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Virtual Training in the Workplace

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Abstract

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The adaptation of virtual training has steadily grown since the start of the century and saw a rapid spike in usage following the global pandemic in 2020. For many companies and organizations, it can still be unfamiliar and intimidating, even after being forced to adapt it due to COVID-19.

This thesis aims to explore, study, and analyze different forms of virtual training, how effective they are from both learning and business perspectives and provide recommendations based on the findings. Additionally, the purpose of this research is to bring awareness to different forms of virtual training and how they can be utilized by different organizations. A comprehensive literature review was conducted to investigate the virtual training market, explore the history of virtual training and the different solutions currently available.

Virtual training can take many forms, with different forms having different requirements for the equipment, the instructors, and the learners. Depending on the form virtual training takes, it can bring several benefits to the organization that has adapted it, such as lower overall costs, increased effectiveness, possibility to simulate situations that could not be simulated in a real world setting and better learner engagement

Keywords: virtual training, virtual reality, extended reality, e-learning

Contents

Glossary

AR	Augmented Reality
MR	Mixed Reality
VILT	Virtual Instructor-Led Training. Virtual training conducted with the help of an instructor.
VR	Virtual Reality
XR	Extended Reality. An umbrella term that includes augmented reality, mixed reality, and virtual reality.

1 Introduction

Organisations need to train their employees to maximise working efficiency, reduce the risk of expensive mistakes and increase employee retention (Ekezie 2016). Traditionally, training has taken place in classrooms, seminars or in the workplace with a designated instructor. However, as more virtual solutions for training have proven to be effective, more organisations have adopted some form of virtual training. Most, however, have stuck to the traditional in-person training. This changed in the spring of 2020, when the COVID-19 pandemic spread rapidly, and lockdowns and other restrictions were implemented by governments to slow its spread. These restrictions meant that many organisations and companies were forced to move off-site and online, therefore meaning that in-person training would become difficult, if not impossible. As such, these organisations were forced to look into the possibility of training their employees remotely and virtually. Virtual training is therefore more relevant now than it has ever been before. The objective of this thesis is to explore the field of virtual training and provide recommendations for organisations that are looking to adopt virtual training.

The main sources of this thesis will be web articles, books, scientific studies and articles as well as newspaper articles written on the relevant topics. These sources will be gathered and combined to provide a holistic, unbiased overview of the field of virtual training. This thesis will act as a literature review inspecting the various forms of virtual training that are available for companies, looking into the history, development, advantages and disadvantages of those forms. The thesis will start with a general overview of virtual training, and then move on to e-Learning and Extended Reality Training. Discussion and analysis will follow in the form of comparisons and recommendations, where the forms of virtual training will be evaluated and recommendations will be made on how to best utilise each form, followed by an overall conclusion.

2 General Overview

Virtual training as a term has multiple definitions, as organisations and people define the term differently. Training Industry defined virtual training as

> ...training done in a virtual or simulated environment, or when the learner and the instructor are in separate locations. Virtual training can be done synchronously or asynchronously. Virtual training and virtual training environments are designed to simulate the traditional classroom or learning experience (Training Industry 2022).

For the purposes of this research, virtual training is defined as training that utilises technology to either supplement or replace traditional in-person training. This thesis will focus on two major categories of virtual training: e-learning and extended reality training. These two categories are different, serve different sectors and industries and have their respective strengths and weaknesses.

Virtual training became highly relevant when the COVID-19 pandemic started in the spring of 2020. As companies and organisations went into lockdown to prevent the disease from spreading, they turned to virtual training in order to keep working. A survey conducted by Simplilearn found that before the pandemic 24 percent of responding companies offered online only training. After the pandemic hit, 86 percent of respondents answered that they shifted to online training. As for the effectiveness of that online training, 68 percent found that the training was as effective as before, while thirteen percent of respondents found that it was more effective. This means that 81 percent found that online training was at least as effective as traditional in-person training (Simplilearn 2020). The pandemic seems to have been a turning point for the training industry, as ATD's State of the Industry report suggests that companies will continue using online training after the pandemic has ended (Ho 2021).

Considering these facts and the overall trend of organisations moving towards virtual training, the topic is relevant and important to explore for organisations looking to overhaul their training processes. As a large variety of different

options exist, having an understanding of the overall market and the options within it helps with picking the best one for the organisation's needs.

3 E-Learning

Online training can take many forms, but for the purpose of this thesis they are divided into two major categories, instructor-led training and training that takes place on an e-learning platform. The common factor among the two categories is that they take place online and are accessed through a device that is connected to the internet, such as a computer, a tablet, or a smartphone. Often online training involves the use of multimedia material, such as images, video, and audio (The Hub 2017).

E-learning has been a growing trend in education and training, and many organisations had already adopted some form of it before 2020 (Wood 2022). However, because of the COVID-19 pandemic, organisations and companies were pushed to adopt it or fall behind. In the spring of 2020, during the early days of the pandemic, many organisations struggled with transitioning to online learning.

3.1 History and development

The field of online training experienced a huge boom during the COVID-19 pandemic, as organisations were forced to close their doors and shift to online training to prevent the spread of the pandemic. A questionnaire conducted by the training management software company Arlo found that in 2020 83 percent of the respondents expected to adopt online live training during the lockdown, while 75 percent anticipated a shift to blended learning (Hall 2020). However, distance learning and virtual training predate the pandemic by almost 300 years, as in 1728 a man called Caleb Phillips advertised a correspondence course for learning shorthand in the Boston Gazette, which was one of the first recorded instances of distance learning (Roderick 2020). Later in 1840, Sir

Isaac Pitman started teaching shorthand via post in England (Simonson, Smaldino & Zvacek 2015: 36).

In Europe, audio recordings were used by instructors for visually impaired people and for all in language learning. In the USA, technology started playing a role in distance learning in the 1920s, when educational institutions started providing courses on radio. However, since television technology started being developed, these radio courses started losing popularity. New York University offered a fairly popular series of televised college courses called Sunrise Semester from 1957 to 1982. As television and satellite technology developed further, the state of Alaska created an educational satellite system to provide instructional programming to remote villages in 1980 (Simonson et al. 2015: 38).

In 1960, the University of Illinois introduced the first computer-based education system, PLATO (Programmed Logic for Automatic Teaching Operations). PLATO was a network of connected terminals which offered coursework and allowed students to listen to recordings of lectures, among other functionalities (Peterson's 2017). Courses that can be completed fully online via the internet have existed since the 1980's. These courses often were supervised by a teacher, who provides the learning material and the assignments for the students, who are able to discuss with each other virtually (Simonson et al. 2015: 39).

During the 1990s, the field of online learning had grown as access to the internet and computers became more common. Many schools had started to offer online courses and by the late 1990s learning management systems (LMS) had become prevalent. These systems allowed the schools to provide and distribute learning materials, conduct exams and track the progress of students as their studies advanced (Ruparel 2014).

In the 2000s, as video conferencing over the internet became easier and more e-learning and virtual training platforms emerged, the online training industry

received large investments by corporations and governmental organisations, which has boosted the industry further. Most of the investment in the 2000s was focused on asynchronous training, where the learners log on at their own convenience and use pre-recorded materials to learn. (Blount 2021: 5-6).

3.2 Virtual Instructor-Led Training

Physical, in-person classroom training has been perceived as the most effective and valuable way to deliver training to employees and students for a long time. However, as this became very difficult to arrange during the COVID-19 pandemic, companies and organisations were forced to shift to virtual training for their employees. Virtual instructor-led training (VILT) is the closest experience to a traditional classroom setting compared to other forms of virtual training, which led many organisations to adopt it as their training form of choice.

Virtual Instructor Led-Training is very similar to traditional in-person training, the major difference between the two is that in VILT the instructor and the learner are in separate locations, often connected using a teleconferencing application, such as Zoom or Microsoft Teams. Unlike traditional training, however, VILT can be conducted either synchronously, meaning the participants are connected virtually in a live setting, or asynchronously, meaning that the learner is using pre-recorded video materials to learn, for example (Training Industry 2013).

3.2.1 Benefits and Challenges of VILT

Traditional in-person classroom training has the potential to be very expensive, because the company looking to train their employees needs to invest in the trainer and the training materials as well as pay for different expenses that come with arranging an in-person event. Some of these expenses can be travel and food expenses, renting of the avenue for the training if it cannot be held in the company’s premises and insurance costs. These non-training related expenses can be higher than the costs for the training itself, hurting the cost-effectiveness of the training (Blount 2021: 16). Shifting from in-person training to

virtual instructor-led training can therefore potentially halve the cost of the training by eliminating the majority of non-training costs, thus making virtual training more cost-effective than traditional training.

When shifting from traditional training to a new form of training, the difficulty of adapting previous materials to the new form of training must be considered. This is relatively easy with virtual instructor-led training, as the instructor can utilise previous materials quite well since the format of the training is very similar. For example, instead of showing presentation slides in the classroom, the instructor can present them through a teleconferencing application without having to change the slides themselves. This makes the shift from in-person to virtual relatively painless. However, the material still needs to be checked through to make sure that necessary context is not missing from the material, and it can be understood even when not in a physical classroom situation (Rees 2016).

Traditional classroom training can be troublesome to conduct to a large audience of trainees. The audience can be split up into multiple groups who are given the training separately, which requires either multiple instructors or a large time commitment from one instructor, who would give the training to all the groups at different times. Another option is to rent out an avenue where all the trainees would be able to get the training simultaneously from one instructor, but this might take away from the effectiveness of the training, as asking questions and getting one-on-one instructions is difficult in a large group. Both of these options can be very expensive for the company. Using VILT, all the participants can take part in the training virtually, and since they are not required to be in the same location, there is no need to rent out a large avenue (Blount 2021: 20). However, the problems regarding questions and one-on-one instructions still persist when a large group is involved in virtual training.

Utilising virtual instructor-led training opens the training up for new potential problems, as the training is completely reliant on technology. Problems with internet connections and system compatibility as well as various technical

difficulties which would not be present in a physical classroom are all potential problems that may affect the effectiveness of training. In the case where employees are taking the training from home, they need to have access to the proper tools and a stable enough internet connection to be able to learn from the training without being distracted by stuttering video and audio. A knowledge and know-how of how to use modern technology and teleconferencing applications is required of the employees, as otherwise they might not be able to access the training (Saminathan 2020).

3.3 E-Learning Platforms

Mohammed, Rida and Chafiq defined an E-Learning Platform as follows:

> "...software that supports the conduct of distance learning. This type of software brings together the tools necessary for the three main users - teacher, student, administrator - of a device, which aims at the remote consultation of educational contents, the individualization of learning, and tele-tutoring." (Mohammed, Rida & Chafiq 2021).

While e-learning platforms are commonly used by educational organisations to enable and support distance learning, many platforms on the market also target organisations looking to train employees. Commonly, e-learning platforms allow for the creation of courses and tests and the distribution of learning materials but depending on what is the target market for the platform, it may offer additional features.

Learning Management Systems (LMS) are a type of e-learning platform which are meant to be a type of "hub" for learning content. As the name suggests, they are meant for the management of studies, and can include one's courses, course materials, tests and exams and grades all in one place. One can add materials to courses, link videos and other content to the courses and use various integrations to enhance the learning materials (Hennigan 2021).

Some e-learning platforms focus on the creation and enhancement of the learning materials and course content. Using these platforms can be beneficial, as instead of simply adapting course content or training materials, the instructor

can create new materials that take full advantage of the features of the platform, which can in turn make the materials more engaging and effective for the learners. One such platform is ThingLink, which focuses on the learning materials, and allows users to turn images and other content into interactive scenes (ThingLink 2022). Articulate is a platform that focuses on course creation and allows users to create courses using ready-made templates that they can then edit and adapt to their training needs (Articulate 2022).

3.3.1 Benefits and Challenges of e-Learning Platforms

Using an e-learning platform to deliver training has the advantage of having all necessary information and material in the same place, which is beneficial for all parties participating in the training. Having everything collected on the same platform simplifies the training process as materials are easy to access and the learner can get the necessary feedback on the platform itself.

Using a platform that is focused on enabling the creation of learning materials can be quite beneficial to an organisation, as often these platforms aim to make the creation of engaging materials simple, meaning that even instructors who might not have the training or experience to create interactive materials are still able to make engaging material for their trainees. When the instructor is able to create the materials by themselves without needing to either licence materials made by someone else or commission someone to make them, they are able to tailor the materials to exactly what they need without extra cost.

As many of these platforms are available on multiple devices, they allow the learners to access the training materials using whatever device they wish. Having the material automatically scale and fit the device without losing information or accessibility is beneficial, as it means no man hours are required to adapt the materials to different devices.

E-learning platforms often have the ability to integrate with other platforms, programs and services. For example, ThingLink has an integration with the online design platform Canva which allows for users to create designs with

Canva to use as backgrounds for their ThingLink content without having to leave the platform (ThingLink 2021). Such integrations allow the platforms to have more features for the users to utilise without having to invest the resources to develop them. E-learning platforms are also available to be integrated with Extended Reality devices, which allows the organisation to gain the benefits of using extended reality and an e-learning platform, with the two forms of training complementing each other.

A potential problem facing organisations that use e-learning platforms is that they simply might not gain enough benefits compared to the cost. Smaller organisations may still benefit, but as the platforms are often aimed at larger organisations, the time and resources required to adopt and maintain the platform might outweigh the benefits that it may bring. While free options for platforms exist, they still require knowledge and technical understanding to set them up properly.

4 Extended Reality Training

Extended Reality (XR) is an umbrella term commonly used when referring to Virtual Reality, Augmented Reality and Mixed Reality, as well as other emerging immersive technologies (Marr 2021: 14). Figure 1 shows how these terms relate to each other by placing them on a reality-virtuality continuum, which was created by researcher Paul Milgram in the 1990s (Mealy 2018: 14).

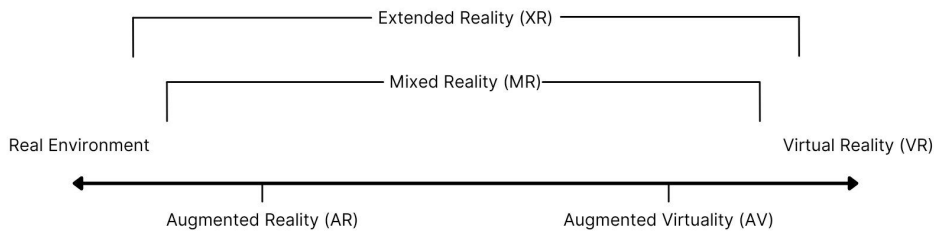

Figure 1. Reality-virtuality continuum adapted from Paul Milgram.

Augmented reality, or AR, refers to technologies that bring digital objects, such as 3D-models, into the real world. Augmented virtuality, or AV, is much rarer, and refers to the opposite of AR, bringing real world objects into a digital environment. Mixed Reality, or MR, refers to both of these technologies. Virtual Reality, or VR, focuses on creating a completely virtual environment instead of mixing virtual and real worlds and therefore falls outside of mixed reality. Extended Reality, or XR, is a term that is used in reference to all of these technologies. In order to understand how these immersive technologies can be used in the training of personnel, they need to be inspected separately.

4.1 Virtual Reality Training

Using virtual reality in training means utilising the VR technology in the training in some form. The training can fully take place in virtual reality using a headset and controllers, or just a part of the training may be done in VR. The prevalence of virtual reality has grown in recent years as consumer-grade virtual reality devices have become more available and affordable. This has translated to more companies adapting virtual reality to enhance their employee training procedures. Using virtual reality in training has multiple benefits: it allows the training to happen fully virtually, meaning that no real-world equipment is needed to conduct it. Dangerous situations, such as emergencies that would not be possible to train for in a real setting without risking injury can be trained for in an immersive virtual simulation using virtual reality. As the training happens mostly in a computer generated 3D environment, VR developers can use pre-made 3D-assets to build different simulations without incurring high costs (Xie et al. 2021).

4.1.1 The Definition of Virtual Reality

The term “virtual reality” is used to refer to a computer generated 3D-environment that the user can explore and interact with (Virtual Reality Society 2017). This is achieved by a virtual reality headset, also known as a head-mounted display (HMD), which covers the user's eyes, completely immersing

them into the virtual environment (Gartner n.d.). A large variety of virtual reality headsets exists, which range from simple phone-mounted displays to high-end headsets. These also vary with the specifications of the display, such as the refresh rate and the resolution of the display and how the motions of the user are tracked.

The way users can experience virtual reality is different with each headset, some focusing on a fully stationary experience, and others allowing for a room-scale experience. Most early headsets were focused on fully stationary experiences, meaning that the experience is designed around the user remaining stationary, either sitting or standing. More higher end headsets support room-scale, which allows for the user to move around in a limited area, that movement being transferred to the virtual environment, which can make the experience more immersive (Mealy 2018: 29).

Often, these HMDs are paired with two motion tracked controllers that the user can use to interact with the virtual environment. These vary in size, shape and the number of buttons, but the principle remains the same: the user can see the controllers in the virtual environment and interact with it by moving the controllers and using the buttons on them. This allows the user to interact with the virtual environment in a way that feels natural, as they can pick virtual items and rotate them in their hands like they would in a real environment (Mealy 2018: 42). These controllers commonly use haptic feedback to enhance the immersion of the user. Haptic feedback refers to simulated physical feedback that the user can feel when interacting with the controller, most commonly taking the form of vibration (Gorya 2021). The controller can vibrate when the user has moved the controller close enough to a virtual item to pick it up, giving the user information through their sense of touch. Some companies are taking this concept further, such as HaptX with their haptic gloves, which accurately track the user's hands within the virtual environment and allow the user to feel virtual objects and environment through the use of tactile feedback and dynamic force feedback (HaptX 2021). These gloves combined with a high-end virtual

reality headset could, for instance, replace high-cost flight simulators used to train pilots.

Learning analytics, or the analysis and use of data generated by the user's interactions in the virtual environment can be combined with virtual reality to provide real-time feedback to learners during virtual reality training. Researchers in the University of Melbourne conducted an experiment in 2013, in which they had learners use simulated surgery tools to conduct a surgery in virtual reality who would get immediate feedback from the program during the simulated surgery (Kennedy, Ioannou, Zhou, Bailey & O'Leary 2013).

4.1.2 History and development of VR Technology

Virtual reality has been around since the 1960's, when an American computer scientist named Ivan Sutherland created the first head-mounted display using small CRT-monitors and a graphical simulation which adjusted the image based on the user's head movements (Turi 2013). Engineers of the National Aeronautics and Space Agency (NASA) of the United States created a VR headset to train astronauts using disassembled Sony Watchman TVs in combination with special optics, which allowed the eyes of the user to focus on the displays despite their close proximity. This same principle is used by most virtual reality headsets to this day (Coiffet & Burdea 2017). The first commercial virtual reality headsets were released in the late 1980's and the technology continued to develop. However, these early headsets were all plagued with the same issues: they were heavy (up to 2 kilograms), the image resolution was low, which made the images look blurry and they were extremely expensive (up to 11000 USD), which made the adoption rates for the technology low (Coiffet & Burdea 2017).

Virtual reality made it to the mainstream in 2012, when Oculus VR launched a crowdfunding campaign to fund the development of a virtual reality headset called The Rift, which was meant for application and game developers to start developing virtual reality products. The campaign raised 2,4 million US dollars

and led to the successful release of the first Oculus Development Kit in 2013. In 2014 Oculus VR was bought by Meta Platforms Inc. (Formerly known as Facebook Inc.) for 2 billion USD (Rubin 2014). By this time, Google and Samsung had already released their solutions for experiencing virtual reality content on a smartphone. Google's Cardboard was a low-cost solution for consumers to "get a glimpse" of what virtual reality has to offer, while Samsung's Gear VR was more expensive, but provided a closer experience to what HMD's such as Oculus's Development Kits had to offer (Barnard 2019). In 2016, when Oculus released its first consumer version of the Rift known as Oculus Rift CV1 (Oculus 2016), more players were entering the market, such as HTC with HTC Vive and Sony with PlayStation VR.

So far, most headsets had acted as displays only, and as such required an external device to run the software that they used. Most commonly this was a computer, but video game consoles were used as well, for example by Sony's PlayStation VR, and as previously mentioned, Samsung's and Google's devices used smartphones for this purpose. The first successful standalone headset, Oculus Go, was released in 2018, but was quickly replaced by the more powerful Oculus Quest in 2019 (Robertson 2018).

While virtual reality was mostly driven forward by the video game industry, the potential to use the technology for training and other purposes was not missed by companies and organisations. In 2017, surgeons at Children's Hospital in Los Angeles (CHLA) together with a group of developers created a VR simulation to help train doctors in making life-saving decisions when working with infants (Takahashi 2017). Similarly, Osso VR created a virtual reality platform where surgeons and doctors could train in the use of new medical devices and learn new, highly complex medical procedures (Cashin-Garbutt 2017). The car manufacturer Audi created virtual showrooms for cars, where users could sit in the car and inspect the interior, or walk around the car and inspect it from outside (James 2016).

4.1.3 Utilising VR in Employee Training

The use of virtual reality technology has seen rapid growth and the global market size for VR is expected to reach 26.86 billion USD in 2027 (PR Newswire 2022). This growth is also seen in the adaptation of the technology to training purposes by different companies and organisations. The benefits of using virtual reality in training are many. The trainee can be put in almost any environment or situation, even situations that would be extremely expensive, time consuming or functionally impossible to create in real-life, such as fire-fighting situations or space walks. As VR is immersive, the trainees take the training more seriously and the skills they learn translate well into real-life situations (Lindner et al. 2019).

There are many different use cases companies have for virtual reality training. Walmart, a large retail store chain in the United States, has trained over a million employees using virtual reality. The employees got immediate feedback from the program when they made a mistake, which led to training being more efficient and the total time to train dropping from eight hours to fifteen minutes. As the training was previously conducted in designated stores, the move to virtual reality allowed it to be done anywhere (Bailenson 2020).

Virtual reality training has seen use in the sports industry, often with great success. Before the 2018 Winter Olympics in Pyeongchang South Korea, Mikaela Shiffrin,an alpine skier from the United States, trained in virtual reality (Maese 2018). This allowed her to become familiar with the Jeongseon course, where the Olympic downhill skiing competition would take place, which was not possible in the real environment before the Olympic games start. She went on to win the gold medal in the giant slalom race (Deal 2018). In the United States, the National Football League NFL is using virtual reality to train their referees, allowing them to train in communicating with officials and identifying penalties before refereeing official games (Booton 2017).

In early 2019, the British army started testing the use of virtual reality in the training of their soldiers. The pilot was known as Virtual Reality in Land Training (VRLT), which was made by Bohemia Interactive Simulations. This pilot combined the use of virtual reality headsets, mixed reality which allowed the training soldiers to see and interact with real physical objects and custom avatars, which replicated the facial features and body shapes of the soldiers, allowing them to recognise one another within the simulation. This pilot allowed the army to quickly set up, simulate and analyse different scenarios and tactical approaches, without putting their soldiers in real risk (GOV.UK 2019).

4.1.4 The Effectiveness of VR Training

There is a wide variety of studies about the efficiency and efficacy of the use of virtual reality training. A study conducted in 2021 on medical trainees found that incorporating immersive VR technology into surgical training improved cost-effectiveness, accuracy, task completion and procedural times. Groups trained in virtual reality performed up to 43% better compared to the control group (Mao, Lan, Kay, Lohre, Ayeni, Goel & Sa 2021). A meta-analysis of virtual reality training programs found that “...VR training programs produce better outcomes than tested alternatives” (Howard, Gutworth & Jacobs 2021).

The effectiveness of virtual reality training in the training of soft skills is proven. A study conducted by PwC in 2020 found that VR learners were four times faster to train than those in the classroom, the time taken to complete the training went from two hours in the classroom to 29 minutes in VR. The learners were also 245% more confident in discussing issues they learned about and 275% more confident in applying the skills they learned. An immersive simulation in virtual reality makes training feel more real and meaningful, and therefore the learners were felt 3.75 times more emotionally connected to the training material as well as four times more focused than learners in a traditional classroom (PwC VR Soft Skills Training Efficacy Study 2020).

The field in which virtual reality training is deployed seems to have some effect on how effective the training is. A study conducted in the training of law enforcement officers compared results from groups that trained in virtual reality and groups that trained in traditional live training exercises and that there were no major differences in the learning outcomes between the groups. However, they noted that this is in fact a positive result in favour of virtual reality training, as it means similar results can be achieved with VR, which has many benefits compared to live training exercises, such as improved cost-effectiveness and ease of access (Saunders, Davey, Bayerl & Lohrmann 2019).

4.1.5 Benefits and Challenges of VR Training

A significant benefit of Virtual Reality is the ability to adapt it to a variety of different training purposes, without needing to invest into new hardware. Often, developers are able to reuse 3D-assets in a variety of different training scenarios, without needing to licence or create new ones. However, few companies have personnel capable of creating immersive virtual reality simulations, which means in order for them to adopt VR into their training, they'd either need to licence generic training modules, or hire an outside company to develop a module for them. This could raise the upfront cost significantly.

The ability to simulate even dangerous scenarios in an immersive way without actually putting the learner in danger of getting injured is another major benefit of VR. Similarly, being able to simulate situations that would be highly expensive to stage in a real environment makes virtual reality a powerful tool for training. Additionally, it can be used to train soft skills, as the nature of the simulation allows the learner to make mistakes without feeling shame or social pressure while still taking the training seriously enough to learn from it.

In many cases, using VR in training can significantly improve the time efficiency of training, effectiveness in terms of knowledge retention and confidence in applying skills learned from the training, such as in the PwC Soft Skills study

(PwC 2020). From a purely business perspective, this combined with the long term reduction of costs that the ability to reuse assets provides, makes virtual reality training an attractive investment to many companies. However, virtual reality is not perfect and has challenges that need to be overcome.

A commonly cited problem with using a virtual reality headset is motion sickness, which in this context is often called “VR sickness” or “cybersickness. Common symptoms for VR sickness are disorientation, nausea and eye fatigue (Chang, Kim & Yoo 2020). These symptoms are commonly caused by movement within the virtual environment when the user’s body is still (Coles 2021). App and game developers have come up with solutions for VR sickness, such as allowing the user to teleport (instantly move to another location) instead of using a controller to move to a location more realistically. Another solution attempted is narrowing the field of view of the user while they are moving (Gordon 2021).

The controllers users use to interact with the virtual environment need to be considered when creating virtual reality training. Most common, out-of-the-box controllers which come with consumer grade headsets can track the human hand quite well, but still lack the ability to track fine hand and finger interactions that many jobs require (Ahir 2018). While solutions to this exist, like the previously mentioned HaptX haptic gloves, they will significantly raise the upfront cost to adopt virtual training.

Overall, the use of virtual reality in training has a variety of benefits to consider, but it is not a perfect solution by any means. The relatively high upfront cost can be a deterring factor for companies, and it is possible that some employees are unable to use a VR headset due to motion sickness. However, the benefits can outweigh the challenges, depending on the company. Adopting virtual reality to their training allows for increased flexibility and can lessen costs in the long run, especially if the company needs to train multiple employees in specific tasks or processes that can be virtualized.

4.2 Mixed Reality Training

Using augmented reality and mixed in training means utilising these technologies to complement and improve training processes. When implemented properly augmented reality training can improve the learning and skills of both seasoned workers and trainees, as well as help improve employee engagement.

4.2.1 The Definition of Mixed Reality

Augmented Reality, or AR, is a way of taking a real-world visual, using either a camera or simply viewing it directly, and augmenting that visual with computer generated content, such as 3D-models, videos or images. Generally, this is done by taking a visual of the real world and adding an overlay, on which the computer generated content is added. As this is simply an overlay, the two “realities” cannot interact. When the digitally added overlay can interact with the real world, the correct term is Mixed Reality, or MR (Mealy 2018: 9). These terms have become somewhat muddied and are often used interchangeably. Mixed reality also includes the much rarer Augmented Virtuality, which can be considered the opposite of augmented reality, as instead of projecting digital objects into the real world, augmented virtuality projects real objects into a virtual one (Mealy 2018: 13).

An example of augmented reality is using the in-camera translation feature of Google Translate, which allows the users to view text written in a different language through their smart-phone, and seeing the text translated on their screen (Gu 2019). Another popular example of the use of AR is the mobile videogame Pokémon GO, which was released in 2016. The game uses GPS hotspots, where it will place creatures that the players can go and catch. When the player reaches one of these creatures, the game will switch the camera on and project a 3D-model of the creature onto the real world (Chamary 2018).

Mixed reality is not limited to smartphones. Devices such as the Microsoft HoloLens and Google Glass aim to create a hands-free experience for users,

allowing for information to be projected directly in front of their eyes, without them having to use a smartphone camera to look through. The Swedish car manufacturer Volvo is aiming to make the entire windshield of a car an AR display, allowing it to project crucial information, such as the speed limit or warnings about crossing people or animals to the driver without them having to take their eyes off the road (McGlaun 2021).

4.2.2 History and Development of MR

The term “Augmented Reality” was first coined in 1990 by Tom Caudell and David Mitzell, employees of Boeing Computer Services Research. The pair created a head mounted display that could overlay positions of wires onto reusable boards for engineers who would be building aircraft, which was one of the first uses of augmented reality in an industrial setting (Mealy 2018: 16).

Similar to virtual reality, augmented reality was mostly absent from the mainstream consciousness until the 2010s. In 2012, Google released its first “smart glasses”, the Google Glass. The glasses were able to project information, such as text and images, to the surface of the glasses, creating a kind of heads-up display for their user. However, even though the first batch of two thousand units of Google Glass sold out immediately, the product was ultimately considered a flop. Google brought the smart glasses back in 2020, releasing a consumer version for 999 USD intended for construction, manufacturing and medical employees (All About Vision 2021).

Microsoft released its own entry, the Microsoft HoloLens, to the mixed reality market in 2016. The device was a head-mounted display that projected holographic images on a visor-like transparent screen in front of the user's eyes, which were able to blend in with the environment. HoloLens acted as a computer, allowing the user to make calls, watch video and browse the internet among other computer-like features (Goode 2016). However, as the device had a high price point of 3000 USD (Savov 2015), it was mostly unavailable to the average consumer, and did not end up making a large impact on the market.

Microsoft would announce the HoloLens 2 in 2019 at a price point of 3,500 USD. The HoloLens 2 was aimed at industrial companies to increase the efficiency of workers by projecting information to them while still leaving their hands free for work (Bohn 2019).

In 2017 Google and Apple both announced their developer tools for developing applications that use AR for smartphones. Apple released its AR developer toolkit ARKit in 2017 and Google's counterpart, ARCore, was released in 2018 (Summerson 2018). These tools made it easier for developers to develop AR applications, and thus kickstarted the development of many AR apps, such as IKEA place, which allows users to see how IKEA furniture would look in their homes before purchase.

4.2.3 Utilising MR in Employee Training

When the COVID-19 pandemic started in 2020, it made it impossible for many teams to meet in-person, which made collaborating and training difficult to achieve without utilising new technologies. The airplane manufacturer Boeing addressed these issues by developing a mixed reality solution to their training. As an US based team could not travel to Australia to oversee maintenance on a C-17 military transport aircraft because of the travel restrictions, the company sent mixed reality headsets to the Royal Australian Air Force (RAAF) maintenance personnel in Australia, which the US based team could utilise to send technical documents as holograms and give real time training and guidance to the RAAF workers (McLaughlin 2020).

Lockheed Martin, an US based aerospace and defence corporation, utilises the Microsoft HoloLens in their manufacturing processes training. The company's manufacturing workers use a process called OODA (Observe, Orient, Decide, Act), when assembling parts. Without the use of mixed reality, the first three elements took 51 percent of the time, on average. HoloLens could automate previously manual processes such as measuring and planning and thus reduce the duration of these by up to 99%, making the process faster and more

enjoyable to workers (Enderle 2021). Both of these examples are from jobs where having both hands free is crucial, and as such using a mixed reality headset is beneficial, as unlike in traditional augmented reality, the headset allows both hands to be free (Fonarov 2021).

In the United Kingdom, HS2 Ltd. used augmented reality to train future workers of the Old Oak Common railway station before the construction of the station was finished. As the station was designed to handle approximately 275 000 people every day, the staff needed to be trained well in advance to ensure smooth proceedings for the passengers starting from day one. The augmented reality solution allowed the staff to see the station in detail, which gave them an opportunity to give feedback and suggestions before the construction started, which in turn could ensure that potentially costly mistakes could be avoided (Global Railway Review 2019).

4.2.4 Effectiveness of MR Training

A study conducted in 2021 on the effectiveness of utilising augmented reality in online distance learning found that “...the results of the statistical analysis indicated the relatively greater effectiveness of AR in the virtual classrooms in both academic achievement and the acquisition of instructional software design skills for students compared to the virtual classrooms without AR” (Eldokhny & Drwish 2021). Therefore, using augmented reality to enhance the teaching and learning procedures can lead to better results. Another study was conducted on students training as Anti-Air Warfare Coordinators. They were divided into two groups, of which one used augmented reality training and the other a training textbook. The study found that the group that utilised AR in their training performed significantly better and showed higher situational awareness than the group which trained using a textbook (Kim,Chan & Du 2015).

An augmented reality training platform was developed for technicians of Sidel, a manufacturing company in France, to support acquisition of assembly and manufacturing skills. The platform was evaluated using a control group who

performed a physical task while watching an instructional video and an experimental group who performed the task using the augmented reality platform. The study found that while performance time did not differ significantly between the two groups, the number of unsolved errors from the AR group was significantly smaller compared to the control group, indicating that the using AR platform led to better results in the same time (Webel, Bockholt, Engelke, Gavish, Olbrich & Preusche 2013).

4.2.5 Benefits and Challenges of MR

In their 2017 article Porter and Heppelmann identified two key ways that augmented reality can improve the way employees work in companies, visualisation as well as instructing and guiding. AR makes it possible for data to be visualised for workers in real time, and as such it can be used to grant workers a type of X-Ray vision, allowing them to see things that would be difficult or impossible to see without AR. This may be used by doctors and nurses, allowing them to locate veins for easier injections or blood draws. Augmented reality makes it possible for real-time in-context instructions to be given to learners while they are completing tasks and processes, which in turn enhances learning and helps with knowledge retention (Porter & Heppelmann 2017).

Lorne Fade identified four main benefits of augmented reality training in his 2021 article “The Benefits of Augmented Reality for Employee Training”. These benefits were the potential to boost employee engagement in the training, increasing safety awareness, alleviating training costs and lowering learning curves (Fade 2021). Augmented reality can increase trainee engagement by allowing them to practise and learn without pressure from other employees, higher ups or customers. In jobs where there is a risk of being injured, AR can allow trainees to practise these situations without being put in real risk of injury. Adopting augmented reality to the training processes can have a high upfront cost, but it may come with lower long term costs as training becomes more effective and efficient, which lowers the risk of costly mistakes.

A significant challenge for any organisation looking to implement mixed reality in their training is the high cost of developing applications. Analysts speculate that creating an app like IKEA place would cost between 30 000 and 50 000 USD (Sokhanych 2017). However, it is not always necessary to create an application from scratch as it is possible to licence a platform which can then be customised to fit the organisation's needs. This can be significantly cheaper compared to creating a completely new application (Baron 2021).

When the popularity and adoption rates of new technology are rising rapidly, but regulation is lagging behind, adopting the new technologies may become a legal risk. This risk also applies to companies that are adopting mixed reality to their training processes as problems with copyright and privacy may become issues if they are not addressed properly. For example, if trainees are carrying a device with them that has the capability to record images and sounds, the data the device collects might become a legal liability (Cook, Mariani & Kishnani 2019).

5 Comparing forms of Virtual Training

Having an understanding of the overall market and what options exist for virtual training is important to have before starting the process of adopting virtual training for the organisation. A significant part of this is researching and comparing different forms of training and analysing them to discover their individual strengths and weaknesses. The different types of virtual training are not mutually exclusive, which means multiple types can be used to compensate for weaknesses and enhance the overall effectiveness of training. For example, an organisation can use an e-learning platform in addition to virtual reality training, hosting non-VR content on the platform and using it as a hub for learning materials. This is a form of synergy, meaning the types of virtual training complement each other.

When comparing and evaluating types of virtual training in order to come to a conclusion on which one to choose for the organisation's needs, one needs to

keep several factors in mind. How well the form fits the training needs of the organisation's training needs is important, as some may demand more resources and time to be effective than others, and these do not always translate to better training outcomes. For example, a company looking to train office workers in information security would not necessarily have a need for virtual reality training, as VR training requires specialised hardware and software to run, which means a significant commitment of resources is required. The company may find utilising an e-learning platform or virtual instructor-led training to be more cost-effective.

5.1 E-Learning

Training can be divided into two categories, synchronous and asynchronous, depending on if it happens live or not. A significant strength of using virtual instructor-led training compared to an e-learning platform is that VILT enables trainees to get one-on-one personified training in real time from a real instructor, while if using an e-learning platform the trainee would often go through the materials themselves at their own pace. Thus, training using VILT is synchronous while training via an e-learning platform is asynchronous.

Synchronous training has the advantage of happening in real time, meaning that trainees are able to ask questions and get help during the training from the instructor. However, as group sizes increase this becomes increasingly harder, as the more people are partaking in the training at the same time the less time the instructor will have for helping individual trainees. In real time training sessions the trainee needs to ask for help if they need it, which may be problematic for people who suffer from social anxiety or other issues which make it difficult to bring attention to oneself. Similarly, people who are naturally more quiet or shy may have trouble being heard, especially if the group is of a large size. This is where asynchronous forms of training, such as using an e-learning platform to deliver the training, have an advantage. Being able to go through the materials at your own pace, revisiting parts at will and revising information may be preferential for people with social anxiety or learning

disabilities. In cases where they may run into problems with unclear materials or questions they can’t find answers to, they can contact the instructor directly to get answers.

E-learning platforms can be used in addition to virtual instructor-led training, by having links to the live training sessions hosted on the platform with additional training materials that the trainee can use to learn outside of the live sessions. The live sessions may be recorded and added to the platform as well, allowing the trainees to revisit them whenever they need to. The instructor may also create materials using the platform to enhance and increase the interactivity of the training. This way, learners who may feel uncomfortable asking questions during the live sessions can use the recordings and additional material to learn, which decreases the risk of them making mistakes later.

5.2 Extended Reality

As mentioned before, the main difference between virtual reality and mixed reality is that virtual reality immerses the user in a completely virtual environment, while mixed reality mixes both a virtual and the real world. Augmented reality is a subcategory of mixed reality, and it can be achieved with any camera-equipped device, but specialised hardware, such as headsets are also available.

Generally, virtual reality is more cost-heavy than mixed reality, as it requires not only specialised hardware, but also specialised software to run. Depending on the type of training that is utilising virtual reality, a customised virtual environment or simulation may have to be created, which requires specialised knowledge that few companies have in-house, and as such they need to hire outside specialists to create and maintain their virtual reality platform.

Mixed reality, in comparison, is often less cost-heavy, but this depends on the way mixed reality is applied. Organisations that use mixed reality through smart phones may be able to have their employees use their personal devices for the training, however this does mean that all employees need to have a device

capable of running the training software. If an organisation decides to utilise a heavily customised mixed reality platform and mixed reality headsets, the costs will significantly increase. However, the effectiveness of the training may increase significantly as a result of heavier investment.

6 Discussion and Recommendations

The virtual training market is a quickly growing and developing one, with new companies entering the market and bringing new solutions for virtual training. Currently, extended reality is a trend that many companies are excited about and hoping to explore further. However, not every organisation needs extended reality training, even if the XR can make the training more efficient. As extended reality often requires heavy commitment and investment from the company, the results may not be worth the cost. Specialised equipment, software development, licensing fees and hiring outside specialists to create and maintain the training platform are all costs associated with extended reality training. As such, it is important for an organisation to pick a form of virtual training that fits their needs and is cost-effective.

6.1 E-Learning Recommendations

Most organisations can gain benefits from using virtual instructor-led training, as it is quite easy to adopt thanks to its closeness to regular training. However, it is important to keep group sizes relatively small, as the larger the group size the less personal one-on-one assistance can be given by the instructor, thus increasing the risk of misunderstandings and weaker knowledge retention. Virtual instructor-led training cannot replace all training, as practical skills are hard to teach through video calls, but it can be used to create a foundation of knowledge, which can make it easier to learn those practical skills afterwards. This can be beneficial as it can make the later practical training sessions that are done in a real environment more efficient, since the learner already has the required theoretical understanding of the subject.

In conclusion, when it comes to virtual-instructor led training the best outcomes can be achieved when the subject of training can be learned completely virtually or the training is used to create a foundation for later, more practical training. As virtual instructor-led training can be adapted from traditional training quite easily, it can also be very cost-effective. Group sizes should be kept relatively small to make sure that the training will be as effective as possible and that the risk of trainees making mistakes later is kept low. A good use case for VILT would be information security training for a company that works from an office. In the case of a larger company, multiple instructors or separating groups into different time slots to keep group size manageable would be recommended.

E-learning platforms are very flexible, as they can be customised to fit the needs of different companies and organisations. They can be used as a hub for the hosting of learning materials and examinations, or as a platform where materials can be created or enhanced, depending on the platform in question. Thanks to numerous integrations, e-learning platforms can be used in addition to other types of virtual training, such as virtual instructor-led training or extended reality training. However, training can also be conducted through the e-learning platform itself, without using other types of training.

Using an e-learning platform can be especially beneficial for larger organisations that need to train large amounts of employees, which may make virtual instructor-led training difficult to organise and can create logistical problems if extended reality training is used. The platforms have the advantage of being asynchronous, meaning that the training does not need to happen at the same time for everyone and that each learner can take the training at their own pace. This helps with scheduling, as each learner can take the training when it fits their schedule and is least disruptive to their workday. However, large organisations are not the only ones that stand to gain benefits from adopting a platform for their training needs. Smaller organisations may find it easier and more cost effective to create engaging materials using an e-learning

platform instead of hiring an outside consultant to do that work. Therefore, both small and large organisations can benefit from using an e-learning platform to enhance their virtual training processes. Depending on the available integrations and the goals of training, an e-learning platform can help make the training more efficient and accessible for learners, even when the training is highly complex.

6.2 Virtual Reality Recommendations

Virtual reality training can be very effective, depending on the goals and the type of training. Using only a headset and controllers can make for immersive training, which helps with knowledge retention and learner engagement. Virtual reality training can be used to train soft skills by placing the user into a virtual environment that can be either completely created from scratch by using 3D-modelling or recorded in a real environment with the help of 360-degree cameras. This is a safe and low-pressure way for the trainee to learn in real situations without any real consequences, allowing them to make mistakes and learn by doing without worrying about embarrassment or awkward social situations. An example of this could be a recorded customer service situation (such as a customer coming to complain about a faulty product), where the learner could choose how they would respond and see the different ways the customer can react. These types of scenarios can be very useful in training for stressful interactions, as afterwards the trainee will be prepared for such a situation and will know how to best handle it.

Another potential use for virtual reality training would be dangerous or risky situations that may be very difficult if not impossible to train for in a real environment. Even if such a situation can be simulated in a real environment, it can be very difficult to make it feel real for the trainees, as if they are not properly immersed in the scenario, they will not have the same stress reactions that they might have in a real situation, which can be quite dangerous if they don’t know how they can handle those reactions. Virtual reality can realistically recreate dangerous situations that are immersive and cause real physiological

reactions in the trainees without ever putting them in real risk of injury. This can be enhanced with additional hardware and equipment, which can increase the immersion of the trainee to make the simulation as close to real as possible.

Virtual reality can be used to support practical real-life training by allowing the trainees to visit real work environments virtually before going to visit them physically. This can make the physical training more effective and efficient, as the trainees already have an idea of what the environment will look and be like, and can focus on the practical training itself. The training can also be virtualized, so that the trainees can do it virtually before doing it in a real environment, allowing them to be prepared and have an understanding of how the training itself will go. As such, virtual reality training is a flexible format that can be adapted to many different purposes.

A significant downside of virtual training is its high cost, which will get higher the more additional and advanced equipment is used (Future Virtual 2021). Using virtual reality also requires a virtualized environment that the simulation will take place in, which may be expensive to create. One would need a specialised skill set in 3D-modelling and environment creation to make the virtual environment look and feel like its real-life counterpart to increase the level of immersion the user can experience within the simulation. These fully 3D interactive environments require more processing power from the platform running the training software, which will raise the upfront cost. Alternatively, the environment can be made from a 360-degree image, which would require a special camera. However, this environment would only be a flat image and therefore complete visual, and the user could not interact with any objects within it, which would lead to a lower level of immersion. On the other hand, these 360-degree environments require much less processing power, and can often be streamed from online, which makes accessing the training easier. It is important to note that 360-videos need to have a high resolution in order to not look blurry to the user, which will increase the videos file size and make it more demanding to stream from the internet.

Virtual reality training can also be combined with other forms of training, virtual and traditional. A combination of multiple different types of training can prove to be quite efficient, as it allows for trainees to gain a comprehensive understanding of the subject. For example, starting with virtual instructor-led training to gain a theoretical understanding of the subject, then having the trainees do some virtual exercises on an e-learning platform that can also host the recording of the instructor-led training session, allowing them to revisit it at their convenience. After these, the trainees could move to train in a virtual environment using virtual reality and finally move to practical in-person training in the real environment. This would allow the learners to first gain the theoretical understanding of the subject and test their knowledge virtually, then moving to training in a virtual environment to prepare them for the practical training. Having already trained virtually and understanding the theoretical aspect of the training, the learners will have a strong foundation on which to build their practical skills. However, such a comprehensive training plan is not always practical, as it requires a lot of time and resources. Some organisations that train personnel for highly dangerous and risky situations, such as the military or firefighters, should consider adopting a multi-faceted comprehensive training plan to ensure strong learning outcomes and knowledge retention.

Organisations with smaller budgets for training that do not require highly advanced virtual reality simulations can get good results from using 360-degree images and videos as their virtual environments, as these can be more immersive and effective than traditional training videos. However, if the organisation requires a highly interactive simulation, the environment would have to be created fully virtually. Generally, if the training aims to develop the soft skills of the employees, the environment does not have to be highly complex, and the resources can be directed to make the interactions deeper and more realistic. For example, when training employees in customer interactions, instead of using time and resources to create a highly interactive and complex environment, they can be used to write a script for and record different customer interactions. In the case that the simulation needs to be

interactive and highly immersive, those resources can then be directed to making the environment better.

6.3 Mixed Reality Recommendations

Utilising mixed reality can be very useful in training for context heavy work processes, as it allows the user to get necessary instructions and instant feedback while they are in process of training, not just before and after the process. This allows the trainees to learn while doing and to adjust their way of working immediately after getting feedback. Mixed reality headsets can be especially useful to achieve these goals, as they allow workers to keep both hands free while working, but still get the information that they need projected to their headsets. This can be very useful for highly technical professions, such as mechanics and electricians, who need training on how to repair or maintain different types of machinery (Gunnink 2019). The instructions on how to find certain parts of the machine can be projected to their headset, allowing them to access them while working with both of their hands. Therefore, using a mixed reality headset in training is recommended for manual, highly technical work during which having instructions always available while having both hands free is most useful (Carlton 2019). Additionally, mixed reality does not bring much benefit if the training is remote, as it is best used to enhance in-person training.

Mixed reality is especially useful when training for specific types of devices of machinery. For example, the worker may already have an understanding on how to repair a smartphone, but the placement, size and appearance of different parts may differ based on the brand and model of the phone. Having access to blueprints or instructions for the specific model they are training to repair on hand without having to stop the repair process may reduce the risk of damaging the device or its parts and make the process faster overall, as the worker does not need to spend time looking for different parts.

Mixed reality can be achieved with smartphones and other mobile devices that have a camera, however this does mean that the experience will not be hands-

free. This can be useful for independent training, where the workers move through an area with different points of interest where they get more instructions and material to their devices. This means that there needs to be a defined area for the training, which can prove problematic for companies with smaller facilities.

7 Conclusion

The aim of this thesis was to investigate and explore the different virtual options for training that companies are using, to gain an understanding of the history of virtual training, and to provide recommendations for potential uses for virtual forms of training. The different types were divided into two categories, e-Learning and Extended Reality, which were inspected separately to discover their potential uses, how effective and efficient they are and which types of organisations could get the most use out of them.

Virtual training and digital solutions are more relevant than they have ever been before, and as such understanding the field and the options available is necessary for companies and other types of organisations that are looking to keep up with the developing technology and find new potential solutions for their training needs.

Companies are already using different virtual solutions for training, and many are utilising both e-learning and extended reality in their training programs. Virtual training has been found to be an effective and efficient alternative to traditional training, and studies have shown it to often have similar or better learning outcomes than traditional, while being more cost-effective. However, as these solutions are not perfect, problems still exist, such as VR sickness, technical issues as well as high system requirements. However, as the technology is constantly evolving, these problems may find their solutions in the near future.

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