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A Study of the Role of Virtual Reality in Reducing Workplace Stress

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ABSTRACT: Virtual reality (VR) is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world. Applications of virtual reality include entertainment (particularly video games), education (such as medical or military training) and business (such as virtual meetings). Other distinct types of VR-style technology include augmented reality and mixed reality, sometimes referred to as extended reality or XR, although definitions are currently changing due to the nascence of the industry.[2]

Currently, standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate some realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback, but may also allow other types of sensory and force feedback through haptic technology.

KEYWORDS- virtual reality, stress, workplace, artificial, auditory, technology

I. INTRODUCTION

A virtual workplace is a work environment where employees can perform their duties remotely, using technology such as laptops, smartphones, and video conferencing tools. A virtual workplace is not located in any one physical space. It is usually a network of several workplaces technologically connected (via a private network or the Internet) without regard to geographic boundaries. Employees are thus able to interact in a collaborative working environment regardless of where they are located. A virtual workplace integrates hardware, people, and online processes.[1]

The phenomenon of a virtual workplace has grown in the 2000s as advances in technology have made it easier for employees to work from anywhere with an internet connection.

The virtual workplace industry includes companies that offer remote work solutions, such as virtual meeting (teleconference) software and project management tools. Consulting firms can also help companies transition to a virtual workplace if needed. The latest technology evolution in the space is virtual office software which allows companies to gather all their team members in one virtual workplace.[2] Companies in a variety of industries, including technology, finance, and healthcare, are turning to virtual workplaces to increase employee flexibility and productivity, reduce office costs, and attract and retain top talent. Recently, there have been four industries that consider remote work suitable: communications and information technology, educational services, media and communications, and professional and business services.[3]

As information technology began to play a greater role in the daily operations of organizations, virtual workplaces developed as an augmentation or alternative to traditional work environments of rooms, cubicles and office buildings.

In 2010, the Telework Enhancement Act of 2010 required each Executive agency in the United States to establish a policy allowing remote work to the maximum extent possible, so long as employee performance is not diminished.[4][5][6]

During the COVID-19 pandemic, millions of workers began remote work for the first time.[7] 88% of office workers worldwide reported working from home during the pandemic, which was novel for 57%.[8]

Research from IWG found that 70% of employees globally work remotely at least one day every week, and more than half do so at least half of the week.[9]

Cities in which the population of remote workers increased significantly were referred to as Zoom towns.[10]

Individual virtual workplaces vary in how they apply existing technology to facilitate team cooperation:

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1. Remote work: the availability and use of communications technologies, such as the Internet, to work in an offsite location.
2. Hot desking: employees do not have individual desks but are rather each day allocated to a desk where they can access technology services including the Internet, email and computer network files. This is similar to "Hoteling": recognizing that employees spend more time at clients' offices than at the employer's office, they are not assigned a permanent desk.
3. Virtual team: employees collaborate by working closely together and in regular contact, although physically located in different parts of the world.
4. There are several factors that drive the interest in using virtual workplaces.
5. Office space and its cost
6. Office space has become a major expense for many organisations,[11] and virtual meetings can save money[12] by being a direct substitute of meeting face to face.[13] One response has been to reduce the amount of space each employee occupies. Another is to increase the flexibility of the office's layout and design It is not easy to make the most of these approaches and keep employees happy — unless flexible work practices are also used.
7. Fuel and energy costs
8. The expenses of the energy consumption to physically commute are increasing rapidly. Planners and public policymakers share a strong belief that remote work with a virtual workspace is one of the most sustainable and competitive modes of commuting in terms of travel time and cost, flexibility, and environmental impacts.[14]

Some common challenges are:

1. Failure to leverage the technology that supports virtual workplaces, resulting in decreased productivity[
2. Lack of human contact could cause decreased team spirit, trust and productivity (and researchers indicate trust is a vital aspect)[15]
3. Increased sensitivity to communication, interpersonal and cultural factors
4. Cultural diversity is not yet achieving the expected benefits [16]
5. Virtual offices might cause a lack of social interactions and creativity, since the on-site office is often one of the most important source of stress for employees.[17]

Virtual workplace software

- Project management: tracks project progress to ensure complete tasks on time and achieve goals(Project management software).[18]
- Productivity management(Performance management): ensures remote workers are doing their work by using time-tracking tools and productivity reports.[19]
- Video conferencing, Web conferencing: allows team access to face-to-face communication through video chat (Comparison of web conferencing software).[20]
- Cloud storage: gives every employee a secure, centralized space to store data(Category:Cloud storage).[21]
- Collaborative software(team collaboration): provides a virtual space for hybrid and remote teams to come together (List of collaborative software).[22]
- Employee engagement: recognizes and rewards employee efforts to increase team engagement.[23]
- Online security(Internet security): for company's privacy, security, and anonymity when employees are online (Comparison of antivirus software).[24]

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- Mental wellness: to help remote employees manage anxiety and stress.[25]

II. DISCUSSION

A virtual office is part of the flexible workspace industry that provides businesses with any combination of services, space and/or technology, without those businesses bearing the capital expenses of owning or leasing a traditional office.

A virtual office can be used by entrepreneurs, freelancers, and small businesses that do not need or cannot afford a traditional office space. It can also be used by larger companies that want to establish a presence in a specific location without committing to a long-term lease.

Some virtual office providers offer additional services such as meeting room rentals, administrative support, and live receptionist services. These services are usually provided remotely, but also some virtual office providers have a physical office space where clients can have access to these services. This can be an attractive option for businesses that want to project a professional image without the cost of a full-time office.

Virtual office services started in the 1960s as serviced offices and have evolved with technology to include a wide variety of personnel, physical space, digital storage and communication services.[1] Customers pay a contract fee for these services which may be offered à la carte, as packages or membership subscription. The concept is popular with companies of all sizes, including self-employed entrepreneurs. One of the primary allures of the virtual office is the flexibility it offers for employees and freelancers to work from a satellite office, home office, remote location or even on-the-go via a mobile device. At the same time, a company can offer its clients and employees a stable home office with access to amenities such as receptionist, conference rooms, desk space, mailboxes, printing and faxing at a permanent address, which are owned and maintained by the virtual office provider or a third party.

In 2018, a number of companies set out to fix the challenges of virtual meetings. This led to the appearance of virtual office software. When referring to a company having a virtual office, this no longer refers to a standard set of business services. Rather a virtual space for employees to gather and perform business-related activities. For example, companies like KumoSpace and Pluto utilize spatial audio to recreate a company's physical offices in a virtual environment. They offer users a wide range of functionality and customization l allowing companies to create a virtual office that matches the company's brand.[2]

Virtual office providers may also include digital capital such as cloud storage, web hosting, email and other web-based applications.

Also, according to the research, the attitudes and policies of employers in the virtual platform affect their employees' personal lives and productivity. Employees will be more productive if they believe their company trusts them, recognizes them, cares about them, and receives the proper training (including online processes, etc.), project management, and support to perform their tasks productively. When employees don't have to spend time, money, or resources on transportation between home and work, it positively impacts employee productivity. That is why it became necessary to create an appropriate software environment to ensure these processes' functioning.[3]

The concept of a virtual office had roots before and during the Industrial Revolution, where parallels to current work styles, specifically working from home, have been drawn.[4] The virtual office concept is an evolution of the traditional executive suite. As an executive suite, lease became increasingly impractical for certain types and stages of business, it naturally opened the door to a virtual office concept.[5]

In the mid-20th century, professionals and executives began to examine ways to make more efficient use of the rising cost of real estate, personnel and other capital. Below are some milestones in the resulting evolution of the virtual office, along with the advent of technologies that help shape the industry.[

Year	Event
1962	The first known serviced office company, OmniOffices Group, was created.
1966	Serviced offices and executive suites were rented by Fegen Law Suites. This included large blocks of office space with furnished suites, reception services, telephone answering, photocopies, conference rooms, and a law library.
1972	ARPANET, the predecessor to the Internet, went public by connecting 40 computers in different locations.
1973	Attorney Office Management, Inc. developed an "off-site" program in response to lawyers wanting to partially retire.[6] Instead of a full executive suite, Attorneys could work from home while continuing a part-time presence through AOMI's Beverly Hills location. Jack Nilles coined the terms "telecommuting" and "telework" to refer to remote work.[7]

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1974	Scientists with the Institute of Electrical and Electronics Engineers developed Transmission Control Protocol/Internet Protocol (TCP/IP), which allows different networks to communicate with each other.
1978	Alf Moufarrige founded Servcorp in Sydney. To reduce his overhead, he began sharing his premium office space, receptionist and clerical staff with other growing businesses. Servcorp took its virtual office concept international in 1980 and in 1999 became a publicly traded company.[8]
1981	Released 1 April, The Osborne 1 became the first successful portable computer, designed by Adam Osborne. Although it still required a power source, it was considered portable as it could easily be transported. This was a first step in allowing professionals to work away from the office.
1982	ARPANET adopted TCP/IP, giving birth to the Internet. The term "virtual office" was used by John Markoff in an article published by InfoWorld magazine. Markoff wrote, "In the future virtual office, workers will no longer be constrained by computer equipment or geographic location, according to this vision. They will be free to travel or to interact with others while communicating information freely. The office as we know it will cease to have the central importance it does today."[9]
1983	Chris Kern coined the term 'virtual office' in his column for the September 1983 issue of the American Way magazine. Kern used the term to describe the possibility of 'doing business while on the go' thanks to portable computers.[10]
1984	The first personal digital assistant (PDA), the Organizer, was released by Psion.
1989	Timothy John Berners-Lee developed the World Wide Web, considered as being a key aspect of the development of the Information Age. Alon Cohen invented the type of audio that later enabled the creation of VoIP. VocalTec was the first company to offer Internet phone services and also became the first successful Internet IPO. Today, VoIP phones are a popular service that virtual offices offer.
1990	The first Internet search engine was developed by McGill University.
1991	The World Wide Web was released to the public. Also the first webcam, located at Cambridge University, was developed.
1992	"Virtual Office" became a registered trademark for the first time when Richard Nissen registered the term with the UK's Intellectual Property Office.[11] IP-based videoconferencing technology evolved with more efficient video compression to allow PC-based use. CU-SeeMe was developed by Tim Dorcey at Cornell, which allowed users to videoconference and instant message other users.
1994	Ralph Gregory presented virtual offices as a franchise opportunity in the United States, turning the business into an industry.
1995	The motto that "work is something you do, not something you travel to" was coined.[12] Variations of this motto include: "Work is what we do, not where we are."[13]
1998	At the Winter Olympics opening ceremony in Nagano, Japan, Seiji Ozawa used IP-based videoconferencing to conduct the Ode to Joy from Beethoven's Ninth Symphony simultaneously across five continents in near-real time.
2000	The first Symbian phone, the touchscreen Ericsson R380 Smartphone, was released in 2000, and was the first device marketed as a "smartphone". It combined a PDA with a mobile phone.
2003	Skype is released to the public, allowing free IP-based communications using microphone, webcam and instant messaging to individual consumers.
2005	The official first "Coworking space" opened in San Francisco by Brad Neuberg. That same year, the first Impact Hub coworking space launched in London.
2006	Frank Cottle introduced the concept of wholesaling virtual offices and services to third-party retailers. This launched an influx of virtual office companies that still operate today.
2019	Due to the COVID-19 pandemic, there was a need to create high-quality software for permanent remote work.[14]
2018	Development of numerous software for virtual offices (Kumospace, mmhmm, etc.). This software looks to replicate the benefits of a physical office within a virtual environment.[2] Companies have adopted this software because they find it helps with company culture, collaboration, and visibility.[15]

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Prerequisites for the spread of virtual offices

The most significant factor in the spread of virtual offices was the forced transition to remote work during the COVID-19 pandemic.

Society introduced remote work quickly, so new technologies and operating systems must be adequately tested and trained.[16]

Communication and getting to know other team members come naturally when everyone is working in the same place, so when working remotely, employees and managers have to make more effort to maintain relationships with colleagues. New employees need to learn organizational habits even while working remotely.[17]

Therefore, there was an urgent need to create not just a tool for communication (like Zoom or Google Meets) but to develop a space where team relationships can be built at a sufficient level. This led to the development of companies creating virtual office software.[18]

Services

Virtual office infrastructure may include a variety of physical locations and services, as well as digital services. The infrastructure is shared across individuals and entities allowing resources to be used more efficiently. This allows users the flexibility of only renting or using the services they need.

Physical

- A business address
- Mail services (receive, pick up and/or forwarding)
- Conference rooms
- Desk space and private offices
- Printing and related services such as copying, binding, faxing, scanning, laminating, and shredding.
- Receptionist services and answering services
- Storage space
- Photography studio[19]

Digital

- A phone number
- Online phone system (VoIP)
- Virtual assistants
- Virtual receptionists
- Website domains and email
- Instant Message, chat and other web-based RTC platforms
- Video conferencing, including webinar-hosting or other screensharing platforms
- Online digital storage
- Project management tools
- Cloud-based applications (e.g. Google Docs, Sheets, and Slides or Office 365)

Emerging Trends

Coworking is a related trend in flexible workspaces that places an emphasis on users interacting with each other to create an organizational culture without working for the same company. Similar to virtual offices, coworking venues offer serviced workspaces and customers can use these on an as-needed basis.

Virtual reality technology is another trend that may soon impact virtual offices. Virtual reality applications have the capability of creating offices spaces that are physical spaces within the virtual world where users can meet and work side-by-side.[20]

III. RESULTS

Virtual reality applications are applications that make use of virtual reality (VR), an immersive sensory experience that digitally simulates a virtual environment. Applications have been developed in a variety of domains, such as education, architectural and urban design, digital marketing and activism, engineering and robotics, entertainment, virtual communities, fine arts, healthcare and clinical therapies, heritage and archaeology, occupational safety, social science and psychology.

Architecture and urban design

One of the first recorded uses of virtual reality in architecture was in the late 1990s when the University of North Carolina virtually modelled Sitterman Hall, home of its computer science department.[1] Designers wore a headset and used a hand controller to simulate moving around a virtual space. With an Autodesk Revit model they could "walk through" a schematic. VR enables architects to better understand the details of a project such as the transition of materials, sightlines, or visual displays of wall stress, wind loads, solar heat gain, or other engineering factors.[2] By 2010, VR programs had been developed for urban regeneration, planning and transportation projects.[3] Entire cities were simulated in VR.[4]

Industrial design

Virtual reality and artificial intelligence are used by automotive firms like Porsche and BMW to optimize their production chain.[5] Software developers are building VR solutions to skip redundant design workflow phases and meet end-user expectations faster and more accurately.[6][

Restorative nature experiences

Studies on exposure to nature environments shows how it is able to produce relaxation, recover attention capacity and cognitive function, reduce stress and stimulate positive mood.[7][8][9]

Immersive virtual reality technology is able to replicate believable restorative nature experiences, either using 360 degree video footage or environments created from 3D real-time rendering often developed using game engines (for example Unreal Engine or Unity) This is useful for users who are deprived from accessing certain areas, due to e.g. physical restraints or complications, such as senior citizens or nursing home residents.[10] Restorative virtual environments are able replicate and mediate real world experiences using video footage, replicate these using 3D rendering or can be based loosely on real world environment using real-time 3D rendering.[10]

Healthcare and medical

VR began to appear in rehabilitation in the 2000s. For Parkinson's disease, evidence of its benefits compared to other rehabilitation methods is lacking.[11] A 2018 review on the effectiveness of VR mirror therapy and robotics found no benefit.[12] Virtual reality exposure therapy (VRET) is a form of exposure therapy for treating anxiety disorders such as post traumatic stress disorder (PTSD) and phobias. Studies have indicated that combining VRET with behavioral therapy, patients experience a reduction of symptoms.[13][14] In some cases, patients no longer met the DSM-V criteria for PTSD.[15]

Virtual reality is also tested in the field of behavioral activation therapy. BA therapy encourages patient to change their mood by scheduling positive activities into the day-to-day life.[16] Due to a lack of access to trained providers, physical constraints or financial reasons, many patients are not able to attend BA therapy.[16] Researchers are trying to overcome these challenges by providing BA via virtual reality. The idea of the concept is to enable especially elderly adults to participate in engaging activities that they wouldn't be able to attend without VR. Possibly, the so called "BA-inspired VR protocols" will mitigate the lower mood, life satisfaction, and likelihood of depressions.[16]

Furthermore researchers are using VR to study how people with social anxiety learn and make decisions. Aim is to improve interventions of anxiety disorders.[16]

Immersive VR can motivate exercise with challenged sedentary users, such as for rehabilitation centers or senior citizen homes, increasing quality of life and independence through increased physical activity (see right image).[10][17] Immersive VR has also been shown useful for acute pain management, on the theory that it may distract people, reducing their experience of pain.[18][19][20][21]

Some companies and researchers are adapting VR for fitness, either motivating physical therapy or exercise, e.g. by contextualizing e.g. biking through VR-based experiences (see right image),[10] or by using gamification concepts to encourage exercise.[22][23]

Research has shown that dementia patients given virtual reminiscence therapy reduced incidences[of dementia related symptoms.[24] Virtual reminiscence therapy allows for creating virtual environments tailored to the patient allowing them to remember old memories more easily which may improve overall quality of life. Developments in VR usage in

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dementia could also make psychological therapies for dementia more cost-effective by providing alternate sources of stimulation that are cheaper and work better.

Virtual reality and surgery

The first collaborative virtual reality surgery was successfully performed June 2017, in Brazil by paediatric surgeron Noor ul Owase Jeelani, of Great Ormond Street Hospital in London. The surgery, a separation of conjoined twins, was conducted collaboratively in a 'virtual reality room' by Dr. Jeelani and Dr. Gabriel Mufarrej, head of paediatric surgery at Instituto Estadual do Cerebro Paulo Niemeyer in Brazil.[25][26]

Virtual reality medical simulation training

With the rise of COVID-19 in 2019, opportunities for clinical training and education were greatly reduced due to the lack of availability of clinical educators and the need to establish social distancing by avoiding in-person interaction.[27]

Digital marketing

Virtual reality presents an opportunity and an alternative channel for digital marketing. International Data Corporation expected spending to increase for augmented and virtual reality, forecasting a compound annual growth rate of 198% in 2015–2019. Revenues were expected to rise to $143.3 billion in 2019.[28][29] Global spending on digital advertisements was forecast to increase to $335.5 billion by 2019.[30][31] A 2015 study found that 75% of companies on Forbes' World's Most Valuable Brands list had developed a VR or AR experience.[32] Although VR is not widespread among consumers compared to other forms of digital media,[33] many companies have invested in VR. Some companies adopted VR to enhance workplace collaboration.[34]

VR can present high definition, three-dimensional interactive imaging.[35] Its marketing benefits were observed by Suh and Lee through via laboratory experiments: with a VR interface, participants' product knowledge and product attitude noticeably increased. VR marketing can engage consumers' emotions.[36] Both studies indicate an increased desire to purchase products marketed through VR; however, these benefits showed minimal return on investment (ROI).[32] Suh and Lee found that products that are primarily experienced through hearing and vision (but not others) benefit more from VR marketing.[35]

Ads that appear during a VR experience (interruption marketing[31]) may be considered invasive.[33] Consumers want to decide whether to accept an ad.[37] Organizations can for example require the user to download a mobile app before experiencing their VR campaign.[38]

Non-profit organizations have used VR to bring potential supporters closer to distant social, political and environmental issues in immersive ways not possible with traditional media. Panoramic views of the conflict in Syria[38] and face-to-face encounters with CGI tigers in Nepal[39] are some examples.

Retailers use VR to show how a product will fit in consumers' homes.[40] Consumers looking at digital photos of the products can virtually spin the product to view it from the side or back.

Architectural design firms allow clients to tour virtual models of proposed buildings. Architects can use VR to experience their developing designs.[41] VR models can replace scale models. Developers and owners can create VR models of existing structures.

Education and training

VR is used to help learners develop skills without the real-world consequences of failing, especially useful in realms with life-or-death implications. The specific device used to provide the VR experience, whether it be through a mobile phone or desktop computer, does not appear to impact on any educational benefit.[42]

In recent case studies the VR training approach not only proofs better understanding, but also higher satisfaction amongst students. The number of errors can be reduced and the completion time for specific tasks can be shortened.[43]

An increasing number of companies rely on virtual reality when it comes to onboarding of employees.[44] VR onboarding is cheaper and more efficient compared to conventional training, as no demo equipment is required.[45]

Mining Industry

Many mining accidents can be attributed to inadequate or insufficient training.[46] With virtual reality training, one may simulate the exposure to a real working environment, without the associated risk.[46]

Flight and vehicular applications

Flight simulators are a form of VR training. They can range from a fully enclosed module to computer monitors providing the pilot's point of view.[47] Driving simulations can train tank drivers on the basics before allowing them to operate the real vehicle.[48] Similar principles are applied in truck driving simulators for specialized vehicles such as fire trucks. As these drivers often have limited opportunity for real-world experience, VR training provides additional training time.[49]

Medicine

VR technology has many useful applications in the medical field.[50] Through VR, novice surgeons have the ability to practice complex surgeries without stepping into the operating room.[51] Physicians who experience VR simulations improved their dexterity and performance in the operating room significantly more than control groups.[52][53][54][55] VR can produce a three-dimensional representation of a particular patient's anatomy that allows surgeons to map out the surgery ahead of time.[56] Trainees may use real instruments and video equipment to practice in simulated surgeries.[57] Through the revolution of computational analysis abilities, fully immersive VR models are currently available in neurosurgery training. Ventriculostomy catheters insertion, endoscopic and endovascular simulations are used in neurosurgical residency training centers across the world. Experts see VR training as an essential part of the curriculum of future training of neurosurgeons.[57]

Military

In 1982 Thomas A. Furness III presented the United States Air Force with a working model of his virtual flight simulator, the Visually Coupled Airborne Systems Simulator (VCASS). The second phase of his project, which he called the "Super Cockpit", added high-resolution (for the time) graphics and a responsive display.[58] The United Kingdom has been using VR in military training since the 1980s.[59] The United States military announced the Dismounted Soldier Training System in 2012.[60] It was cited as the first fully immersive military VR training system.[61]

Virtual training environments have been claimed to increase realism while minimizing cost,[62][63][64] e.g., by saving ammunition.[62] In 2016, researchers at the U.S. Army Research Laboratory reported that instructor feedback is necessary for virtual training. Virtual training has been used for combined arms training and instructing soldiers to learn when to shoot.[65]

Military programs such as Battle Command Knowledge Systems (BCKS) and Advanced Soldier Sensor Information and Technology (ASSIST) were intended to assist the development of virtual technology.[62] Described goals of the ASSIST initiative were to develop software and wearable sensors for soldiers to improve battlefield awareness and data collection.[66] Researchers stated that these programs would allow the soldier to update their virtual environment as conditions change.[62] Virtual Battlespace 3 (VBS3, successor to the earlier versions named VBS1 and VBS2) is a widely used military training solution adapted from a commercial off the shelf product.[67] Live, Virtual, Constructive – Integrated Architecture (LVC-IA) is a U.S. military technology that allows for multiple training systems to work together to create an integrated training environment. Reported primary uses of the LVC-IA were live training, virtual training, and constructive training. In 2014, the LVC-IA version 1.3 included VBS3.[68]

Space

NASA has used VR technology for decades.[69] Most notable is their use of immersive VR to train astronauts before flights. VR simulations include exposure to zero-gravity work environments, training on how to spacewalk[70][71] and tool usage using low-cost tool mock-ups.[72]

High School and College Education

Immersive virtual reality is used in the High school classroom as a tool to help students learn and be immersed in their subject matter.[73] Immersive virtual reality has been used to teach students interactive history lessons[74] and STEM subjects such as physics.[75] In some cases, virtual reality laboratories have been set in up in schools to provide students with immersive virtual reality experiences focused on specific curriculum outcomes and subject matter.[75] Through virtual reality mediums such as Google Cardboard, foreign languages have also been taught in the classroom by teachers.[73] These few examples, showcase some of the applications of virtual reality and immersive virtual reality in the secondary classroom. Virtual reality is also being applied at the collegiate level to help enhance student education in core subjects such as science, geography,[76] and history.[77]

Engineering and robotics

In the mid-to-late 1990s 3D computer-aided design (CAD) data took over when video projectors, 3D tracking and computer technology enabled its use in virtual reality environments. Active shutter glasses and multi-surface projection units appeared. Virtual reality has been used in automotive, aerospace, and ground transportation original equipment manufacturers. Virtual reality aids prototyping, assembly, service and performance use-cases. This enables engineers from different disciplines to experience their design. Engineers can view the bridge, building or other structure from any angle.[78] Simulations allow engineers to test their structure's resistance to winds, weight, and other elements.[79]

Virtual reality can control robots in telepresence, teleoperation and telerobotic systems.[80][81] VR has been used in experiments that investigate how robots can be applied as an intuitive human user interface.[19] Another example is remotely-controlled robots in dangerous environments.[19]

Entertainment

Video games

Early commercial virtual reality headsets were released for gaming during the early-mid 1990s. These included the Virtual Boy, iGlasses, Cybermaxx and VFX1 Headgear. Since 2010, commercial headsets for VR gaming include the Oculus Rift, HTC Vive and PlayStation VR.[82] The Samsung Gear VR is an example of a phone-based device.[83]

Other modern examples of VR for gaming include the Wii Remote, the Kinect, and the PlayStation Move/PlayStation Eye, all of which track and send player motions to the game. Many devices complement VR with controllers or haptic feedback.[84] VR-specific and VR versions of popular video games have been released.

Cinema

Films produced for VR permit the audience to view scenes in 360 degrees. This can involve the use of VR cameras to produce interactive films and series.[85][86] Pornography makers use VR, usually for POV-style porn.[87][88]

The 2016 World Chess Championship match between Magnus Carlsen and Sergey Karjakin was promoted as "the first in any sport to be broadcast in 360-degree virtual reality."[89] However, a VR telecast featuring Oklahoma hosting Ohio State, preceded it on September 17, 2016.[90][91] The telecasts (which used roughly 180 degrees of rotation, not the 360 required for full VR) were made available through paid smartphone apps and head-mounted displays.

Music

VR can allow individuals to virtually attend concerts.[92][93] VR concerts can be enhanced using feedback from the user's heartbeat and brainwaves.[94] Virtual reality can be used for other forms of music, such as music videos[95] and music visualization or visual music applications.[96][97]

Family entertainment centers

In 2015 roller coasters and theme parks began to incorporate VR to match visual effects with haptic feedback. The Void is a theme park in Pleasant Grove, Utah that offers VR attractions that stimulate multiple senses.[98] In March 2018, a VR water slide was launched using a waterproof headset.[99]

Virtual communities

Large virtual communities have formed around social virtual worlds that can be accessed with VR technologies. Popular examples include VRChat, Rec Room, and AltspaceVR, but also social virtual worlds that were originally developed without support for VR, for example Roblox.

Fine arts

David Em was the first fine artist to create navigable virtual worlds, in the 1970s.[100] His early work was done on mainframes at Information International, Inc., Jet Propulsion Laboratory, and California Institute of Technology. Jeffrey Shaw with Legible City in 1988 and Matt Mullican with Five into One in 1991, were among the first to exhibit elaborate VR artworks.

Virtopia was the first VR artwork to premiere at a film festival. Created by artist/researcher Jacquelyn Ford Morie with researcher Mike Goslin, it debuted at the 1992 Florida Film Festival. A more developed version of the project appeared at the 1993 Florida Film Festival.[101][102] Other artists to explore the early artistic potential of VR through the 1990s include Jeffrey Shaw, Ulrike Gabriel, Char Davies, Maurice Benayoun, Knowbotic Research, Rebecca Allen and Perry Hoberman.[103]

The first Canadian virtual reality film festival was the FIVARS Festival of International Virtual & Augmented Reality Stories, founded in 2015 by Keram Malicki-Sánchez.[104] In 2016, the first Polish VR program, The Abakanowicz Art Room was realized – it documented the art office of Magdalena Abakanowicz, made by Jarosław Pijarowski and Paweł Komorowski.[105] Some museums have begun making some of their content virtual reality accessible including the British Museum[106] and the Guggenheim.[107]

Great Paintings VR[108] is a fully immersive virtual reality museum on Steam. It provides more than 1000 famous paintings from different museums of all over the world.[109]

Heritage and archaeology

Virtual reality enables heritage sites to be recreated.[110] The sites may have restricted or no access for the public,[111] such as caves, damaged/destroyed structures, or sensitive environments that are closed to allow them to recover from overuse.[112]

The first use of VR in a heritage application was in 1994 when a museum visitor interpretation provided an interactive "walk-through" of a 3D reconstruction of Dudley Castle in England as it was in 1550. This consisted of a computer controlled laserdisc-based system designed by engineer Colin Johnson. The system was featured in a conference held by the British Museum in November 1994.[113]

Occupational safety

VR simulates real workplaces for occupational safety and health (OSH) purposes. Within work scenarios, for example, some parts of a machine move of their own accord while others can be moved by human operators. Perspective, angle of view, and acoustic and haptic properties change according to where the operator is standing and how he or she moves relative to the environment.

VR can be used for OSH purposes to:

- Review and improve the usability of products and processes during design and development.
- Safely test potentially hazardous products, processes and safety concepts.[114][
- Identify cause-effect relationships following accidents on and involving products. This saves material, personnel, time and financial outlay associated with in-situ testing.[115][

Social science and psychology

Virtual reality offers social scientists and psychologists a cost-effective tool to study and replicate interactions in a controlled environment. It allows an individual to embody an avatar. "Embodying" another being presents a different experience from simply imagining that you are someone else.[116] Researchers have used immersion to investigate how digital stimuli can alter human perception, emotion and physiological states, and how can change social interactions, in addition to studying how digital interaction can enact social change in the physical world.

Altering perception, emotion and physiological states

Studies have considered how the form we take in virtual reality can affect our perception and actions. One study suggested that embodying the body of a child can cause objects to be perceived as much larger otherwise.[117] Another study found that white individuals who embodied the form of a dark-skinned avatar performed a drumming task with a more varied style than otherwise.[118]

Research exploring perception, emotions and physiological responses within VR suggest that virtual environments can alter how a person responds to stimuli. For example, a virtual park coupled affects subjects' anxiety levels.[119] Similarly, simulated driving through dark areas in a virtual tunnel can induce fear.[120] Social interaction with virtual characters has been shown to produce physiological responses such as changes in heart rate and galvanic skin responses.[121]

Research suggests that a strong presence can facilitate an emotional response, and this emotional response can further increase the feeling of presence.[119] Similarly, breaks in the presence (or a loss in the sense of presence) can cause physiological changes.[121][

Understanding biases and stereotypes

Researchers have utilized embodied VR perspective-taking to evaluate whether changing a person's self-representation may help in reducing bias against particular social groups. However, the nature of any relationship between embodiment and bias is not yet defined. Individuals who embodied old people demonstrated a significant reduction in negative stereotyping when compared with individuals embodying young people.[122] Similarly, light-skinned individuals placed in dark-bodied avatars showed a reduction in their implicit racial bias.[123] However, other research has shown individuals taking the form of a black avatar had higher levels of implicit racial bias favoring whites after leaving the virtual environment.[116]

Investigating basal mental abilities like Spatial Cognition

One of the most general abilities in order to perform in everyday life is Spatial Cognition, which involves orientation, navigation etc. Especially in the field of its investigation, virtual reality became an invaluable tool, since it allows to test the performance of subjects in an environment which is highly-immersive and controllable at the same time.

Furthermore, the newest head-mounted displays allow also the implementation of eye-tracking, which provides precious insight in cognitive processes, for example in terms of attention.[124]

Fostering the human griefing process

Starting in the early 2019s, virtual reality has also been discussed as a technological setting that may support people's griefing process, based on digital recreations of deceased individuals. In 2018, this practice received particular media attention following a South Korean TV documentary, which invited a griefing mother to interact with a virtual replica of her deceased daughter.[125] Subsequently, scientists have debated several potential implications of such endeavours, including its potential to facilitate adaptive mourning behavior, but also many ethical challenges involved.[126][127]

Obstacles

As of 1997, motion sickness is still a major issue for virtual reality. The delay between a motion and the updating of the screen image is the source. Users often report discomfort. One study reported that all 12 participants complained of at least two side effects while three had to withdraw from severe nausea and dizziness.[128]

Along with motion sickness, users can also become distracted by the new technology hardware. A study showed how when VR was incorporated into a laboratory environment, the students felt more engaged with the concept, but retained less information due to the new distraction.[129]

Virtual reality users remove themselves from the physical environment. This creates a risk that the user will experience a mishap while moving. Immersion in a virtual world has the potential for social exclusion that may decrease positive mood and increase anger. Behavior in virtual reality may have lasting psychological impact when returning to the physical world.[130][131] Russian news agency, TASS, reported in 2017, a death from VR use, when a 44-year old man "tripped and crashed into a glass table, suffered wounds and died on the spot from a loss of blood".[132] It is thought to be the first death from VR use.[133]

Philosopher David Pearce argues that even with the most sophisticated VR, "there is no evidence that our subjective quality of life would on average significantly surpass the quality of life of our hunter-gatherer ancestors". According to Pearce, without genetically reprogramming the negative feedback mechanisms of the brain, one returns to one's baseline level of happiness or ill-being, which is determined by one's genes and life history. He thus argues that VR, like any other "purely environmental improvement", cannot deliver a sustainable level of elevated happiness on its own.[134][135][136]

IV. CONCLUSIONS

Imagine a world where you could have a beachside conversation with your colleagues, take meeting notes while floating around a space station, or teleport from your office in London to New York, all without taking a step outside your front door. Feeling under pressure with too many meetings scheduled today? Then why not send your AI-enabled digital twin instead to take the load off your shoulders? These examples offer but a glimpse into the future vision of work promised by “the metaverse,” a term originally coined by author Neal Stephenson in 1992 to describe a future world of virtual reality. While defying precise definition, the metaverse is generally regarded as a network of 3-D virtual worlds where people can interact, do business, and forge social connections through their virtual “avatars.” Think about it as a virtual reality version of today’s internet.

While still nascent in many respects, the metaverse has suddenly become big business, with technology titans and gaming giants such as Meta (previously Facebook), Microsoft, Epic Games, Roblox, and others all creating their own virtual worlds or metaverses. The metaverse draws on a vast ensemble of different technologies, including virtual reality platforms, gaming, machine learning, blockchain, 3-D graphics, digital currencies, sensors, and (in some cases) VR-enabled headsets.

How do you get to the metaverse? Many current workplace metaverse solutions require no more than a computer, mouse, and keyboard keys, but for the full 3-D surround experience you usually have to don a VR-enabled headset. However, rapid progress is also taking place in computer-generated holography that dispenses with the need for headsets, either by using virtual viewing windows that create holographic displays from computer images, or by deploying specially designed holographic pods to project people and images into actual space at events or meetings). Companies such as Meta are also pioneering haptic (touch) gloves that enable users to interact with 3-D virtual objects and experience sensations such as movement, texture, and pressure.

Within the metaverse, you can make friends, rear virtual pets, design virtual fashion items, buy virtual real estate, attend events, create and sell digital art — and earn money to boot. But, until recently, the implications of the emerging metaverse for the world of work have received little attention.

That is now changing. The effects of the pandemic — especially limitations on physical meetings and travel — are spurring a search by enterprises for more authentic, cohesive, and interactive remote and hybrid work experiences. The metaverse seems set to reshape the world of work in at least four major ways: new immersive forms of team collaboration; the emergence of new digital, AI-enabled colleagues; the acceleration of learning and skills acquisition through virtualization and gamified technologies; and the eventual rise of a metaverse economy with completely new enterprises and work roles.

Like Being There: Teamwork and Collaboration in the Metaverse

The metaverse promises to bring new levels of social connection, mobility, and collaboration to a world of virtual work. NextMeet, based in India, is an avatar-based immersive reality platform focused on interactive working, collaboration, and learning solutions. Its mission is to remove the isolation and workforce disconnectedness that can result from remote and hybrid work. I interviewed Pushpak Kypuram, Founder-Director of NextMeet, who explained the inspiration behind their virtual workplace solution: “With the shift to remote working from the pandemic, keeping employees engaged has become a top challenge for many companies. You can’t keep 20 people engaged in the flat 2-D environment of a video call; some people don’t like appearing on camera; you’re not simulating a real-life scenario. That is why companies are turning to metaverse-based platforms.”

With NextMeet’s immersive platform, employee digital avatars can pop in and out of virtual offices and meeting rooms in real-time, walk up to a virtual help desk, give a live presentation from the dais, relax with colleagues in a networking lounge, or roam a conference center or exhibition using a customizable avatar. Participants access the virtual environment via their desktop computer or mobile device, pick or design their avatar, and then use keyboard buttons to navigate the space: arrow keys to move around, double click to sit on a chair, and so forth. Kypuram gives the example of employee onboarding: “If you’re onboarding 10 new colleagues and show or give them a PDF document to introduce the company, they will lose concentration after 10 minutes. What we do instead is have them walk along a 3-D hall or gallery, with 20 interactive stands, where they can explore the company. You make them want to walk the virtual hall, not read a document.”

Other metaverse companies are emphasizing workplace solutions that help counter video meeting fatigue and the social disconnectedness of remote work. PixelMax, a UK-based start-up, helps organizations create immersive workplaces designed to enhance team cohesion, employee wellness, and collaboration. Their virtual workplaces, which are entered via a web-based system on your computer and don’t require headsets, include features such as:

- “Bump into” experiences: PixelMax’s immersive technology allows you to see your colleagues’ avatars in real-time, making it easier to stop them for a chat when you bump into them in the virtual workplace. In a recent interview, Shay O’Carroll, co-founder of PixelMax, explained that: “Informal and spontaneous conversations account for a huge amount of business communications — research suggests up to 90% in areas such as R&D — and during the pandemic we lost a lot of this vital communication.
- Well-being spaces: These are dedicated areas for users of the world to take a break and experience something different. As Shay O’Carroll explained: “We have created well-being areas designed as forests, or aquariums. They could even be on the moon. These areas can contain on-demand content such as guided meditations and/or exercise classes.”
- Delivery to your physical space: Clients can add features such as the ability to order take-out food or books and other merchandise within the virtual environment and have these delivered to your physical location (e.g., home).

- Live status tracking: Just as in the physical workplace, you can walk around and get that panoramic sweep of the office floor, see where colleagues are located and who's free, drop in for a quick chat, etc.

The ultimate vision, according to Andy Sands, co-founder of PixelMax, is being able to connect different virtual workplaces. It is currently building a virtual workplace for a group of 40 leading manufacturers in interior design that are co-located in Manchester, England. "It's about community building, conversations and interactions. We want to enable worker avatars to move between a manufacturing world and an interior design world, or equally take that avatar and go and watch a concert in Roblox and Fortnite."

Remote work can be stressful. Research by Nuffield Health in the UK found that almost one third of UK remote workers were experiencing difficulties in separating home and work life, with more than one quarter finding it hard to switch off when the work day finishes. Virtual workplaces can provide a better demarcation between home and work life, creating the sensation of walking into the workplace each day and then leaving and saying goodbye to colleagues when your work is done. In the virtual workplace, your avatar provides a means of communicating your status — in a meeting, gone for your lunch break, and so on — making it easier to stay connected to colleagues without feeling chained to the computer or cellphone, a frequent source of stress in traditional remote work situations.

Better teamwork and communication will certainly be key drivers of the virtual workplace, but why stop there? The metaverse opens up new possibilities to rethink the office and work environment, introducing elements of adventure, spontaneity, and surprise. A virtual office doesn't have to be a drab, uniform corporate environment downtown: why not a beach location, an ocean cruise, or even another world? This vision provides the inspiration for Gather, an international virtual reality platform that allows employees and organizations to "build their own office." These dream offices can vary from "The Space-Station Office" with views of planet Earth to "The Pirate Office," complete with ocean views, a Captain's Cabin, and a Forecastle Lounge for socializing. For the less adventurous, you can choose from options like the virtual Rooftop Party or meeting in the Zen Gardens.

Introducing Your Digital Colleague

Our work colleagues in the metaverse will not be limited to the avatars of our real-world colleagues. Increasingly, we will be joined by an array of digital colleagues — highly realistic, AI-powered, human-like bots. These AI agents will act as advisors and assistants, doing much of the heavy lifting of work in the metaverse and, in theory, freeing up human workers for more productive, value-added tasks.

Recent years have seen tremendous progress in conversational AI systems — algorithms that can understand text and voice conversations and converse in natural language. Such algorithms are now morphing into digital humans that can sense and interpret context, show emotions, make human-like gestures, and make decisions. One example is UneeQ, an international technology platform that focuses on creating "digital humans" that can work across a wide variety of fields and different roles. UneeQ's digital workers include Nola, a digital shopping assistant or concierge for the Noel Leeming stores in New Zealand; Rachel, an always-on mortgage adviser; and Daniel, a digital double of the UBS Chief Economist, who can meet multiple clients at once to provide personalized wealth management advice.

Emotions are the next frontier in the metaverse. SoulMachines, a New-Zealand-based technology start-up, is bringing together advances in AI (such as machine learning and computer vision) and in autonomous animation (such as expression rendering, gaze direction, and real-time gesturing) to create lifelike, emotionally-responsive digital humans. Its digital humans are taking on roles as diverse as skincare consultants, a covid health adviser, real-estate agents, and educational coaches for college applicants.

Digital human technology opens up a vast realm of possibilities for workers and organizations. Digital humans are highly scalable — they don't take coffee breaks — and can be deployed in multiple locations at once. They can be deployed to more repetitive, dull, or dangerous work in the metaverse. Human workers will increasingly have the option to design and create their own digital colleagues, personalized and tailored to work alongside them. But digital humans will also bring risks, such as increased automation and displacement of human work for lower-skilled workers who generally have fewer opportunities to move to alternative roles, or possible erosion of cultural and behavioral norms if humans become more disinhibited in their interactions with digital humans, behavior that could then carry over to their real-world interactions.

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Faster Learning in the Metaverse

The metaverse could revolutionize training and skills development, drastically compressing the time needed to develop and acquire new skills. AI-enabled digital coaches could be on-hand to assist in employee training and with career advice. In the metaverse, every object — a training manual, machine, or product, for example — could be made to be interactive, providing 3-D displays and step-by-step "how to" guides. Virtual reality role-play exercises and simulations will become common, enabling worker avatars to learn in highly realistic, "game play" scenarios, such as "the high-pressure sales presentation," "the difficult client," or "a challenging employee conversation."

Virtual-reality technologies are already being used in many sectors to accelerate skills development: Surgical technology company Medivis is using Microsoft's HoloLens technology to train medical students through interaction with 3-D anatomy models; Embodied Labs have used 360-degree video to help medical workers experience the effects of Alzheimer's Disease and age-related audiovisual impairments, to assist in making diagnoses; manufacturing giant Bosch and the Ford Motor Company have pioneered a VR-training tool, using the Oculus Quest headset, to train technicians on electric vehicle maintenance. UK-based company Metaverse Learning worked with the UK Skills Partnership to create a series of nine augmented reality training models for front-line nurses in the UK, using 3-D animation and augmented reality to test learners' skills in specific scenarios and to reinforce best practices in nursing care.

With deep roots in online gaming, the metaverse can also start to tap the potential of gamified learning technologies for easier and faster skills acquisition. PixelMax's O'Carroll observed: "The game becomes the learning activity. In the medical world, we've used gamified technologies to train lab technicians; you'll break out in different groups and then go to, say, a virtual PCR testing machine where you'll go through stages of learning about how operate that machine, with your training result then recorded." For the first responder community in the UK — police, fire fighters, medical crew, etc. — PixelMax is working on games that combine physical training with immersive gamification to enable first responders to do repeat training, try different strategies, see different outcomes, and look at different ways of working as a team.

Research has established that virtual-world training can offer important advantages over traditional instructor or classroom-based training, as it provides a greater scope for visually demonstrating concepts (e.g., an engineering design) and work practices, a greater opportunity for learning by doing, and overall higher engagement through immersion in games and problem-solving through "quest-based" methods. Virtual-world learning can also make use of virtual agents, AI-powered bots that can assist learners when they get stuck, provide nudges, and set scaled challenges. The visual and interactive nature of metaverse-based learning is also likely to appeal particularly to autistic people, who respond better to visual as opposed to verbal cues. Virtual reality tools can also be used to combat social anxiety in work situations, for example by creating realistic but safe spaces to practice public presentations and meeting interactions.

New Roles in the Metaverse Economy

The internet didn't just bring new ways of working: it brought a whole new digital economy — new enterprises, new jobs, and new roles. So too will the metaverse, as the immersive 3-D economy gathers momentum over the decade ahead. IMVU, an avatar-based social network with more than 7 million users per month, has thousands of creators who make and sell their own virtual products for the metaverse — designer outfits, furniture, make-up, music, stickers, pets — generating around $7 million per month in revenues. Alongside the creators are the "meshers," developers who design the basic 3-D templates that others can customize and tailor as virtual products. A successful mesh can be replicated and sold thousands of times, earning significant income for its developer. The Decentraland platform is creating virtual realtors, enabling users to buy, sell, and build businesses upon parcels of virtual land, earning a digital money called "Mana."

Looking further ahead, just as we talk about digital-native companies today, we are likely to see the emergence of metaverse-native enterprises, companies entirely conceived and developed within the virtual, 3-D world. And just as the internet has brought new roles that barely existed 20 years ago — such as digital marketing managers, social media advisors, and cyber-security professionals — so, too, will the metaverse likely bring a vast swathe of new roles that we can only imagine today: avatar conversation designers, "holoporting" travel agents to ease mobility across different virtual worlds, metaverse digital wealth management and asset managers, etc.

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Challenges and Imperatives

Despite its vast future promise, the metaverse is still in its infancy in many respects. Significant obstacles could stymie its future progress: the computing infrastructure and power requirements for a full-fledged working metaverse are formidable, and today's metaverse consists of different virtual worlds that are not unified in the way the original internet was. The metaverse also brings a thicket of regulatory and HR compliance issues, for example around potential risks of addiction, or unacceptable behaviors such as bullying or harassment in the virtual world, of which there has been some concern of late. While many issues remain, business leaders, policy makers, and HR leaders can start with the following imperatives for successful collaboration in the metaverse:

- Make portability of skills a priority: For workers, there will be concerns around portability of skills and qualifications: "Will experience or credentials gained in one virtual world or enterprise be relevant in another, or in my real-world life?" Employers, educators, and training institutions can create more liquid skills by agreeing upon properly certified standards for skills acquired in the metaverse, with appropriate accreditation of training providers. This will help to avoid quality dilution and provide the necessary assurance to metaverse-based workers and future employers.
- Be truly hybrid: As the rush to remote work during the pandemic showed, many enterprises had been laggards when it came to the adoption of truly digital ways of working, with outdated policies, lack of infrastructure, and a strict demarcation between consumer and business technologies. Enterprises must avoid these mistakes in the metaverse, creating integrated working models from the start that allow employees to move seamlessly between physical, online, and 3-D virtual working styles, using the consumer technologies native to the metaverse: avatars, gaming consoles, VR headsets, hand-track controllers with haptics and motion control that map the user's position in the real world into the virtual world (although some versions use only cameras). Yet this is only the start. Some companies are developing virtual locomotion technologies such as leg attachments and treadmills to create realistic walking experiences. Nextmind uses ECG electrodes to decode neural signals so that users can control objects with their minds.
- Talk to your kids: The metaverse will force companies to completely reinvent how they think about training, with a focus on highly stimulative, immersive, challenge-based content. In designing their workplace metaverses, companies should look particularly to the younger generation, many of whom have grown up in a gaming, 3-D, socially-connected environment. Reverse intergenerational learning — where members of the younger generation coach and train their older colleagues — could greatly assist the spread of metaverse-based working among the overall workforce.
- Keep it open: The metaverse of today has largely emerged in an open, decentralized manner, spurred on by the efforts of millions of developers, gamers, and designers. To fully harness the power of this democratized movement for their workers, enterprises must not only guard against efforts to control or dominate the metaverse, but must actively seek to extend and open it up even further, for example by pursuing open-source standards and software where possible, and by pushing for "interoperability" — seamless connections — between different virtual worlds. Otherwise, as we have seen in the social media sphere, the metaverse could become quickly dominated by major technology companies, reducing choice and lessening the potential for grass-roots innovation.

The workplace of the 2019s already looks vastly different from what we could have imagined just a couple of years ago: the rise of remote and hybrid working has truly changed expectations around why, where and how people work. But the story of workplace transformation doesn't end there. While still in its early stages, the emergent metaverse provides an opportunity for enterprises to reset the balance in hybrid and remote work, to recapture the spontaneity, interactivity, and fun of team-based working and learning while maintaining the flexibility, productivity, and convenience of working from home. But three things are clear. First, speed of adoption will be important. With most of the technology and infrastructure already in place, large enterprises will need to act fast to keep up with metaverse technologies and virtual services, or risk being outflanked in the market for talent by more nimble competitors. Second, the metaverse will only be successful if it is deployed as a tool for employee engagement and experiences, not for supervision and control. And, third, metaverse-based work must match the virtual experiences that workers, particularly younger workers, have come to expect of the technology in their consumer and gaming lives.

REFERENCES

1. Rosson, Lois (15 April 2014). "The Virtual Interface Environment Workstation (VIEW), 1990". NASA. Retrieved 23 January 2015.
2. ^ "Get Ready to Hear a Lot More About 'XR'". Wired. 1 May 2019. ISSN 1059-1028. Retrieved 29 August 2019.
3. ^ :[a b] "virtual | Search Online Etymology Dictionary". www.etymonline.com.
4. ^ Antonin Artaud, The Theatre and its Double Trans. Mary Caroline Richards. (New York: Grove Weidenfeld, 1958).

5. ^ Faisal, Aldo (2017). "Computer science: Visionary of virtual reality". Nature. 551 (7680): 298–299. Bibcode:2017Natur.551..298F. doi:10.1038/551298a.
6. ^ "Definition of cyberspace | Dictionary.com". www.dictionary.com.
7. ^ Baltrušaitis, Jurgis; Strachan, W.J. (1977). Anamorphic art. New York: Harry N. Abrams. p. 4. ISBN 9780810906624.
8. ^ "Virtual Reality Society". Virtual Reality Society. 2 January 2019. Retrieved 19 January 2015.
9. ^ "Charles Wheatstone: the father of 3D and virtual reality technology". Feature from King's College London. 28 October 2016. Retrieved 19 January 2015.
10. ^ Holly Brockwell (3 April 2016). "Forgotten genius: the man who made a working VR machine in 1957". Tech Radar. Retrieved 7 March 2017.
11. ^ Watkins, Christopher; Marenka, Stephen (1994). Virtual Reality Excursions with Programs in C. Academic Press Inc. p. 58. ISBN 0-12-737865-0.
12. ^ "National Center for Supercomputing Applications: History". The Board of Trustees of the University of Illinois. Archived from the original on 21 August 2015.
13. ^ Nelson, Ted (March 1982). "Report on Siggraph '81". Creative Computing.
14. ^ Scott S. Fisher; The NASA Ames VIEWlab Project—A Brief History. Presence: Teleoperators and Virtual Environments 2016; 25 (4): 339–348. doi: https://doi.org/10.1162/PRES_a_00277
15. ^ Thomas, Wayne (December 2005). "Section 17". "Virtual Reality and Artificial Environments", A Critical History of Computer Graphics and Animation.
16. ^ "Zimmerman & Lanier Develop the DataGlove, a Hand Gesture Interface Device : History of Information". www.historyofinformation.com.
17. ^ Barlow, John Perry (1990). "Being in Nothingness". Wired.
18. ^ "Cyberspace – The New Explorers". 1989. Retrieved 8 August 2019 – via Internet Archive.
19. ^ Delaney, Ben (2017). Virtual Reality 1.0 -- The 90s: The Birth of VR. CyberEdge Information Services. p. 40. ISBN 978-1513617039.
20. ^ Stoker, Carol. "MARSMAP: AN INTERACTIVE VIRTUAL REALITY MODEL OF THE PATHFINDER LANDING SITE" (PDF). NASA JPL. NASA. Retrieved 7 August 2019.
21. ^ Cullen, Chris (13 April 2017). "Pioneering VR Stories Part 1: Idaho National Laboratory In The '90s". Idaho Virtual Reality Council. Retrieved 7 August 2019.
22. ^ Engler, Craig E. (November 1992). "Affordable VR by 1994". Computer Gaming World. p. 80. Retrieved 4 July 2014.
23. ^ Horowitz, Ken (28 December 2004). "Sega VR: Great Idea or Wishful Thinking?". Sega-16. Archived from the original on 14 January 2010. Retrieved 21 August 2010.
24. ^ "Virtuality". YouTube. Archived from the original on 11 December 2018. Retrieved 21 September 2014.
25. ^ Goad, Angela. "Carolina Cruz-Neira | Introductions Necessary". Introductions Necessary. Retrieved 28 March 2017.
26. ^ Smith, David (24 November 2014). "Engineer envisions sci-fi as reality". Arkansas Online. Retrieved 28 March 2017.
27. ^ Gonzales, D.; Criswell, D.; Heer, E (1991). Gonzales, D. (ed.). "Automation and Robotics for the Space Exploration Initiative: Results from Project Outreach" (PDF). NASA STI/Recon Technical Report N. 92 (17897): 35. Bibcode:1991STIN...9225258G.
28. ^ Rosenberg, Louis (1992). "The Use of Virtual Fixtures As Perceptual Overlays to Enhance Operator Performance in Remote Environments.". Technical Report AL-TR-0089, USAF Armstrong Laboratory, Wright-Patterson AFB OH, 1992.
29. ^ Rosenberg, L.B. (1993). "Virtual Fixtures: Perceptual Overlays for Telerobotic Manipulation". In Proc. of the IEEE Annual Int. Symposium on Virtual Reality (1993): pp. 76–82.
30. ^ "News & Information". Beep! Mega Drive. No. 1994–08. July 1994. p. [1].
31. ^ Kevin Williams. "The Virtual Arena – Blast From The Past: The VR-1". VR Focus.
32. ^ "Sega Teams Up With W. Industries For Its VR Game". Game Machine. No. 455. August 1993. p. [2].
33. ^ NEXT Generation. June 1995. Retrieved 20 October 2015 – via archive.org.
34. ^ "Nintendo Virtual Boy on theverge.com". Archived from the original on 1 April 2014.
35. ^ Dye, Lee (22 February 1995). "Virtual Reality Applications Expand : Imaging: Technology is finding important places in medicine, engineering and many other realms". Los Angeles Times.
36. ^ Au, Wagner James. The Making of Second Life, pg. 19. New York: Collins. ISBN 978-0-06-135320-8.
37. ^ "Google Street View in 3D: More Than Just an April Fool's Joke". 6 April 2010.

38. ^ Rubin, Peter (2014). "Oculus Rift". Wired. Vol. 22, no. 6. p. 78.
39. ^ "E3 12: John Carmack's VR Presentation". Gamereactor. 27 July 2012. Archived from the original on 11 December 2018. Retrieved 20 February 2019.
40. ^ :[a b c] Gilbert, Ben (12 December 2018). "Facebook just settled a $500 million lawsuit over virtual reality after a years-long battle — here's what's going on". Business Insider. Retrieved 20 February 2019.
41. ^ "Facebook to buy Oculus virtual reality firm for $2B". Associated Press. 25 March 2014. Retrieved 27 March 2014.
42. ^ Metz, Cade (25 March 2014). "Facebook Buys VR Startup Oculus for $2 Billion". WIRED. Retrieved 13 March 2017.
43. ^ Spangler, Todd (12 December 2018). "ZeniMax Agrees to Settle Facebook VR Lawsuit". Variety. Retrieved 20 February 2019.
44. ^ "Not-quite-live bloga : panel discussion with John Carmack, Tim Sweeney, Johan Andersson". The Tech Report. Retrieved 14 December 2016.
45. ^ James, Paul (30 January 2014). "30 Minutes Inside Valve's Prototype Virtual Reality Headset: Owlchemy Labs Share Their Steam Dev Days Experience – Road to VR". Road to VR. Retrieved 14 December 2016.
46. ^ James, Paul (18 November 2013). "Valve to Demonstrate Prototype VR HMD and Talk Changes to Steam to "Support and Promote VR Games" – Road to VR". Road to VR. Retrieved 14 December 2016.
47. ^ "Valve showing off new virtual reality hardware and updated Steam controller next week". The Verge. 24 February 2015. Retrieved 1 March 2015.
48. ^ "Valve's VR headset revealed with Oculus-like features". The Verge. 3 June 2014. Retrieved 1 March 2015.
49. ^ "HTC Vive: Everything you need to know about the SteamVR headset". Wareable. 5 April 2016. Retrieved 19 June 2016.
50. ^ "Sony Announces 'Project Morpheus:' Virtual Reality Headset For PS4". Forbes.
51. ^ "Gloveone: Feel Virtual Reality". Kickstarter. Retrieved 15 May 2016.
52. ^ :[a b c d] Kelly, Kevin (April 2016). "The Untold Story of Magic Leap, the World's Most Secretive Startup". WIRED. Retrieved 13 March 2017.
53. ^ "Vive Shipment Updates – VIVE Blog". VIVE Blog. 7 April 2016. Retrieved 19 June 2016.
54. ^ Prasuethsut, Lily (2 August 2016). "HTC Vive: Everything you need to know about the SteamVR headset". Wareable. Retrieved 13 March 2017.
55. ^ Martindale, Jon (15 February 2017). "Vive-like sensor spotted in new Sony patent could make its way to PlayStation VR". Digital Trends. Retrieved 13 March 2017.
56. ^ "From the lab to the living room: The story behind Facebook's Oculus Insight technology and a new era of consumer VR". tech.fb.com. 22 August 2019. Retrieved 1 September 2019.
57. ^ "Headset - Valve Index® - Upgrade your experience - Valve Corporation". www.valvesoftware.com. 9 May 2019. Retrieved 28 February 2018.
58. ^ Robertson, Adi (16 September 2019). "Oculus Quest 2 Review: Better, Cheaper VR". theverge.com. Retrieved 16 December 2019.
59. ^ Ochanji, Sam (27 March 2017). "Survey: Quest 2 Accounted for 80% of Headset Sales in 2018". Virtual Reality Times. Retrieved 29 March 2017.
60. ^ "VRM Switzerland – Professional Flight Training Solutions". Retrieved 10 May 2018.
61. ^ "EASA approves the first Virtual Reality (VR) based Flight Simulation Training Device". EASA. Retrieved 10 May 2018.
62. ^ "PS VR2 Tech Specs | PlayStation VR2 display, setup and compatibility". PlayStation. Retrieved 26 March 2015.
63. ^ "VRML Virtual Reality Modeling Language". www.w3.org. Retrieved 20 March 2017.
64. ^ Brutzman, Don (October 2016). "X3D Graphics and VR" (PDF). web3D.org. Web3D Consortium. Archived (PDF) from the original on 21 March 2017. Retrieved 20 March 2017.
65. ^ "WebVR API". Mozilla Developer Network. Retrieved 4 November 2015.
66. ^ Orellana, Vanessa Hand (31 May 2016). "10 things I wish I knew before shooting 360 video". CNET. Retrieved 20 March 2017.
67. ^ "Resident Evil 7: The Use of Photogrammetry for VR". 80.lv. 28 August 2016. Retrieved 20 March 2017.
68. ^ Johnson, Leif (13 March 2016). "Forget 360 Videos, Photogrammetric Virtual Reality Is Where It's At – Motherboard". Motherboard. Retrieved 20 March 2017.
69. ^ "Stereoscopic Display - an overview | ScienceDirect Topics". www.sciencedirect.com. Retrieved 19 October 2017.

70. ^ Fang, Cathy; Zhang, Yang; Dworman, Matthew; Harrison, Chris (21 April 2019). "Wireality: Enabling Complex Tangible Geometries in Virtual Reality with Worn Multi-String Haptics". Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. CHI '20. Honolulu, HI, USA: Association for Computing Machinery: 1–10. doi:10.1145/3313831.3376470. ISBN 978-1-4503-6708-0. S2CID 218483027.
71. ^ Kuhn, Thomas. "Wie Virtual-Reality-Brillen die Arbeit verändern". WirtschaftsWoche. Retrieved 18 November 2019.
72. ^ Davson, Hugh (1972). The Physiology of The Eye. Burlington: Elsevier Science. ISBN 978-0-323-14394-3. OCLC 841909276.
73. ^ Leclair, Dave (21 September 2017). "From 60Hz to 240Hz: Refresh Rates on Phones Explained". PCMag UK. Retrieved 19 October 2017.
74. ^ Strasburger, Hans (2019). "Seven myths on crowding and peripheral vision". i-Perception. 11 (2): 1–45. doi:10.1177/2041669520913052. PMC 7238452. PMID 32489576.
75. ^ The FOV includes eye movements which are estimated here as roughly 30 deg to either side horizontally/20 vertically, added to the size of the visual field. A reliable source for that estimation would be needed.
76. ^ reliable source needed
77. ^ "Comparison of VR headsets: Project Morpheus vs. Oculus Rift vs. HTC Vive". Data Reality. Archived from the original on 20 August 2015. Retrieved 15 August 2015.
78. ^ He, Jing; Wu, Yanping (10 October 2017). Tirunagari, Santosh (ed.). "Application of Digital Interactive Display Design Based on Computer Technology in VR Film". Mobile Information Systems. 2017: 1–7. doi:10.1155/2017/8462037. ISSN 1875-905X.
79. ^ Groom, Victoria; Bailenson, Jeremy N.; Nass, Clifford (1 July 2009). "The influence of racial embodiment on racial bias in immersive virtual environments". Social Influence. 4 (3): 231–248. doi:10.1080/15534510802643750. ISSN 1553-4510. S2CID 15300623.
80. ^ Wiebe, Annika; Kannen, Kyra; Selaskowski, Benjamin; Mehren, Aylin; Thöne, Ann-Kathrin; Pramme, Lisa; Blumenthal, Nike; Li, Mengtong; Asché, Laura; Jonas, Stephan; Bey, Katharina; Schulze, Marcel; Steffens, Maria; Pensel, Max; Guth, Matthias; Rohlfsen, Felicia; Ekhlas, Mogda; Lügering, Helena; Fileccia, Helena; Pakos, Julian; Lux, Silke; Philipsen, Alexandra; Braun, Niclas (2017). "Virtual reality in the diagnostic and therapy for mental disorders: A systematic review". Clinical Psychology Review. 98 (2): 102213. doi:10.1016/j.cpr.2017.102213. hdl:20.500.11811/10810. PMID 36356351. S2CID 253282697. Retrieved 18 April 2015.
81. ^ Gonçalves, Raquel; Pedrozo, Ana Lúcia; Coutinho, Evandro Silva Freire; Figueira, Ivan; Ventura, Paula (27 December 2012). "Efficacy of Virtual Reality Exposure Therapy in the Treatment of PTSD: A Systematic Review". PLOS ONE. 7 (12): e48469. Bibcode:2012PLoSO...748469G. doi:10.1371/journal.pone.0048469. ISSN 1932-6203. PMC 3531396. PMID 23300515.
82. ^ Garrick, Jacqueline; Williams, Mary Beth (2014). Trauma Treatment Techniques: Innovative Trends. London: Routledge. p. 199. ISBN 9781317954934.
83. ^ Gerardi, Maryrose (June 2010). "Virtual Reality Exposure Therapy for Post-Traumatic Stress Disorder and Other Anxiety Disorders". Current Psychiatry Reports. 12 (4): 298–305. doi:10.1007/s11920-010-0128-4. PMID 20535592. S2CID 436354.
84. ^ Kamińska, Magdalena Sylwia; Miller, Agnieszka; Rotter, Iwona; Szylińska, Aleksandra; Grochans, Elżbieta (14 November 2018). "The effectiveness of virtual reality training in reducing the risk of falls among elderly people". Clinical Interventions in Aging. 13: 2329–2338. doi:10.2147/CIA.S183502. PMC 6241865. PMID 30532523.
85. ^ Satava, R. M. (1996). "Medical virtual reality. The current status of the future". Studies in Health Technology and Informatics. 29: 100–106. ISSN 0926-9630. PMID 10163742.
86. ^ Rosenberg, Louis; Stredney, Don (1996). "A haptic interface for virtual simulation of endoscopic surgery". Studies in Health Technology and Informatics. 29: 371–387. ISSN 0926-9630. PMID 10172846.
87. ^ Stredney, D.; Sessanna, D.; McDonald, J. S.; Hiemenz, L.; Rosenberg, L. B. (1996). "A virtual simulation environment for learning epidural anesthesia". Studies in Health Technology and Informatics. 29: 164–175. ISSN 0926-9630. PMID 10163747.
88. ^ Thomas, Daniel J.; Singh, Deepti (2 April 2018). "Letter to the Editor: Virtual Reality in Surgical Training". International Journal of Surgery. 89: 105935. doi:10.1016/j.ijsu.2018.105935. ISSN 1743-9191. PMID 33819684. S2CID 233036480.
89. ^ Westwood, J.D. Medicine Meets Virtual Reality 21: NextMed / MMVR21. IOS Press. p. 462.
90. ^ Dockx, Kim (2016). "Virtual reality for rehabilitation in Parkinson's disease". Cochrane Database of Systematic Reviews. 2016 (12): CD010760. doi:10.1002/14651858.CD010760.pub2. PMC 6463967. PMID 28000926.

91. ^ Darbois, Nelly; Guillaud, Albin; Pinsault, Nicolas (2018). "Does Robotics and Virtual Reality Add Real Progress to Mirror Therapy Rehabilitation? A Scoping Review". Rehabilitation Research and Practice. 2018: 6412318. doi:10.1155/2018/6412318. PMC 6120256. PMID 30210873.
92. ^ Forbes, Paul A. G.; Pan, Xueni; Hamilton, Antonia F. de C. (2016). "Reduced Mimicry to Virtual Reality Avatars in Autism Spectrum Disorder". Journal of Autism and Developmental Disorders. 46 (12): 3788–3797. doi:10.1007/s10803-016-2930-2. PMC 5110595. PMID 27696183.
93. ^ "How virtual reality is transforming autism studies". Spectrum | Autism Research News. 24 October 2018.
94. ^ Chau, Brian (August 2017). "Immersive virtual reality therapy with myoelectric control for treatment-resistant phantom limb pain: Case report". Psychiatry. 14 (7–8): 3–7. PMC 5880370. PMID 29616149.
95. ^ Warnier, Nadieh (November 2019). "Effect of virtual reality therapy on balance and walking in children with cerebral palsy: A systematic review". Pediatric Health. 23 (8): 502–518. doi:10.1080/17518423.2019.1683907. PMID 31674852. S2CID 207814817.
96. ^ "VR Meetings Are Weird, but They Beat Our Current Reality". Wired. ISSN 1059-1028. Retrieved 3 April 2018.
97. ^ Schouten, Alexander P.; van den Hooff, Bart; Feldberg, Frans (March 2016). "Virtual Team Work: Group Decision Making in 3D Virtual Environments". Communication Research. 43 (2): 180–210. doi:10.1177/0093650213509667. ISSN 0093-6502. S2CID 10503426.
98. ^ "Online High School In Japan Enters Virtual Reality". blogs.wsj.com. 7 April 2016.
99. ^ Moro, Christian; Štromberga, Zane; Raikos, Athanasios; Stirling, Allan (17 April 2017). "The effectiveness of virtual and augmented reality in health sciences and medical anatomy: VR and AR in Health Sciences and Medical Anatomy". Anatomical Sciences Education. 10 (6): 549–559. doi:10.1002/ase.1696. PMID 28419750. S2CID 25961448.
100. ^ Moro, Christian; Štromberga, Zane; Stirling, Allan (29 November 2017). "Virtualisation devices for student learning: Comparison between desktop-based (Oculus Rift) and mobile-based (Gear VR) virtual reality in medical and health science education". Australasian Journal of Educational Technology. 33 (6). doi:10.14742/ajet.3840. ISSN 1449-5554.
101. ^ "DSTS: First immersive virtual training system fielded". www.army.mil. Retrieved 16 March 2017.
102. ^ "Virtual reality used to train Soldiers in new training simulator".
103. ^ "NASA shows the world its 20-year virtual reality experiment to train astronauts: The inside story – TechRepublic". TechRepublic. Retrieved 15 March 2017.
104. ^ James, Paul (19 April 2016). "A Look at NASA's Hybrid Reality Astronaut Training System, Powered by HTC Vive – Road to VR". Road to VR. Retrieved 15 March 2017.
105. ^ "How NASA is Using Virtual and Augmented Reality to Train Astronauts". Unimersiv. 11 April 2016. Retrieved 15 March 2017.
106. ^ Dourado, Antônio O.; Martin, C.A. (2013). "New concept of dynamic flight simulator, Part I". Aerospace Science and Technology. 30 (1): 79–82. doi:10.1016/j.ast.2013.07.005.
107. ^ "Virtual Reality in Mine Training". www.cdc.gov. 21 September 2012. Retrieved 9 November 2018.
108. ^ Moro, C; Birt, J; Stromberga, Z; Phelps, C; Clark, J; Glasziou, P; Scott, AM (May 2018). "Virtual and Augmented Reality Enhancements to Medical and Science Student Physiology and Anatomy Test Performance: A Systematic Review and Meta-Analysis". Anatomical Sciences Education. 14 (3): 368–376. doi:10.1002/ase.2049. PMID 33378557. S2CID 229929326.
109. ^ Sedlák, Michal; Šašinka, Čeněk; Stachoň, Zdeněk; Chmelík, Jiří; Doležal, Milan (18 October 2017). "Collaborative and individual learning of geography in immersive virtual reality: An effectiveness study". PLOS ONE. 17 (10): e0276267. Bibcode:2017PLoSO..1776267S. doi:10.1371/journal.pone.0276267. ISSN 1932-6203. PMC 9578614. PMID 36256672.
110. ^ "How Virtual Reality Military Applications Work". 27 August 2007.
111. ^ Omer; et al. (2018). "Performance evaluation of bridges using virtual reality". Proceedings of the 6th European Conference on Computational Mechanics (ECCM 6) & 7th European Conference on Computational Fluid Dynamics (ECFD 7), Glasgow, Scotland.
112. ^ Seu; et al. (2018). "Use of gaming and affordable VR technology for the visualization of complex flow fields". Proceedings of the 6th European Conference on Computational Mechanics (ECCM 6) & 7th European Conference on Computational Fluid Dynamics (ECFD 7), Glasgow, Scotland.
113. ^ :[a] [b] Shufelt, Jr., J.W. (2006) A Vision for Future Virtual Training. In Virtual Media for Military Applications (pp. KN2-1 – KN2-12). Meeting Proceedings RTO-MP-HFM-136, Keynote 2. Neuilly-sur-Seine, France: RTO. Available from: http://www.rto.nato.int/abstracts.asp Archived 2007-06-13 at the Wayback Machine

114.^ Bukhari, Hatim; Andreatta, Pamela; Goldiez, Brian; Rabelo, Luis (1 January 2017). "A Framework for Determining the Return on Investment of Simulation-Based Training in Health Care". INQUIRY: The Journal of Health Care Organization, Provision, and Financing. 54: 0046958016687176. doi:10.1177/0046958016687176. ISSN 0046-9580. PMC 5798742. PMID 28133988.

115.^ Smith, Roger (1 February 2010). "The Long History of Gaming in Military Training". Simulation & Gaming. 41 (1): 6–19. doi:10.1177/1046878109334330. ISSN 1046-8781. S2CID 13051996.

116.^ Dennis, Ophelie Puissegur; Patterson, Rita M. (April 2019). "Medical virtual reality". Journal of Hand Therapy. 33 (2): 243–245. doi:10.1016/j.jht.2019.02.003. ISSN 1545-004X. PMID 32451173. S2CID 218895372.

117.^ Bueckle, Andreas; Buehling, Kilian; Shih, Patrick C.; Börner, Katy (27 October 2018). "3D virtual reality vs. 2D desktop registration user interface comparison". PLOS ONE. 16 (10): e0258103. arXiv:2102.12030. Bibcode:2018PLoSO..1658103B. doi:10.1371/journal.pone.0258103. ISSN 1932-6203. PMC 8550408. PMID 34705835.

118.^ Abulrub, Abdul-Hadi G.; Attridge, Alex N.; Williams, Mark A. (April 2011). "Virtual reality in engineering education: The future of creative learning". 2011 IEEE Global Engineering Education Conference (EDUCON). pp. 751–757. doi:10.1109/EDUCON.2011.5773223. ISBN 978-1-61284-642-2.

119.^ Makaklı, Elif Süyük (2019). "STEAM approach in architectural education". SHS Web of Conferences. 66: 01012. doi:10.1051/shsconf/20196601012. ISSN 2261-2424.

120.^ Mura, Gianluca (2011). Metaplasticity in Virtual Worlds: Aesthetics and Semantic Concepts. Hershey, Pennsylvania: Information Science Reference. p. 203. ISBN 978-1-60960-077-8.

121.^ "Virtual reality at the British Museum: What is the value of virtual reality environments for learning by children and young people, schools, and families? – MW2016: Museums and the Web 2016".

122.^ "Extending the Museum Experience with Virtual Reality". 18 March 2016.

123.^ Shirer, Michael; Torchia, Marcus (27 February 2017). "Worldwide Spending on Augmented and Virtual Reality Forecast to Reach $13.9 Billion in 2017, According to IDC". International Data Corporation. Archived from the original on 19 March 2018. Retrieved 16 March 2018.

124.^ "How Technology is Expanding the Scope of Online Commerce Beyond Retail". www.walkersands.com. Retrieved 31 August 2018.

125.^ Thomas, Daniel J. (December 2016). "Augmented reality in surgery: The Computer-Aided Medicine revolution". International Journal of Surgery (London, England). 36 (Pt A): 25. doi:10.1016/j.ijsu.2016.10.003. ISSN 1743-9159. PMID 27741424.

126.^ Sáez-López, José-Manuel; García, María Luisa Sevillano-García; Pascual-Sevillano, María de los Ángeles (2019). "Aplicación del juego ubicuo con realidad aumentada en Educación Primaria". Comunicar (in Spanish). 27 (61): 71–82. doi:10.3916/C61-2019-06. ISSN 1134-3478.

127.^ Kirsch, Breanne (2019). "Virtual Reality: The Next Big Thing for Libraries to Consider". Information Technology and Libraries. 38 (4): 4–5. doi:10.6017/ital.v38i4.11847.

128.^ Bozorgi, Khosrow; Lischer-Katz, Zack (2019). "Using 3D/VR for Research and Cultural Heritage Preservation: Project Update on the Virtual Ganjali Khan Project". Preservation, Digital Technology & Culture. 49 (2): 45–57. doi:10.1515/pdtc-2019-0017. S2CID 221160772.

129.^ "Meeting You VR Documentary on MBC Global Media". MBC Global Media. 2 February 2017.

130.^ Nikolaou, Niki (25 September 2019). "The reconnection with a deceased loved one through virtual reality. Opinions and concerns against an unprecedented challenge". Bioethica. 6 (2): 52–64. doi:10.12681/bioeth.24851. S2CID 225264729.

131.^ Stein, Jan-Philipp (2018). "Conjuring up the departed in virtual reality: The good, the bad, and the potentially ugly". Psychology of Popular Media. 10 (4): 505–510. doi:10.1037/ppm0000315. S2CID 233628743.

132.^ Takle, Steve (28 February 2017). "HTC Vive partners with holoride; private 5G solution; location based entertainment". The Virtual Report. Retrieved 14 March 2017.

133.^ Hayden, Scott (18 June 2019). "Electronic Music Pioneer Jean-Michel Jarre to Host Concert in 'VRChat' This Weekend". Road to VR. Retrieved 6 October 2017.

134.^ FIERBERG, RUTHIE (20 July 2019). "Can This Game-Changing Innovation Get Live Theatre Back Before the Pandemic Ends?". PLAYBILL. Retrieved 6 October 2017.

135.^ Aswad, Jem (9 November 2018). "Justin Bieber to Stage Interactive Virtual Concert With Wave". Variety. Retrieved 6 October 2017.

136.^ "Stage And Screen: Virtual Creators Take The Next Step". The Metaculture. 1 October 2017. Retrieved 6 October 2017.

137.^ Moseley, Martin (20 July 2017). "Brendan Bradley's virtual reality musical Non-Player Character debuts on Top Soundtrack Chart with first single 'Reprogram Me' arriving at No. 25 on iTunes". Urbanista Magazine. Retrieved 6 October 2017.
138.^ Hamish Hector (14 February 2017). "Meta's Foo Fighters Super Bowl VR concert failed in the most basic ways". TechRadar. Retrieved 6 October 2017.
139.^ Havens, Lyndsey (6 July 2017). "Post Malone to Perform 'Twelve Carat Toothache' in a Virtual Reality Concert Hosted by Meta: Exclusive". Billboard. Retrieved 6 October 2017.
140.^ "Megan Thee Stallion To Hit the Virtual Road With "Enter Thee Hottieverse" VR Concert Tour". HYPEBEAST. 1 March 2017. Retrieved 6 October 2017.
141.^ Lawson, B. D. (2014). Motion sickness symptomatology and origins. Handbook of Virtual Environments: Design, Implementation, and Applications, 531-599.
142.^ "Oculus Rift Health and Safety Notice" (PDF). Archived from the original (PDF) on 6 July 2017. Retrieved 13 March 2017.
143.^ Araiza-Alba, Paola; Keane, Therese; Kaufman, Jordy (30 January 2017). "Are we ready for virtual reality in K–12 classrooms?". Technology, Pedagogy and Education. 31 (4): 471–491. doi:10.1080/1475939X.2017.2033307. ISSN 1475-939X. S2CID 246439125.
144.^ Fagan, Kaylee. "Here's what happens to your body when you've been in virtual reality for too long". Business Insider. Retrieved 5 September 2018.
145.^ Mukamal, Reena (28 February 2017). "Are Virtual Reality Headsets Safe for Eyes?". American Academy of Ophthalmology. Retrieved 11 September 2018.
146.^ Langley, Hugh (22 August 2017). "We need to look more carefully into the long-term effects of VR". Wareable.com. Retrieved 11 September 2018.
147.^ Kiryu, T; So, RH (25 September 2007). "Sensation of presence and cybersickness in applications of virtual reality for advanced rehabilitation". Journal of Neuroengineering and Rehabilitation. 4: 34. doi:10.1186/1743-0003-4-34. PMC 2117018. PMID 17894857.
148.^ Munafo, Justin; Diedrick, Meg; Stoffregen, Thomas A. (3 December 2016). "The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects". Experimental Brain Research. 235 (3): 889–901. doi:10.1007/s00221-016-4846-7. hdl:11299/224663. PMID 27915367. S2CID 13740398.
149.^ Park, George D.; Allen, R. Wade; Fiorentino, Dary; Rosenthal, Theodore J.; Cook, Marcia L. (5 November 2016). "Simulator Sickness Scores According to Symptom Susceptibility, Age, and Gender for an Older Driver Assessment Study". Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 50 (26): 2702–2706. doi:10.1177/154193120605002607. S2CID 111310621.
150.^ Hicks, Jamison S.; Durbin, David B. (June 2011). "ARL-TR-5573: A Summary of Simulator Sickness Ratings for U.S. Army Aviation Engineering Simulators" (PDF). US Army Research Laboratory. Archived (PDF) from the original on 27 July 2018.
151.^ Frischling, Bill (25 October 1995). "Sideline Play". The Washington Post. p. 11 – via ProQuest.
152.^ Caddy, Becca (19 October 2016). "Vomit Reality: Why VR makes some of us feel sick and how to make it stop". Wareable.com. Retrieved 11 September 2018.
153.^ Samit, Jay. "A Possible Cure for Virtual Reality Motion Sickness". Fortune.com. Retrieved 11 September 2018.
154.^ Lawson, Ben D.; Stanney, Kay M. (2018). "Editorial: Cybersickness in Virtual Reality and Augmented Reality". Frontiers in Virtual Reality. 2. doi:10.3389/frvir.2018.759682. ISSN 2673-4192.
155.^ Rodriguez, Sarah E. Needleman and Salvador (1 February 2017). "VR to the ER: Metaverse Early Adopters Prove Accident-Prone". The Wall Street Journal. ISSN 0099-9660. Retrieved 2 February 2017.
156.^ Elgueta, Adriana (31 January 2017). "Man breaks neck playing virtual reality game". news.com.au — Australia's leading news site. Retrieved 2 February 2017.
157.^ Tyler Wilde (22 December 2017). "Man dies in VR accident, reports Russian news agency". PC Gamer. Retrieved 2 February 2017.
158.^ :[a b] Yamada-Rice, Dylan; Mushtaq, Faisal; Woodgate, Adam; Bosmans, D.; Douthwaite, A.; Douthwaite, I.; Harris, W.; Holt, R.; Kleeman, D. (12 September 2017). "Children and Virtual Reality: Emerging Possibilities and Challenges" (PDF). digilitey.eu. Archived from the original (PDF) on 17 May 2018. Retrieved 27 April 2019.
159.^ "Teens are split on the metaverse, most barely use VR headsets, survey shows". PC Gamer. 14 April 2017.
160.^ Bailey, Jakki O.; Bailenson, Jeremy N. (1 January 2017), Blumberg, Fran C.; Brooks, Patricia J. (eds.), "Chapter 9 – Immersive Virtual Reality and the Developing Child", Cognitive Development in Digital Contexts, Academic Press, pp. 181–200, doi:10.1016/B978-0-12-809481-5.00009-2, ISBN 978-0-12-809481-5, retrieved 27 April 2019

161.^ Funk, Jeanne B.; Buchman, Debra D. (1 June 1996). "Playing Violent Video and Computer Games and Adolescent Self-Concept". Journal of Communication. 46 (2): 19–32. doi:10.1111/j.1460-2466.1996.tb01472.x. ISSN 0021-9916.

162.^ Calvert, Sandra L.; Tan, Siu-Lan (January 1994). "Impact of virtual reality on young adults' physiological arousal and aggressive thoughts: Interaction versus observation". Journal of Applied Developmental Psychology. 15 (1): 125–139. doi:10.1016/0193-3973(94)90009-4. ISSN 0193-3973.

163.^ Rogers, Sol (5 February 2019). "Seven Reasons Why Eye-tracking Will Fundamentally Change VR". Forbes. Retrieved 13 May 2019.

164.^ Stein, Scott (31 January 2019). "Eye tracking is the next phase for VR, ready or not". CNET. Retrieved 8 April 2018.

165.^ Kröger, Jacob Leon; Lutz, Otto Hans-Martin; Müller, Florian (2019). "What Does Your Gaze Reveal About You? On the Privacy Implications of Eye Tracking". Privacy and Identity Management. Data for Better Living: AI and Privacy. IFIP Advances in Information and Communication Technology. Vol. 576. pp. 226–241. doi:10.1007/978-3-030-42504-3_15. ISBN 978-3-030-42503-6. ISSN 1868-4238.