Virtual Reality and Enterprise Training

Alejandro D. Dinsmore

Abstract

This white paper seeks to review and synthesize previous research on the use of virtual reality (VR) for training purposes and to discuss how companies can leverage the growing potential of VR technology to revolutionize training and education within their organizations. Based on the existing research we found several key attributes of VR that make it an effective tool for training. The key attributes of VR include that it is more memorable than video content, a safe alternative to real world training, is easily repeatable and scalable, and provides isolation from distractions. What research exists to date already confirms that VR is effective for training of cognitive skills, psychomotor skills and affective skills. These are promising findings, given that the quality of hardware and content used in previous research was significantly lower than that available today. There is a strong likelihood that further research and development will lead to new and concrete ways in which VR can be used to change the way companies train their employees.

Keywords: Virtual reality, VR, training, presence, immersion, skill acquisition, upskilling, Industry 4.0, digitization

Introduction

In the real world, we always feel “presence” – the subjective experience of reality, of navigating and existing in an environment in which our sensory input responds to our movements and actions. This coordinated sensory input is also the basic mechanism our brains use to determine what is real. As humans, we need to be able to distinguish representations of reality from reality itself, and this is done via the coordinated processing of sensory and emotional input. When our brains send a signal to our hands to move, they immediately receive the coordinating visual feedback of seeing our hands move. When all our sensory inputs confirm the same thing, our brains can safely assume that what is happening is real. (Ramachandran, 1998).

Virtual reality (VR), for the first time, provides us with a way to deliver enough synchronous sensory input to confuse our brains into thinking that what is happening inside a virtual environment is real. This means that the benefits of “in-person” interactions can be distributed via digital channels.

There is immense potential here. It takes a lot of resources and time to move people around and get them into specific real-world environments. However, digital environments are accessible to anyone, anywhere, given the right hardware. The true potential of VR therefore lies in its power to deliver physical, real-world experiences, with the scalability and accessibility of digital technology. We already achieve presence in the physical world just by existing in it; VR allows us to achieve presence in a digital world (Slater & Sanchez-Vivez, 2014).

Before discussing the research, it is important to explain two of the key concepts involved in evaluating and understanding the power of VR and to underline their differences. The first, “immersion,” is the subjective experience of being in a virtual environment. The second, presence, is achieved when the brain and the nervous system start to react as if they were in a real-world environment, despite being in a virtual one. To understand the latter, we need to understand that the brain reacts differently – both physiologically and emotionally – when a subject is experiencing presence versus when it is not (Jensen and Konradsen, 2017). Presence and immersion are central components of the VR experience, but they are often – incorrectly – used interchangeably. 2D games and video, for example, can be immersive but achieve very little, if any, presence.

Presence is not binary and can occur on a scale: the more coordinating and overlapping (synchronous) layers of sensory input added, the more presence achieved. Visual input alone can only achieve a certain level of presence. Adding spatial audio further increases that upper limit. With the addition of haptic feedback and accurate motion tracking, there is a substantial leap in achievable presence (Banakou, Groten and Slater, 2013).

Almost all of VR’s benefits as a training tool are possible because of presence. This is also what separates it from previous 2D video, image and text-based training materials.

Attributes of VR

VR is more memorable

VR is a highly effective training tool because of the benefits conferred by varying levels of presence. For one, the memory retention and recollection ability of subjects after a VR experience tends to be higher than after viewing video- or text-based materials. We know that memory is anchored and made stronger when there is increased multi-sensory (Clark & Paivio, 1991) and emotional input. As presence, and thus emotional responsiveness, increases, so therefore should memory retention. The stronger an emotional reaction to a stimulus, the stronger the memory will be (Christianson, 1992). Additionally, when subjects feel presence in a VR experience, what they experience feels like something that is actually happening to them, instead of something they simply observed.

In one recent study, participants were presented with either a 360° VR video or a 2D video of a motorcycle ride, followed 48 hours later by a memory test. The results showed that the VR group performed twice as well as the video group in the memory recollection test (Schone et al. 2017). The researchers explained the performance differential by hypothesizing that immersive VR experiences become part of an extensive autobiographical associative network, whereas conventional video experiences remain as memories of isolated episodic events.

These findings are supported by a common observation from people who have watched a cinematic 360º video experience (in headset) that, when reflecting retrospectively on the experience, it feels more like a memory of something that actually happened to them (autobiographical associative network), than just a memory of a video of something that happened to someone else. The more presence that a subject feels during an experience -- the more sensory and emotional input associated with that experience (Ramachandran, 1998) – the more that the brain processes the memory egotistically, just as it would process a memory of something that happened in real life. Recollection of an autobiographical memory seems to be much stronger than the memory of an isolated episodic event. (Schone et al. 2017).

Repeatable and controlled exposure to emotional stimuli

Another powerful attribute of VR that stems from presence is that our emotional and physiological response to stimuli is closer to what we would experience in real life situations. This finding is most strongly supported by decades of research showing that VR can be used to treat phobia disorders and post-traumatic stress disorder, or PTSD (Rizzo et al. 2014). While in a VR experience, patients can be repeatedly exposed to a stressful stimulus in safe conditions, which, over time, reduces the stress or fear response to that stimulus. Additionally, because the experience is virtual, subjects can be exposed to varying levels of intensity (or dosage) of the experience (Bohill et al. 2011). Being able to apply dosage is important because the subject can become gradually accustomed to stronger stimuli.

The standard treatment for patients with a phobia includes exposure therapy in which the source of the patient's phobia is presented in increasing intensity. And in fact, any stressful situation can be turned

into a safe VR experience, from seeing a snake or entering a plane to dealing with an angry customer. The subject could experience the VR versions of these scenarios repeatedly and with slowly increasing levels of intensity to reduce their stress or fear response over time.

Isolation from distractions

A smaller, less-researched attribute of VR, but a practical one nonetheless, is the isolation and freedom from distraction that headsets provide. While it may sound Orwellian, this isolation is less about being trapped inside a headset and more about the increased engagement offered by VR. The more engagement and interactivity they experience, the less likely people are to feel the urge to check their phones or move on to the next distraction.

In today's world, even if we're binge-watching an incredibly addicting show on Netflix, we're still prone to checking our phones every once in a while. Yet addiction research has shown that keeping the attention focused on a specific activity reduces the impact and occurrence of addictive urges. By providing a sensory rich experience in a VR headset, therefore, it is likely that engagement in the content will remain high as long as comfort levels remain high. Also, it helps that to check their phones, someone watching VR would have to go through the steps of removing the headset and taking the phone out. Part of the reason that we check our phones so often is because it's such an easy urge to act on.

Safety

Another wonderful thing about VR is that it provides so many of the benefits of training in a physical environment without the accompanying safety risks. If a subject becomes overwhelmed, they can easily take off the headset or adjust the experience to be less overwhelming. This simple fact makes it imperative that companies prioritize finding ways to utilize VR for training to its fullest extent before moving to training that has any safety risks to the trainee.

No one should handle dangerous equipment or be exposed to potentially hazardous environments without first gaining as much preparation as possible in a safe environment. VR can provide that. It is even likely that in the future, people will be able to do the work itself remotely via VR and remove any safety risks altogether.

Previous Research

Researchers to date have broadly examined three major types of skill acquisition through VR – cognitive, affective, and psychomotor – each of which is described in more detail in the following subsections. While their research has not been extensive, it does provide some early indications of the effectiveness of VR.

We note that most of this research was conducted on hardware that is now outdated. The industry has been moving so fast that the standards and quality of hardware and content from even two years ago are dramatically different to those we see in VR today

Cognitive skill acquisition

Cognitive skill acquisition includes the learning and processing of different types of information. Based on research reviewed by Jensen and Konradsen (2017), cognitive

skill acquisition via head-mounted display (HMD) is usually similar in effectiveness to that of in-person instruction and, in certain cases, is actually more effective than in-person instruction.

Specifically, research shows that VR instruction is more effective than traditional instruction when used for learning visual and spatial information. “When used specifically to help the learner remember and understand visual and spatial aspects of a place, the low-interaction virtual experience seems to have an advantage over non-HMD instruction. In cases where the learning involved more basic fact recollection that wasn’t visual or spatial, normal classroom teaching was more effective” (Rasheed et al. 2015).

Clearly, the effectiveness of VR as a training tool for cognitive skill acquisition will be specific to the skills in question. It is also worth noting that in this case, VR is being compared to in-person training, but for most applications of training it is more relevant to determine if VR is more effective than video or text-based training.

Psychomotor skill acquisition

Psychomotor skills involve coordination and the execution of simple or complex physical movements. Research shows that the effectiveness of VR training for psychomotor skills depends primarily on simulator fidelity. In other words, the more realistic the VR training, the better the learning outcome.

The more complex the technique being trained, however, the harder it is to achieve simulator fidelity. As a result, the effectiveness of VR training for more complex psychomotor skills is actually limited. Given the state of VR today, “in cases where the psychomotor skill is related to the movement of the head, such as visual scanning or observational scanning or observational skills, the current technology offers high simulator fidelity.” However, other types of psychomotor training would require better peripheral technology to achieve higher simulator fidelity. “For the plethora of other psychomotor skills that require physical interaction with specific artefacts and your surroundings in general, efficient psychomotor skills acquisition with HMDs will not be possible until there are significantly improved peripheral technologies for including the user’s body movements into the simulation” (Jensen and Kondradsen, 2017).

Scanning a virtual environment in a headset is very similar to scanning an environment in real life, so the learning outcome for this type of training is likely to be strong. This finding suggests a promising direction for training scenarios, such as using VR to help users get better at scanning an environment for safety hazards. In fact, Ragan et al. (2015) studied a system for teaching a scanning technique in which the task was to identify armed targets in an urban setting. Perhaps not surprisingly, they found that the more realistic the training scenarios, the better the resulting technique

Affective skill acquisition

Affective skills involve the controlling of feelings or emotions. They are related to interpersonal and social skills, in which human emotions play a crucial role. While there is less research to date on this type of training than on others, there are several reasons that this is a promising place to use VR. “Training simulators for affective skills are less dependent on immersive peripheral

devices that include your bodily movements in the simulation, and more dependent on the ability of the simulation to evoke an emotional response in the learner" (Jensen and Konradsen, 2017).

As we saw earlier, one reason that VR is so effective is that emotional responses can be created by exposure to the VR experience in way that isn't possible with 2D video, given the effects of presence. We can already see evidence to support this in the way that VR is being used to treat phobias (Anderson et al. 2013) and to practice stress management (Pallavicini et al. 2016). And there are only two ways to elicit an emotional response – through a live session or through VR – with the latter being the more scalable and affordable of the two. This knowledge could be used to develop training scenarios that include experiences in which users can practice remaining calm when confronted with a stressful situation, from an angry colleague or customer to a chaotic factory floor.

Conclusions from previous research

Overall, there is some promising early research that points towards a few areas in which additional research should be conducted. For example, we can determine that VR is currently most suited to the training of cognitive skills related to remembering and understanding spatial and visual information and knowledge; psychomotor skills related to head movement, such as visual scanning and observational skills; and affective skills related to controlling emotional responses to stressful or difficult situations.

There is not yet enough research for these results to be definitive or entirely inclusive of all the potential ways in which VR can be effectively used for training. In addition, all of this research should be evaluated within the context in which it was conducted, including now-outdated VR hardware and content.

Nonetheless, we have a starting point. Despite a much lower quality of experience, a lot of these studies have still been able to show promising results for the potential of VR as a highly effective training technology. Additionally, a lot of the barriers addressed in these studies have now been overcome or are in the process of being eliminated. For example, Shone et al. (2017) stated that , "For HMDs to become a relevant tool for instructors, [the instructors] must have the ability to produce and edit their own content. This is starting to happen with content based on 360 degree video footage, and currently the most promising use of HMDs in education may not be educational VR simulations, but the HMD as a viewer of 360 degree video content, which can form the basis of subsequent educational activities such as classroom discussions, written analysis, group work, or assessments."

These production and editing tools exist today – just look at what we're doing at eevo – and the creation of 360 video experiences is becoming increasingly accessible.

Next Steps

Having covered some of the fundamental ways in which VR is effective for training, we can outline the actionable steps that companies can take to capitalize on this opportunity for innovation.

Step 1: Examine your curriculum

Companies should first take a step back to evaluate their entire training curriculum. This may seem tedious, but others have found this step to be one of the most valuable they have taken. According to Keith Daly of Farmers Group Inc., taking the opportunity to "discover gaps in your curriculum that you might not have otherwise found… can give you the opportunity to improve your training, adding value to the employee experience and strengthening customer service" (Keith Daly, "We Used Virtual Reality as a Training Tool. Here's What We Learned").

Step 2: Identify opportunities for testing

After examining their curriculum, companies should identify the portions that could potentially benefit from VR, using the attributes outlined previously as a guide. The research discussed so far should provide a starting point for identifying whether VR could be a good fit.

VR is more memorable

As shown in the research by Schone et al. (2017), subjects who trained with VR video performed twice as well on memory retrieval tests in the subsequent 48 hours as did subjects who trained with 2D video. Given this research, VR should be explored as a viable option for any training that involves memorization, especially of spatial or visual information.

This finding is particularly relevant for the examples discussed previously, such as fire safety training, in which using VR not only reduces distractions but increases the retention of critical safety information. To go further, because fire evacuation training is also spatial and visual in nature, research suggests that VR training could be even more effective than in-person training (Rasheed et al. 2015). In conclusion, for any training in which memorization is critical, VR should be examined as a potential option for increasing training effectiveness.

Isolation from distraction

Are there any portions of the training curriculum that are critical but not necessarily engaging? For example, fire safety training is something most employees (or students) will generally ignore, or pay very little attention to, even though engagement with this training has the potential to save lives. Oftentimes in evacuations, everyone goes to the most visible or familiar emergency exit path, ignoring other exit routes.

In fact, Kinatader, Communale, and Warren (2018) have found that exit route familiarity influences evacuation behavior, which leads to slower evacuations because of heavy foot traffic in some exit routes, while other routes remain almost unused. Transferring training procedures that rely on focused engagement and freedom from distractions, such as fire safety training, to a VR platform can be both a practical and an ethical choice.

Repeatable and controlled exposure to stimuli

This attribute of VR is applicable to many different types of training. It has already been proven effective in training people to get more comfortable with public speaking by letting the user practice in front of varying crowd sizes. This feature of VR training can also be used in any way that

requires the employee to become habituated to potentially stressful situations. For example, VR could be used to improve CEO performance when giving keynote presentations by reducing the stress response to public speaking through repetition. Customer representatives could practice being confronted by angry customers, while learning to remain calm. And HR staff could learn to mediate heated conflicts between employees.

There are a number of ways in which VR could be applied to make use of this important attribute, providing the ability to practice and train in way that was previously only possible through repeated experience or specialized and expensive in-person training.

Safety

This is the most important attribute, as we cannot place a value on a human life. All companies should explore any and all potential technologies that could help increase the safety of their employees. If a company engages in any activities that expose its employees to health risks, it is worth immediately conducting tests to determine if VR can help reduce those risks.

A simple, yet useful training application for any company that operates factories might be one that familiarizes employees with the facility floor. The company could add onto this training by having employees identify potential health hazards or by training them on the proper emergency and evacuation procedures even before they set foot in the facility. And since this training involves scanning behavior, previous research reviewed here suggests that VR would likely be an effective tool for this type of training.

Step 3: Start testing with linear and interactive 360° video

Some VR use cases will achieve outstanding results, whereas others may not have the same outcomes, given the current limitations and attributes of the technology. And, while previous research may point us in the right direction, only testing and iterating the various uses of VR will lead us to the best results.

As highlighted by one of the researchers, given the state of VR and available tools, the use of more-limited 360° videos may be the best way to start using VR technology for training. 360° video is much more cost-effective and scalable than going full out to create computer graphics or live-rendered content for the Oculus Rift and HTC Vive headsets. It also performs well on mobile VR platforms such as GearVR and the upcoming OculusGO. In addition, 360º video today is simply more realistic. Knowing the importance of simulation fidelity, we therefore have good reason to believe that it will lead to better training outcomes.

Additionally, previous research has found that a limiting factor in the effectiveness of VR training is that people can be easily overwhelmed by fully interactive (six degrees of freedom) and room-scale VR experiences. In contrast, 360º video and interactive 360º provide much more accessible experiences, while still giving users the opportunity for simple interactions.

Using 360º video, the tools and software available today should make it easy to get started on testing different use cases.

Step 4: Measure results

Since results will likely vary depending on each specific use case, measuring effectiveness is critical. Determining which results to measure and how to measure them will therefore be important parts of the planning process. The most straightforward solution is to work with a partner or software that provides in-depth analytics on any of the training content being tested.

Step 5: Scale fast

It is not so much a question of *whether* to use VR for training as it is a question of *when* and *how*. Without doubt, most companies of any significant size will offer opportunities to use VR as a training tool.

If they find a good use case for VR training, these companies will already be ahead of many others, but if they are to take advantage of that lead and have it boost the bottom line, speed of implementation and scale will be critical. Companies should therefore take the time to identify the appropriate tools and workflows that will allow them to scale up rapidly once they determine the most effective training use cases.

Conclusions

As we can see, there are substantial reasons to use VR to improve training exercises. No prior technology has shown as much potential to revolutionize the way we provide employees with the knowledge and skills to succeed (and stay safe).

Our most important takeaways include the fact that VR is different to previous technology because of its ability to generate presence, which leads to more memorable experiences. In addition, VR provides repeatable and controllable exposure to stimuli, isolation from distractions, and increased safety vis-à-vis in-person training (or failure to train).

While previous research is limited, results are particularly promising given that the research was completed using what are now outdated hardware and content.

In conclusion, it would be both highly effective and ethically responsible for companies to develop viable use cases for VR training and education. Given this conclusion, we have also provided a framework through which to take tangible action, including an emphasis on testing with linear and interactive 360° video while building the foundation of scalable VR training processes.

References

1. Banakou, D., Groten, R., Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. *Proceedings of the National Academy*
2. Bohil, C. J., Bradley, A., Biocca, F. A. (2011). Virtual reality in neuroscience research and therapy. *Nature Reviews: Neuroscience*, 12, 752-762.
3. Christianson S. Å. (1992). Emotional stress and eyewitness memory: a critical review. *Psychol. Bull.*112 284–309.
4. Clark, J.M. and Paivio, A. (1991) Dual coding theory and education. *Educ. Psychol*. 37, 250–263
5. Jensen, L. & Konradsen, F. (2017). A review of the use of virtual reality head-mounted displays in education and training. *Educ Inf Techno.* https://doi.org/10.1007/s10639-017-9676-0
6. Keith Daly, "We Used Virtual Reality as a Training Tool. Here's What We Learned". Url: https://www.entrepreneur.com/article/311288
7. Ragan, E. D., Bowman, D. A., Kopper, R., Stinson, C., Scerbo, S., & McMahan, R. P. (2015). Effects of field of view and visual complexity on virtual reality training effectiveness for a visual scanning task. *IEEE Transactions on Visualization and Computer Graphics*, 21(7), 794–807.
8. Ramachandran,V. S. (1998). Consciousness and body image. *Philosophical Transaction of the Royal Society* B,13. 353(1377), 1851-185.
9. Rasheed, F., Onkar, P., & Narula, M. (2015). Immersive virtual reality to enhance the spatial awareness of students. *Paper presented at the 7th international conference on human computer interaction, IndiaHCI* 2015.
10. Rizzo, A. A., Schultheis, M., Kerns, K. A., & Mateer, C. (2004). Analysis of assets for virtual reality applications in neuropsychology. *Neuropsychological Rehabilitation,* 14(1-2), 207–239.
11. Schöne, B., Wessels, M. & Gruber, T. (2017). Experiences in Virtual Reality: a Window to Autobiographical Memory. *Curr Psychol.* https://doi.org/10.1007/s12144-017-9648-y
12. Slater, M. (2003). A note on presence terminology. *Presence Connect*, 3(3), 1–5
13. Slater, M., & Sanchez-Vives, M. V. (2014). Transcending the self in immersive virtual reality. *Computer*, 47(7)24-30.