new applications.
- A good set of technicians should come along with VR to adjust the virtual content and to deal with problems.

When asking for teachers' requirements, the right mindset was the first thing that came up. Teachers who aim for integrating VR in their teaching, should be open minded for this technology and all the possibilities it offers. Further an interest in technology in general and being ready to learn from students - who already are for the most part digital natives – were mentioned. Basic technical skills, like understanding VR in principle and a safe handling of soft- and hardware, are characteristics teachers should have.

The requirements for staff simply using VR are similar. Knowing what VR is about and where the current boundaries (AR vs. VR, technical barriers) are, leads to an understanding why you should use it. A virtual environment has different laws inherent, what makes it important to adapt ones behaviour and didactic approach to it, so that virtual events are of value for all participants.

4.2. SME field

4.2.1. Current status and examples of use

Cyprus

In SME field participants discuss the following examples:

- VR technologies in business and training
- VR in architecture: experience of being immersed in future houses/spaces and help clients to decide for materials and understand how the space will looks like in terms of design
- The use of VR in promotion of a new product or service: realistic experience to clients, see their reactions and feedback to meet the needs of my clients and maximize my profits but also release a product or service that has a meaning to people
- Professional training: allow staff to attend virtually in different types of technology use in an easy way.
- In management: a future vision of the organization and see how we would like to evolve our organization
- One initiative in the business sector is the use of VR devices in architecture and real estate. One architectural company, situated in Larnaca-Cyprus, uses 3D models and VR tools that turn their architectural designs into reality. This is only a part of the services that this company provide to clients.
- 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.

Finland

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. Different social VR applications (i.e. multi-user VR with avatar-based interactions) had started to appear in the Finnish landscape during the year 2018. 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. All of these companies interviewed were familiar with different VR platforms (e.g. Oculus, Vive, Windows MR). There were diverse set of business build around VR. Some companies delivered content and build applications for industrial use; some were consulting industry in use and implementation of VR, and so on.

Belgium

VR in SMEs developing solutions using VR. Examples include:

- Nanopixel, https://www.nanopixel3d.com/, Roeselaere (Belgium)
- Viu More (only AR applications), https://www.viumore.com/, Merelbeke (Belgium)
- In The Pocket, https://inthepocket.com/ , Ghent (Belgium)
- Yondr, https://yondr.agency/, Beveren (Belgium), New York, Ibiza
- OneBonsai, https://onebonsai.com/#virtual-reality-development, Zaventem (Belgium)
- Many companies/organisations/shops/parcs/… already have a virtual company tour
- Experts at PipeXperts already have 15 years of expertise creating a 3D model of a (petro)chemical/pharmaceutical/food processing/… installation using a Leica laser
- scanner. Naviswork software allows to walk around in the 3D space using a VR headset.
- Game parcs: see document < Links to VR game parcs_Belgium.docx >
- Construction company Willemen: project 'Step into your future': A VR-application integrated in a safety helmed allows job candidates to experience their future work environment.
- Poppr: "All companies can benefit from VR, especially from 360° virtual tours. Center Parcs, property of the French group Pierre et Vacances, is one of our main clients. They are convinced about the massive impact of VR. They rapidly understood that authenticity, qualitative content and a well thought strategy directly lead to higher sales. 330% higher!
- 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 to foresee safety issues and prepare safety measures.

Spain

Find below a list of VR initiatives for SMEs:

- VirtualTriage. An innovative tool aimed at all emergency personnel who may intervene in multiple-victim situations (paramedics, ambulance workers, firefighters, armed forces, police, etc). It is an effective and a validated training method for the classification of the injured in an accident.
- VirtualRet. The first Virtual Reality platform aimed at all personnel involved in the Mental Health sector such as psychologists and psychiatrists. VirtualRet was designed specifically for the evaluation and treatment most common anxiety disorders.
- Tevrene. 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. You can feel the adventure through the stars and the vast space! Also works in panoramic mode without VR headset. It works with any mobile stereoscopic headset, Cardboard, Daydream and compatibles.
- Prevention of falling from heights simulator. The simulation provides a safe environment in the decision-making process when those risks had to be dealt with and also to design the working system, identify means of safe access or using personal protection equipment.

- Risk Prevention. Virtual training system for industry staff providing identification and decision-making processes related to occupational risk scenarios.
- Prevention of Occupational Risks Simulator. Customized simulation of the truck manufacturing Plant of Group Iturri. This way, the operator are able to interact with the manufacturing plant, where the fire trucks' assembly are carried out.
- Forklift VR Simulator. This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein. The forklift simulator recreates different stages with didactic content to learn and improve the skills needed to drive and handle freights with the forklift. This simulator enables learners to work with the machinery the same way as they were in their workplace. Therefore, the behaviour of the forklift has been recreated in a completely realistic way.

Germany

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. Interestingly the gains will not be made in VR hardware but approx. €700million of the 1 billion in revenue will generated in Content-Production. The potential growth estimates in the German market for VR/AR vary source to source, all agreed that the majority of the growth will come from Content-production & solutions. Current usage in Germany is numbered at approx. 2.5 million users, and this is set to rise to 8,6 million in 2020. This trend is also reflected in the uptake of VR technology into German business and industry at the SME level. 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.

The Company Big Data in Berlin currently provides VR/AR technology service to a large Aerospace company. The technology is used in training and upskilling of staff in a virtual setting, and staff can acquire the technical skills before they move to the shop floor. The technology provides a Models of Turbine engines which can be built, repaired and maintained virtually by learners.

Austria

Bigger companies take advantage of the fact, that you can copy reality and re-enact scenes in a virtual environment. This way training of emergency and stressful situations, operational procedures in hazardous environments, operations without negative effects for ongoing production and such is possible:

- 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 don't 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. But it has to be said, that the SMEs interviewed are relatively small with little staff. Most of the interview partner could hardly think of VR applications in business management. More than one recommended VR utilization for training staff, in bigger companies, to easily train more people, in less time.
- Virtual meetings and working collaborative in VR: VR is a known tool for virtual meetings. It allows you, for example, to have meetings about ongoing projects with customers. Such virtual meetings are extended conference calls, with problems similar to those of telephone conferences. It's likely that the participants start talking at the same time, what makes a tutor (comparable to a teacher in a classroom) necessary. In VR this can be solved with the distribution of rights, a set of virtual meeting rules and most important a moderator for the meeting. 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.
- Elevator Pitch: The VR market is developing quickly, so new devices are released continuously. One manager buys new products and lets his employees experiment and toy with them, so they generate ideas and new application approaches in that process. The manager requires then an elevator pitch presentation, if and how an application is possible and where the development might go. This way he gets new ideas for future applications. "People need to try it themselves to see what is/what might be possible."
- Experiencing big things: 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. Potential customers can walk and experience a power plant, what wouldn't be possible without VR. The same presentation was used for giving new staff members a first impression about what the company does and the product

4.2.2. Challenges – Barriers

Cyprus

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:

- The high cost of almost all VR technologies/devices
- VR implementation requires space to move around to make use of motion tracking
- it is complicated to set up
- It is not suitable for people who don't have some knowledge and experience with VR
- Lack of flexibility
- It provides limited opportunities for collaboration
- Lack of digital skills

Finland

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. This is one of the biggest bottlenecks of using VR at large scale: there is no network effect. Major barrier to VR adoption was also a simple fact that (especially older) employees have not used VR before. For example, controllers that are used to interact and navigate in VR are too complex for intuitive use. Tackling this issue would require a lot of time for educating employees. On the other hand, simpler user interface for VR could also help (like current stand-alone devices with simpler controllers). There was no VR related education provided in this company, but the company hired this interviewee specifically because of his existing VR competence. Making VR as a work related routine requires still a lot of work. With this, hiring individuals with sufficient VR competence is crucial. This would, eventually, improve organizational capabilities, effectiveness and, in turn, relational competitiveness as well.

Belgium

Findings from Belgium have revealed some important challenges and barriers, such as:

- In many cases, companies don't know the potential of VR, they have no idea how long a VR application development will take and they expect VR applications to be very expensive.
- 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.
- Another boundary is the long payback time of certain VR investments.
- The lack of a vision to transform to a digitalized company.
- Teachers let us know that if they would have more time, they would be interested in developing a VR application for their course.

Spain

In Spain, challenges/barriers regarding the use of VR are summarized as follows:

- The lack of knowledge about the real potential of VR
- High investment and content costs
- Clients before SMEs implementation

Germany

From most companies involved with VR/AR there was common ground on where improvements could be made in future. Mostly the lack of integration with other systems and interfaces was the biggest stumbling block for companies, and the inability to import/export data conveniently and connect to or create new libraries of data so content in a VR environment can be adjusted or altered quickly and conveniently such as “drag & drop function” when creating VR scenarios. There is need for an easy interface to create animations. Like MS Powerpoint with extract to VR”. Companies also sighted a necessity for connectivity to business information systems for analysing data with companies and corporations as a constraint to be overcome.

Austria

Training needs in Austria, according to the analysis of Austrian surveys, include among others:

- Technical boundaries
- Investment costs
- Personal boundaries
- Availability of devices: To use VR in teaching, students and teachers also need to fulfil the technical requirements and have VR devices at hand. They feel certain to use VR in teaching, as soon as it becomes state of the art in teaching and is widely-used from students.
- Know-how

4.2.3. Opportunities

Cyprus

According to Cypriots’ surveys, VR usage in HE field creates a lot of opportunities.

- Users can immerse in an unknown world
- VR gives a full and detailed view of the place
- VR tools allow widest range of application
- It provides outstanding visualizations that aren’t possible in the traditional classroom
- Users have awesome experiences
- With VR the experience is more interactive as the users can fell the experiences with their senses
- It promotes self-guided exploration and independent practice – autonomy learning
- It creates interest in learning

Finland

However, it was clear that availability and usability of different VR solutions has improved significantly in past couple of years. For example, Oculus Go was a major milestone in this development. It was the first product that was able to provide cordless and cheap VR experience for the masses. Almost every interviewee saw that 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. Many interviewee saw that 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. Shared 3D-models could act as "living documents" in different construction projects, reducing the amount of confused communication in other channels (e.g. email, chats). Another important aspect of using VR was in visualising something that is 3D and/or otherwise complex.

Belgium

In Belgium, opportunities regarding VR in different sectors include:

- More performant hardware: faster (graphics) processors for more lifelike natural graphics, stable 5G wireless connection speed, wider view
- More mobile (wireless, lighter, longer battery life, plug and play)
- Lower costs for hardware and software: further development of free open source collaborative software
- Shorter development time (better GUI, faster rendering, better contextual menus, more (freely) available 3D libraries,…)
- More integrated software (e.g. Unreal + Unity; at this moment, Unreal cannot be used for online development).
- An important benefit would be the ability to render graphics in the cloud at high speed.
- Specialists in companies will be able to develop VR applications themselves when software becomes more intuitive and cheaper and packed with predefined shapes/volumes/textures.
- There are lots of opportunities in machine design and machine training, safety procedures, start-up procedures, shut-down procedures, … for a fraction of the cost of physical (face-to-face) training.

Spain

In line with previous countries, results from Spain, indicate that the use of VR offers a variety of possibilities such as:

- 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.
- It would allow to manage the production lines of the companies, allowing to introduce new variables and being able to observe the effect of these variables in a virtual environment, before transferring it to reality. In this way, the most appropriate actions could be adopted in each case, anticipating and reducing the risk of a negative impact on production.

Germany

For companies providing a VR/AR service or application, many made their business in two key areas. Firstly, marketing is an area with huge development potential, as the VR/AR can potentially deliver a very interactive experience for product customers and consumers. The second current field is in industry and manufacturing, with the integration of VR/AR into areas such as vocational training, on

the job training, and induction of new employees. These companies also see further development in engineering design and product evaluation, however again these potentials can only be realized when current constraints are overcome by further linking the compatibility of VR/AR technology with existing 3D CAD programs and software to allow for convenient transfer of data.

Austria

In Austria, according to surveys' results, opportunities in VR area are unlimited. Some opportunities include:

- Spatial sense: VR is a tool that solves the problem of spatial sense. For example it's hard imagining proportions when looking at a 2D plan of a house. But walking through a house, that's has not been built gives you an impressive spatial experience.
- Marketing – unique selling point: VR is a trend topic and attracts customers. Some said, using VR e.g. for product presentation is a unique selling point and helps acquiring customers. With VR you can reach for people and get their awareness for the company and the product.
- Solving problems: SMEs said, that they use VR because it solved problems they had. "What do I want? What's hindering me in real life? How can I use VR to do, what's not possible in real life?"
- Immersion: Immersion was recurring when talking to SME managers using VR. 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, what wouldn't be possible in real life. Often it is very helpful to re-enact things or scenes, and replay those.
- Knowledge transfer: VR gives you the possibility to communicate special knowledge to other people in a seemingly real situation.
- Interdisciplinary use in Education

4.2.4. Training needs

Cyprus

Training needs for VR, based on the findings from Cyprus, are:

- Basic technical and digital skills
- Expertise in handling different type of technologies
- Adaptability
- Creativity
- Willingness to learn new things
- Openness

Finland

Most of the technology companies that we interviewed worked closely with the VR and, therefore, training their staff was a critical part of their work. They either sell VR software or consult other companies in the use of VR. However, industry seemed to have "clusters of VR enthusiasts" instead of organized, large-scale VR training. 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.

Interviews indicate that 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).

Many technological barriers including resolution (low resolution does not enable, for example, text-based interaction in VR), low refresh rate, motion sickness, etc. was expected to be eliminated in the near future. Resolution and refresh rate is getting better rapidly, cost of high quality HMDs is going down and high quality content with many different options for navigation eliminate most of the issues with motion sickness.

Belgium

The Findings from Belgium regarding the training needs focus on the specific training needs for developers. These needs include:

- If the development of VR-applications is part of their job, all VR expertise is welcome and in that case companies are looking for people especially with knowledge and expertise concerning the use of Unity, .net, C and Java. On top of these skills they have to understand the 'why' of the application. What's the purpose of the application? In bigger companies there will be a business analyst to answer this question. We need people that can find out the ideal solution for the clients problems or wishes.

- When applicants attained a bachelor in Digital Arts and Entertainment or a similar degree, selection is not based on VR software skills. The ideal candidate should be able to think out-of-the-box.
- Enthusiasm, flexible attitude and creative problem solving
- Diplomas are not so important. Practical competences are useful, like: have they previously worked for a technology company, for a start-up? have they experience with 3D? project management? Of course, experience with the use of Blender, Unity and other VR software is a lead. Empathy concerning the effect on the user of the immersive aspect of a VR application is a plus but, in fact, the project owner should have this competence.
- ICT skills and programming knowledge motivation, determination, vibe, enthusiasm and the belief that the application represents an added value for teaching. This last one is more important than all technical competences. If this belief is not strong enough, motivation will be low and the development will stop as soon as there is a minor technical problem.
- Empathy, understanding customer needs, awareness of the impact of the immersive experience on the student (too much excitement can provoke epilepsy), awareness of the impact of the VR application on the learning process.
- Spatial awareness, creativity to create scripts, attention for spatial sound, industrial design, 3D insight.

Spain

More than 65% respondents (SMEs) mentioned they need an overall training to know the benefits, tools, ways of use and implementation of the technology. In many cases, they don´t have any idea about what specific needs/trainings are required, and obviously, most of them are not implementing any kind of training activity in the field. Just in 2 cases, SMEs are already doing VR piloting activities to measure the potential of the technology, implemented by the IT department (automotive and cooling sectors). Below can be found some other comments mentioned about training needs:

- Use and development of this kind of “machines” by senior workers.
- Would be useful to do an application and viability study.
- Creation of virtual spaces and PLC´s programming.
- 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.
- When hiring we do not ask for VR competences.

The 8% of respondents consider training the staff in the following fields:

- 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.
- Keep on doing training activities both skills related and training in the production line

Germany

SMEs stressed that for companies to embrace VR/AR, it needs to become more than just a display/presentation tool or a and needs to develop into practical tool for real problem solving. And for this to happen, it needs the ability to integrate with existing business systems. From most companies involved with VR/AR there was common ground on where improvements could be made in future. There is need for an easy interface to create animations. Like MS Powerpoint with extract to VR". Companies also sighted a necessity for connectivity to business information systems for analysing data with companies and corporations as a constraint to be overcome.

Austria

SMEs working with VR see the staff training needs for applying VR solutions quite low, saying that "applying VR is no rocket science" and very intuitive. For most of the SMEs contacted, it's training-on the job, due to the small teams or expertise in the field. In general they see that it is important to be open-minded, curious, trying new things, being excited, and not to be afraid of technical devices. But knowledge about software and experience with 3D visualisation is recommended/of advantage, depending of the VR application.

In Austria, the training needs for people designing VR solutions, is very high, because training in various fields is needed. Up until now, there are no special VR studies at universities or universities of applied sciences. The main reason is that VR is a relatively new technology. People with fundamental VR knowledge are to a great extend self-taught and/or have a background in video game design. Together with an increasing VR market, the demand for VR software engineers is increasing as well, but there are not enough available.

Furthermore, managers don't need in-depth knowledge about VR, although they should have a basic understanding. Information technology courses in business management studies should include VR, to get students already acquainted with VR. Those SMEs with a VR related product claim naturally, that ready-made solutions are offered and managers would only need to try VR to see what's possible. Further they reported that most managers come up with the best suiting ideas for VR applications, after just trying VR for themselves. They should know about the initial investment of time, money and (human) resources. The effort it takes is for some reason enough to not further think of possible applications, thinking it wouldn't pay off.

5. Conclusions – Recommendations

We received a number of helpful comments and opinions regarding the state of the art in VR developments, VR frameworks, demands, needs, experiences, attitudes, and mindsets within HEIs and SMEs with regards to applying VR solutions.

All reports point out that VR will gain higher impact in the future and will be established as working technology, but they claimed that 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 a lot of 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 adopting VR technology: 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 also how VR could potentially affect to the specific industry (e.g. construction, education).

Partners suggest the following recommendations for the future development:

- 360 degree photo and 360 degree video applications may be useful for education and development of these applications is practicable for teachers
- Teachers need help to describe the scenario of their VR-idea.
- Management have to be aware of the possibilities and restrictions of VR.
- Disseminate the benefits of the technology, starting from VR basics.
- Find a profitable or economical way to apply the VR technology in SMEs and HEIs.
- Reduce the lack of knowledge in how VR is used and how can be implemented in a friendly and easy way in the companies and HEIs.
- Reduce the cost of the technology and maintenance of the contents for piloting activities will be important barriers in the future, due to nowadays most of the implementations are supported by public funds.
- Develop training materials for the better understanding of the technology.
- Take into consideration the low ICT skills of manufacturing workers.

Furthermore, in business management studies information technology courses should equip students with technical basic knowledge to prepare them for their future assignments. Information campaigns specifically for business management should be considered to raise awareness for VR. An education program specific for business management should be started in any case. VR basics for students could easily be integrated in already existing information technology courses. Teachers would need to know

about VR, with its opportunities, barriers, strength and weaknesses. Because of the fast-changing character of VR, the training needs to be continuous.

A catalogue of possible VR applications in (business management) teaching could be very helpful for professionals to see the potential that lies within and how disadvantageous it would be to miss out on VR. To make a VR kick-off as simple as possible, ready-made solutions for HEIs, with full support should be considered. Still teachers would need didactic training for moderation in VR.

A database with learning scenarios, open to all HEI teaching staff, could make VR more applicable at HEIs. In the long run, it will be important to increase usability when creating VR content, so VR content can be easily created. The mobility with VR should increase, so that you don't need to stay at your computer, but can use VR with mobile devices, respectively with your smartphone. Correct steps in this direction, are already taken. It is good to have a realistic approach, while still using all the possibilities of the virtual world.

Last but not least, 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. But trend is going there anyway. Future VR solutions should be applicable with equipment that's already available, like glasses, smartphones, and tablets.

IMPRINT

VRinSight Survey – Cumulative Report

2019

University of Nicosia

Makedonitissis 46,

Nicosia 2417, Cyprus

www.unic.ac.cy

Fachhochschule des Mittelstands (FHM)

Ravensberger Straße 10G

33602 Bielefed, Germany

www.fh-mitttelstand.de

EDITORIAL

Charalambos Vrasidas

(University of Nicosia, Cyprus)

DISCLAIMER

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

The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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