Virtual Reality in Workplace Learning

Affordances, Limitations, and Future Directions

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The interest and use of Virtual Reality (VR) technology for workplace learning has been increasing and is projected to increase further based insights from scholarly literature, industry reports, and interviews with organization and learning leaders. We present and discuss perceived affordances, limitations, and future directions of VR learning based on interviews with 21 workplace learning leaders across sectors and industries. Perceived affordances include: (1) simulation of dangerous or difficult real life scenarios, (2) interpersonal and leadership skill development, (3) affordability, (4) data and assessments, (5) social learning, and (6) bridging the real and virtual. On the other hand, perceived limitations include: (1) limitations of experiences in VR, (2) hardware bottlenecks, (3) costs, and (4) limited acceptance of VR learning. Many study participants anticipated improvements in VR hardware fidelity and comfort, simplification of VR learning creation, and expansion of AR learning opportunities, while some anticipate no significant changes in VR learning opportunities and adoption. We also discuss recommendations for VR instructional design and implementation and various directions for further research.

Virtual reality (VR) learning can be broadly categorized into games, simulations, and virtual worlds (Hamilton et al., 2020). Recent findings demonstrate that it is increasingly more common for companies to: (1) purchase VR headsets for employee use and (2) develop or purchase VR learning programs (Xie et al., 2021; J. Timmons, personal communication, June 29, 2022). There are multiple factors that contribute to the rising prevalence of VR learning in the workplace, including advances in technology (both hardware and software), reduced cost of VR headsets and VR application development, and the impact of working from home due to the Covid-19 pandemic (Sinha, 2022; A. Tumasin, personal communication, July 6, 2022).

Based on industry reports and interview data, just like how the advent of E-learning did not completely replace Instructor-Led Training (ILT), VR learning likely will not completely replace either ILT or E-learning. It is expected that VR learning will be an additional channel for learning within the ecosystem of options (Hernandez et al., 2021). The purposes of this article are, through analysis of publications and interview data, to help the community see what the impact of VR learning could be and why that is the case based on specific characteristics of VR. As VR becomes increasingly common in learning environments, there is a need for scholarship on the design of such environments. The insights discussed will provide instructional designers and other learning practitioners approaches for working with VR.

This article presents the ways that learning leaders across multiple industry sectors use and describe VR learning as a way to understand an expanded ecosystem of learning options. We discuss features, limitations, future directions, and associated principles to consider when designing VR learning. We discuss each affordance and principle through the lens of instructional design practice.

Literature Review

Workplace Learning

Workplace learning entails learning through and from paid employment, including on-the-job learning, occupational practices, and work activities and interactions within workplaces and work practices (Billett, 2012). Workplace learning theories have some themes in common, including a focus on individual learners, stressing rational and cognitive aspects of workplace performance, viewing performance as thinking followed by application of thinking, and recognition of the role of social, organizational, and cultural factors in shaping workforce learning and performance (Hager, 2011). For knowledge workers, workplace learning entails awareness of competencies, identification of learning needs based on requirements or responsibilities, and is initiated by the perception of a gap between knowledge or competencies and what is needed for certain tasks (Siadaty et al., 2012).

VR Foundations

To better understand the applications of VR, it is helpful to distinguish VR from augmented reality (AR). Milgram and Kishino (1994) described a Reality-Virtuality Continuum: a continuous scale based on how much of a person's experience is virtual, with completely real or physical on one end and completely virtual or simulated at the other end. In their scale, AR is close to the experience of a real environment, with digital elements layered onto the real world. VR is a simulated environment in which the user "is immersed in and interacts with a synthetic world (virtual environment)" (Zahabi & Razak, 2020, p. 725). Augmented Reality (AR), on the other hand, "allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it" (Azuma, 1997, p. 2). While VR leverages real-life data to generate simulated phenomena that people can see, hear, feel, and smell, AR renders and layers virtual images over the real world. VR uses Head-Mounted Display (HMD), positioning devices, motion capture, and interaction devices. AR uses cameras and imaging devices to interact with the real world. While VR is immersive, AR takes people into an intertwined real-virtual world (Pu et al., 2022).

Early attempts at providing a VR experience include panoramic paintings of the nineteenth century, which intend to make the viewer feel present at a different location (Virtual Reality Society, 2020). The aviation industry was an early adopter when it began using flight simulators. The development of cost-effective HMD and software packages to enable non-VR developers to create their own content have made VR accessible to many people (Likens & Mower, 2022). This is driving the adoption of VR across various industries including gaming (Xie et al., 2021).

VR Learning in the Workplace

An enterprise headset currently costs less than $1,000 USD and such units can be managed like other enterprise mobile devices to be used repeatedly for training delivery (Likens & Mower, 2022). With the price of headsets generally reducing, increasing numbers of companies are purchasing them for employee use, especially for training (Hernandez

et al., 2021). Disciplines where VR is being successfully deployed for training include medical training, patient rehabilitation, military training, aeronautics, architecture and engineering education, manufacturing, employee interpersonal and leadership skill development, transportation, and athletics (Hamilton et al., 2020; Xie, et al., 2021; Zahabi & Razak, 2020).

Workplace VR Learning Within the Metaverse

Real and virtual experiences for social, consumer, and organizations, including learning, will become intertwined in the metaverse because of AR and VR (Bobier et al., 2022). The metaverse is "a seamless convergence of our physical and digital lives, creating a unified, virtual community where we can work, play, relax, transact and socialize" (Moy & Gadgil, 2022, p. 3). It is considered "the next evolution of the internet" and will consist of "a continuum of rapidly emerging capabilities, use cases, technologies and experiences" (Accenture, 2022, p. 2). The metaverse is expected to be "the next significant paradigm for how we use digital technologies and networks to interact and collaborate with others and have virtual experiences of all kinds" (Blau et al., 2022, p. 3).

It is expected that among many other activities, people can "purchase and sell goods and services, sign and enforce contracts, recruit and train talent, and interact with customers and communities" in the metaverse (Likens & Mower, 2022). Recent forecasts project that employee learning and development will be the second most predominant enterprise use case of the metaverse (Elmasry et al., 2022).

Methods

The purpose of this research was to explore the affordances, limitations, and future directions of workplace VR learning. We interviewed 21 workplace learning leaders across industries and sectors who have experience with or interest in VR learning and reviewed relevant academic and industry publications. Specifically, the 21 participating workplace learning leaders represented healthcare, corporate, and industry research fields, as well as the government and military sector. The titles of the participants included: CEO, CLO, co-founder, director of learning, learning architect, and learning experience designer. See Table 1 for a description of each participant. There has been little recent research and analysis on the features, affordances, limitations, and future implications of VR learning in the workplace as a result of the shifts in the modern workplace and the Covid-19 pandemic.

Table 1

Interview Participants

Participant	Industry/Sector	Role	Location
1	Government	Learning Leader	USA
2	Corporate Learning Solutions	CEO	Netherlands
3	Military	Learning Architect	USA
4	Healthcare	Learning & Development Specialist	USA
5	Healthcare	Learning Director	USA
6	Healthcare	Chief Learning Officer	USA
7	Corporate Learning Solutions	Interactive Script Writer	USA
8	Healthcare	Learning Technology Partner	USA
9	Military	Training Leader	Singapore
10	Corporate Learning Solutions	Consultant	USA
11	Corporate Learning Solutions	Learning Solutions Architect	USA
12	Corporate Learning Solutions	Consultant	USA
13	Corporate Learning Solutions	CEO	India

Participant	Industry/Sector	Role	Location
14	Learning Technology Research	Co-founder	USA
15	Technology	Learning Experience Designer	USA
16	Military	Learning Leader	USA
18	Corporate Learning Solutions	Founder	USA
19	Healthcare	Design & Innovation Consultant	USA
20	Academia	Instructional Design	USA
21	Military	Human Capital Development Leader	USA

Research Questions

1. What are the perceived strengths of VR learning?
2. What are the perceived limitations of VR learning?
3. What do scholars and interviewees describe as the future directions of VR learning?

Research Design

We adopted a qualitative, exploratory approach to provide clear understanding of VR use for training. We studied 21 leaders and senior professionals in learning and development roles across industries. The study employed a purposeful sampling method: each person interviewed had at least 10 years of experience designing, facilitating, or managing learning programs for organizations (see Table 1). We also analyzed academic and industry publications. The interview transcript and publication data were triangulated through pattern-matching, explanation-building, and cross-case synthesis.

Interviews

The qualitative interviews were conducted over an online video conference tool. Both the participant and the interviewer were in private rooms. The interviews lasted up to 75 minutes. The interviews were recorded with the permission of the research participants so that the recordings could be transcribed and analyzed. The interviews were semi-structured. We took steps to preserve the confidentiality and anonymity of the interview participants and data.

Data Analysis

Our qualitative analysis utilized procedures intended for exploratory and inductive research (Corley & Gioia, 2004; Corbin & Strauss, 2014; Creswell, 2014; Gioia et al., 2013; Lester et al., 2020). This approach informed the completion of four analytical steps. First, we reviewed the raw interview transcript and article data, adding interpretation of salient sections in order to establish first-order codes (Van Maanen, 1979). Second, we analyzed the first-order codes asking ourselves, "What is happening here?" to establish second-order codes. Next, we grouped similar second-order codes into categories. Lastly, the categories were combined into aggregate dimensions that we labeled as themes. Across these four steps our data analysis was an interpretive process (Creswell, 2014; Gioia et al., 2013; Lester, et al., 2020). Once we established the themes, we next asked ourselves, "How are these similar?" We then clustered each theme based on similarity, and for the duration of this paper refer to each cluster of themes as a category. In sum, the themes and categories serve as our initial findings.

Findings

The findings from our research are presented as themes under the following three categories: (1) perceived affordances of VR learning, (2) perceived limitations of VR learning, and (3) perceived future directions of VR learning (see Table 2). We next discuss each category using data from interview responses, scholarly literature, and industry reports.

Table 2

Perceived affordances, limitations, and future directions of VR learning

Category	Theme
Perceived affordances of VR learning	1. Simulation of dangerous or difficult real-life scenarios
	2. Interpersonal and leadership skill development
	3. Affordability and cost savings
	4. Data and assessments
	5. Social and collaborative learning
	6. Bridging real and virtual
Perceived limitations of VR learning	1. Limited experiences in VR
	2. Hardware bottlenecks
	3. Costs
	4. Limited acceptance of VR learning
Perceived future directions of VR learning	1. Improved hardware fidelity and comfort
	2. Simplification of VR learning creation
	3. Expansion of AR learning
	4. No significant change

Perceived affordances of VR learning

1. Simulation of Dangerous or Difficult Real-Life Scenarios

Multiple participants discussed the ability to simulate experiences that would be dangerous or difficult in real life. For example, in preparing for medical and nursing exams, learners can interact with a virtual human body, manipulating bones and organs. VR surgical simulations are "mature" according to a participant. He shared:

> [...] we need people to practice and in healthcare [VR learning is] huge because you don't want to practice on a live person and have them bleed out on the table [...] Hand recognition has come so far. The fact that it can see what you're actually touching and doing.

Interview participants shared that VR learning can be used in heavy construction and industrial manufacturing settings to train people on equipment and vehicles. For example, VR serves as an effective mechanism to simulate infrastructure repairs. One participant described:

> If you're working on a pipeline [...] got to make sure we're not going to dig in a place that's going to blow up the whole neighborhood, and so they would let you blow up the whole neighborhood in virtual reality because you'll know never to do that in real life.

Additionally, several participants shared flight training examples. Various conditions or circumstances can be simulated in VR that would be difficult or impossible to simulate in in-person training reliably and safely, for example certain weather conditions. Another participant commented:

> They put people in a robbery simulation where the store was being robbed [...] People said, 'Oh my God, I now know what to do, like I've been told the procedure and the policy, you know, give the cash or hit the floor [...] I never really got it until I was in that situation.

2. Interpersonal and Leadership Skill Development

A participant shared that the range of categories of interpersonal skill development in VR environments is broad, including "emotional intelligence, and empathy, decision making, and sympathy." VR simulations can create powerful interpersonal skill learning experiences that may not have been possible previously, for example, with diversity, equity, and inclusion. One participant asked, "do you know what it's like to experience things through someone else's eyes? We couldn't do that before [...] and now we can put you in a completely different world as someone else and feel things that you couldn't feel."

Through VR learning, organizations can help leaders learn to conduct performance management conversations and help their employees feel psychologically safe. One participant shared, "having them practice this kind of stuff without real employees in safe spaces in an immersive way has made VR very attractive."

3. Affordability and Cost Savings

Though VR learning generally requires investments in hardware, VR program development, or licensing, there are numerous potential cost savings. One participant described:

> If you compare it to the cost of actually acting out live simulations [...] [it] is quite a bit cheaper than that and much more efficient that you don't have to send people away anywhere. They can just sit in their own offices and do this on their own time.

For machinery training, one said: "I don't have to run the real machinery and incur the operations costs, the depreciation costs, the repair costs, the potential risk of damaging the equipment." Travel time associated with training is also reduced. The same participant said that with VR learning, "we have managed to reduce our training time by close to 50% and we reduced our annual training cost by up to 40%." Several participants described the costs to develop VR learning programs have been declining. "The cost is not as high as what you would think [...] if your company is [...] investing in E-learning they can invest in VR," as one participant described.

Another avenue of cost savings is the ability to focus on specific scenario types and training segments. In other words, being able to focus on or repeat key parts of the simulation. One participant elaborated:

> In the traditional context, if you start a certain training, you have to complete the training from start to end, although with the simulator system we are able to decide where to start training. I just teleport you to that place and then you continue with what you need to learn.

4. Data and Assessments

A key capability of VR technology is collection of learner performance data, which can help to optimize individual learning journeys and, when combined with data from other learners, the learning of larger audiences (e.g., classes, cohorts, or populations). VR learning programs could include pre- and post-assessments of performance. At the start of a program learners could complete an assessment and:

> [...] it could sort of give them an opportunity to interact with an avatar, or assemble a widget, perform a process before they've really learned anything. One way or another, you can use that as a baseline. And then, at the end [of the training], you could do the exact same assessment [...] [to] evaluate how much they learned or how much they attained.

Several participants discussed live feedback and adaptation to learner performance, for example, "you're practicing sales skills and [...] are talking to this avatar, but it recorded your body language, recorded your words, and the avatar reacted as a real person would." Another said you can "hook up with other modern technologies like natural language understanding, and that transcribes what's being said and then can give you feedback on how you performed." Zahabi & Razak (2020) describe this adaptation to real time performance as dynamic adapting.

Eye tracking is a feature currently available in VR headsets, which can help people, for example, practice public speaking: "you can make eye contact with the people in your audience and not only that, but it'll track the eye contact that you're making, if you're making eye contact." This program can also provide feedback on your delivery such as, the number of times a person says "um" or other fillers.

5. Social and Collaborative Learning

Participants described a variety of possibilities for social and collaborative learning in VR experiences, involving multiple people at the same time. It could be as simple as "having someone just there as an eye in the sky, watching what's going on and providing some assistance." There are simulations for multiple learners at the same time:

> they all jump into the same scenario or lab or office or mine and they can have one person leading to show them what to do, or you could have a group of people who are collaborating to complete a task.

VR learning experiences could begin as solo experiences and layer to involve more people. In the military context, individuals often focus on solo drills and competencies and then as they progress, they work with more people. A participant stated, "in this simulated environment, we train not just your individual skills, we train your crew level, close proximity peers, integration and communication, all the way to being able to communicate and act in concert with up to 600 people."

Some options for social learning in VR are simple and cost free. One participant described:

> I don't have to create any content to go into VR. All I have to do is to go into one of the open, free apps, like Engage, Spatial, AltspaceVR, and there's VR chat [...] we'll break out into small groups and talk... so they're getting the experience, what it's like to learn and use virtual reality... where we're talking about social learning, situation learning, learning from each other in groups, just like we do in a classroom setting.

6. Bridging Real and Virtual

Several participants described the valuable applications of passthrough, or layering, in VR learning. One described this as having "an augmented experience in the VR space, so it can track the room simultaneously while you're in a totally other world. You can also just see the world in front of you." For example, with an AR device, a person can look at information provided by the device while working on machinery.

In an onboarding context, a participant described that you can have a learner wear an AR device "who has never done something before, and they can do it with 100% accuracy while still learning it." In some contexts, it is preferable for learners to interact with real machinery and controls instead of VR simulated controls, so that "they remember this is the tactile feel," as one participant described. In this way, AR can help bridge between VR and real learning environments.

Perceived Limitations of VR learning

1. Limits of Experiences in VR

Many VR learning experiences are individual, with one participant wearing a headset and completing a solo learning experience, for example a VR E-learning simulation in which they are interacting with an environment, simulated equipment, or avatars. The solo nature of many of these learning experiences can mean limited applicability in team or group learning experiences. VR learning experiences for teams or groups are generally more complex to design and may need facilitation. At present, VR is not capable of providing large groups the same immersive experience (Xie et al., 2021).

For some audiences and types of work, hands on and in person learning are predicted to remain the dominant approaches to learning. For example, one participant described that live interpersonal skills training is required to be a psychological therapist:

> *They do have the ability to be observed in real time [practicing therapy]... to record them and to give them feedback on that is required, in some cases for their programs... I think by the nature of what psychologists do, [VR learning is] unnecessary.*

VR learning experiences tend to be limited in duration, whereas in-person or computer-based learning experiences can take place over much longer timeframes and therefore go into more depth and breadth of learning content. Based on current hardware and software for VR, some people may develop disorientation or discomfort relatively quickly.

Another perceived limit of VR learning experience is the ability of pre-programmed or artificial intelligence bots (avatars) to react and behave convincingly throughout simulations. A participant explained, "imagine you're in the middle of a learning practice activity and the bot isn't quite understanding. It's pulling you out of the immersion." Though the technology may improve over time, for the time being there is "potential for an AI bot to create more problems than to be more helpful."

2. Hardware Bottlenecks

VR learning is inherently dependent on hardware. Many people are not familiar with VR headset usage and the lack of familiarity can be a hindrance to VR learning initiatives and broader adoption. Headsets used in workplaces or those shipped back and forth by organizations for employee usage need to be cleaned and maintained. The logistics for cleaning and maintenance need to be factored in. In addition, organizations need to make sure all software installed on headsets is up to date. Dependence on hardware can limit scalability of VR learning initiatives, which means these experiences may remain niche or for specialized uses. One participant described that if an employee needs to complete an E-learning program, access to the program can easily and quickly be sent to them via their laptop or phone. With VR learning, there can be a "bottleneck that exists around the devices." While employees can access E-learning on their laptop or phone, "we can't do that same thing for VR [learning experiences] because we just don't have the expectation that everyone is going to have a device [...]"

3. Costs

Several participants discussed the costs involved in implementing VR learning and believe the costs are high, particularly for some organizations. They talked about the "high investment" needed for both course development and hardware. One participant described it is "challenging for smaller organizations to actually implement" VR learning based on costs and resources needed. Though affordability and cost savings were described as one of the perceived affordances of VR learning, for training experiences that would be dangerous, difficult, or inconvenient to arrange in real life. For other types of training experiences or learning needs VR learning was seen as more costly than existing methods.

4. Limited Acceptance of VR Learning

In some organizations, VR learning is not seen as a priority. VR is seen by many as a technology for entertainment, which may limit its acceptance in workplace learning applications. A participant described that due to the increase in popularity and availability of a major VR headset device, "there's become a little bit more mainstream use of virtual reality as... an entertainment tool in our lives... I still think it's a little bit of a novelty." Some people may have an aversion or hesitation to wear headsets and try VR experiences altogether. One learning leader described, "I think putting on a full headset kind of freaks some people out..."

Perceived future directions of VR learning

1. Improved Hardware Fidelity and Comfort

Several participants discussed expectations of hardware quality increasing, for example headsets becoming more comfortable. Participants described that as hardware quality improves, and if prices remain affordable and competitive, wider populations are expected to have their own or have access to headsets. Upcoming generations of headsets are expected to sense our facial expressions and allow our avatars to display them. As facial expression tracking improves, more feedback can be provided to learners in interpersonal simulations. For example, when a learner is trying to sell or

negotiate in a simulation, the learning application can provide feedback on the appropriateness or effectiveness of the learner's eye contact and facial expressions.

One participant described the importance of training their learners on machinery they will be using in their roles because it is important for learners to have tactile knowledge. Future generations of VR hardware are expected to have improved haptics, which are reproductions of tactile sensations that would be felt by interaction with physical objects. This could alleviate the need to train learners on machinery. Similarly, olfactory VR is an emerging dimension of VR learning, which can have a range of applications. A device that releases a range of scents can be worn and paired with a VR device. As one participant stated:

> What if you brought in the smell of the airplane, or the smell of electrical fire in the airplane [into the training]? [...] Smell is the strongest sense we have, connected to the limbic system, which creates all the memories and emotions and muscle memory.

2. Simplification of VR Learning Creation

While advanced technical knowledge was required to create early generations of VR learning, today there are multiple VR learning providers who have created and are offering software that lets instructional designers create their own VR learning offerings relatively easily (Likens & Mower, 2022). As one participant described, "they're creating software that you as a non-VR developer, coder person [...] can build your own VR environments and scenarios and create branching scenarios through VR."

VR learning providers are also creating libraries of learning options that individual consumers and organizations can purchase. Another participant shared, "we are seeing marketplaces [...] where organizations of all sizes can just go buy an off-the-shelf VR program."

Creating learning pathways in VR simulations can become much simpler in the future with the support of artificial intelligence. One participant, who designs VR learning simulations, described:

> I'm writing choices. It really is just a glorified branching multiple choice test where you put people in a little scenario and then you basically say, 'what would you do next?' [...] The Holy Grail is that you wouldn't have to write those scripts because you know that artificial intelligence would be so sophisticated that the learner would say something and the avatar or whatever would recognize enough of what he's saying to respond in an appropriate way and then the branching would happen more organically.

3. Expansion of AR Learning

Although the focus of interviews was VR learning, and AR learning was not explicitly part of our interview protocol, several participants discussed the value of AR to bridge real and virtual environments and the future opportunities and potential of AR. Some participants described AR learning as having lower barriers to adoption and greater usefulness than VR learning. One described that AR can already be accessed through our mobile devices:

> In a classroom where somebody just takes their smartphone, puts it over a trigger in a workbook page, and up comes the model, or up comes something they can look at in 3D. Or, we're in a virtual class and I put a trigger on the display and everyone grabs their mobile device and brings it to life. The potential is huge.

Another described that you can wear an AR device to see reality as it is with a digital layer over it. This technology has helped with "reducing the time to onboard people, because we could have a command center where one super user was actually supporting multiple people through [an AR device], basically stepping in drawing on their real world, guiding them through things."

4. No Significant Change

While all our study participants work in the field of workplace learning, some of them shared they believe the applications and trajectory of VR learning are not going to change significantly. This highlights the diversity of thinking within the field about future directions of VR learning. One participant described:

> I think most companies are not going to be changing what they're doing. I think some companies definitely will [adopt VR learning] and you're going to keep seeing major really cool developments, but in terms of a percentage of adoption... I don't think that it's going to [change] [...] In the [19]50s there were all these futuristic photos of what stuff's going to look like, but it still just looks like a futuristic photo and we still drive cars with rubber tires on concrete.

Discussion

Considerations for Learning Professionals When Designing and Implementing VR Learning

Jaeger (2021) found significant, positive differences in learning outcomes as a result of a four-part instructional model when designing for extended reality environments, known as the SIM (Simple Instructional Model). The four components of the model, which center around the desired learning outcome, include: "(1) Motivation, (2) Connection, (3) Medium, and (4) Assessment" (Jaeger, 2021, p. 3). While intended for designers of any extended reality environment, these four components provide a useful framework upon which to discuss the design of VR training (see Table 3).

Table 3

Components of Simple Instructional Model and implications for practitioners

Component of SIM	Implication for Practitioners
Motivation	• Gain and keep learner attention • Explain to the learner "why" they are here • Provide moments for focused reflection • Provide the learner with a model or demonstration of successful behavior
Connection	• Design for social connection to others and the world around the learner • Connect new concepts to the learner's prior knowledge
Medium	• Manage the climate of the virtual environment • Ensure clear, consistent, user-friendly UX in the environment • Leverage the virtual medium through use of a contextually relevant story
Assessment	• Provide feedback that is both direct and immediate

Motivation

The literature suggests that there are several key mechanisms designers of VR training consider to increase the motivation of training participants. First, designers should focus on gaining and maintaining the learner's attention. In VR environments, this is achieved through the use of vivid storytelling, realistic scenarios, role playing, conflict, and humor (DiCarlo et al., 2017; Huberman, 2021a; Ziv, 1988).

Additionally, because of the intensity of the audio-visual experience in VR, moments of reflection in VR training are of particular importance for the retention of learned material (Huberman, 2021b). First, reflection time momentarily

pauses the constant flow of audio-visual input that must be processed. Second, intentional reflection allows the learner to begin forming neural connections related to the learned concepts and behaviors (Huberman, 2021b). As a result, we recommend learning professionals consider inserting pauses in the training experience to allow learners time for undisturbed, focused reflection.

Next, the VR environment is ideal for providing learners with a model of desired behavior or performance. Viewing a model of success allows the learner to see a desired behavior or performance is possible and what they are about to experience is relevant. Research shows both: (1) viewing success as within one's grasp, and (2) understanding relevance, serve to increase learner motivation (Ericsson et al., 2018).

Third, designers should design training scenarios that have multiple or, ideally, infinite possible outcomes. In this manner, as opposed to a single correct path, the learners in the VR training will have options to arrive at a correct solution to the VR learning experience. Research suggests choice increases intrinsic motivation in adults participating in training (Merriam & Bierema, 2013).

Connection

While researching the Pokemon Go phenomenon of 2016-2017, Shen (2019) found "building a connection to others and the world around us enhances the attractiveness and effectiveness" of an AR environment (Jaeger, 2021, p. 8). However, as supported by many of our interviews, the same principle applies to VR environments as well (I. Luna, personal communication, July 8, 2022; L. Aaronson, personal communication, August 2, 2022). In fact, VR allows for heightened, realistic social interactions when compared to AR or traditional two-dimensional environments. Therefore, VR training experiences should include interaction or collaboration when appropriate.

Beyond social connection, research also suggests a topic's connection to prior knowledge is an effective mechanism for reducing the cognitive load on the learner in a VR environment (Petersen et al., 2020). Specifically, connection to prior knowledge serves to reduce non-essential cognitive load while maximizing the germane cognitive load, thereby allowing the learner to process and retain greater amounts of information experienced in the virtual learning environment (Kalyuga, 2007).

Medium

While the data suggests VR for training is increasing in prevalence, the immersive and virtual nature of VR training environments automatically introduces the benefits associated with the novelty effect. These benefits include increased learner motivation and extended engagement (Huberman, 2022). The factors related to the medium of VR center on the design of the environment itself. Therefore, designers should be intentional about the design and management of the climate created by the virtual environment. This includes both the social and physical components of the environment. For the social component, the ideal learning experience is one that maximizes reinforcement of desired behaviors/performance while minimizing undesired behavior (Ericsson et al., 2018). For the physical component, the graphics and visual elements should reach a level of fidelity that reasonably approximates the real environment. Additionally, the design of the physical component should also incorporate principles of clear, consistent, user experience design (including navigation, controls, buttons, etc.).

Lastly, while designing the VR environment, training designers should consider including the use of story. Research shows that storytelling in a remote environment is a particularly successful mechanism to increase learner brain activity and the production of oxytocin (Huberman, 2021a). Stated simply, a contextually relevant story causes learners in remote environments to (1) relate more to the material, and (2) care more deeply about the topic, both of which enhance retention and recall (Huberman, 2021a).

Assessment

For training designed in virtual environments, the single, most critical form of assessment is that of feedback from the system. Specifically, researchers Taylor and Clayton (2021) concluded that effective feedback in virtual learning environments must be both direct and immediate. That is, regardless of the learning experience being designed or the

knowledge/skill being developed (i.e., interpersonal, motor, decision-making, leadership, culture, language, or a combination of knowledge or skills) feedback should be directly related to the task completed and offered immediately after completion of that task. For example, in pilot simulation training within a VR environment, the direct and instantaneous feedback when a pilot makes a mistake resulting in a crash is clear and undeniable, and as a result contributes to VR's highly effective use in the training of pilots (L. Aaronson, personal communication, August 2, 2022).

Incongruence and Ethical Challenges of VR Learning

VR learning characteristics and affordances may be incongruent for informational learning necessary for types of knowledge work. For example, when learners need to learn and apply text-based policies and protocols, where the only relevant visuals are simple two-dimensional charts or images, VR learning approaches could be a hindrance or an unnecessary complication. Current approaches including E-learning, ILT, quizzes, discussion, and self-study may remain the best methods for text-based informational learning.

Additionally, when learners are co-located and are participating in group activities as part of their learning experiences, VR learning could create unnecessary distance and complications between facilitators and learners. When learners are already in the same room, it may remain easier and more productive to facilitate ideation or discussion activities involving physical flipcharts or whiteboards than hosting these activities in VR environments.

VR learning experiences may likely be diminished for those who have visual or auditory disabilities. Individuals who are neurodivergent may have varying experiences with VR learning. Some people may have physical discomfort with headsets or virtual environments. VR technology developers may be able to address some or all of these accessibility and inclusivity considerations.

Lastly, social inequity could become exacerbated if VR technology is not available across the global population. While much of the world's population owns mobile phones, which can provide some AR experiences, it is uncertain whether VR devices will become as ubiquitous. If VR remains a technology for wealthier populations, many groups around the world may be unable to participate and benefit from it.

Recommendations for Further Research

Further research should be conducted on the affordances and effectiveness of VR learning. Hamilton et al. (2020) described that game-based VR learning produces higher educational attainment than simulations or virtual worlds. Research should be conducted across industries and geographies to further validate this finding and highlight what aspects of game-based VR learning produce greater outcomes. Hamilton et al. (2020) wrote that research focusing on learning outcomes, intervention characteristics, and assessment measures associated with virtual reality has been sparse.

Companies who offer VR learning design and delivery services often highlight effectiveness data in their websites and marketing material. Further research should be conducted to validate these claims, which may have been generated from research on small, non-representative samples. Some of the positive feedback and high satisfaction scores for VR learning initiatives may be linked to the excitement people have about participating in VR learning. Research should better establish the distinction between the excitement levels and the quality and outcomes of the learning experience itself.

Researchers could study how to expand accessibility and inclusivity of VR learning. Some audiences may be unable to benefit from VR learning experiences, for example those who have visual or auditory impairment, or those who feel disoriented or nauseous. How can we maximize the benefit of VR learning for these populations?

As the Covid-19 situation evolves from pandemic to endemic, it is unclear how the extent of the reemergence of in-person learning programs may impact the demand for VR learning. Further research could look at the demand for VR learning relative to in person learning and conventional E-learning. Understanding the demand can help industry professionals gauge the pace of VR learning development and adoption.

Finally, with the development of the Metaverse, research on immersive virtual learning platforms can help guide how best to design, implement, facilitate, and evaluate learning opportunities in this exciting space.

Conclusion

Through this research study, we aimed to better understand VR learning and inspire professionals in how they can leverage VR for training purposes. As researchers and workplace professionals consider whether to engage in or further invest in VR learning, it can be helpful to think about the ways they can simulate scenarios that would be dangerous, difficult, or expensive. There are many potential applications for VR learning for interpersonal and leadership skill development which provide a safe and immersive environment for skill practice. VR for training creates new avenues for data collection and assessments to aid in learner development. There are many useful applications for AR learning, which can bridge the real and virtual.

The limitations to be aware of include the limits and usefulness of experiences in VR for learning audiences. Hardware needs to be acquired and maintained, so there may be bottlenecks around the deployment of headsets for audiences. Also, there might be a low acceptance of VR learning that may need to be addressed. Costs for VR hardware and software licensing or development may or may not be considered high, depending on the industry and learning goals.

For future directions, many study participants expect improvements in VR hardware fidelity and comfort, simplification of VR learning creation, and expansion of AR learning opportunities, while some anticipate no significant changes in VR learning opportunities and adoption. Some of the limitations discussed may be resolved over time, particularly as VR software and hardware improve and costs tend to decrease, though some limitations may persist.

Just as E-learning did not eliminate ILT, VR learning likely will not eliminate or replace either ILT or E-learning. It is and will remain an additional channel for learning that offers certain affordances. As a participant described, "It's never gonna be the one big tool replacing a lot of the other tools because... it's still very useful for certain areas and less useful for other areas." Though it may take time for organizations and L&D teams to become familiar with, buy into, build, and deliver VR learning, we anticipate computing power to continue to increase and that more tools will become available to build VR and AR solutions. This may help the increased adoption of VR learning. While VR and AR may be considered novelties by some organizations, if VR and AR devices become as ubiquitous as laptops and mobile phones, VR learning can be more easily scaled. For instructional designers, some upskilling may be needed to be able to design VR learning experiences. Fortunately, coding is no longer essential and simpler VR software options are becoming more prevalent. Eventually, all instructional designers may be able to design VR learning.

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