Future Student Experience Project

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XR-HE 2035

The coming together of extended reality technologies and hybrid learning for an inclusive and inspiring higher education student experience in 2035

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1 Scenario

1.1 Vision

Extended reality (XR) is an umbrella term that covers virtual reality (VR), augmented reality (AR) and mixed reality (MR). Virtual reality (VR) technology creates 3D environments where users are immersed in simulated realities via headsets and haptic touch. Augmented reality (AR) technology overlays digital images onto the real world via a screen or projection interface. Mixed reality (MR) technology creates blended environments where physical and digital elements are present together. In MR, one can be immersed in a virtual environment via a headset, but also able to view the physical environment around oneself, due to the real-time integration of environmental objects in the virtual world.

In the scenario presented in this report, we envisage how immersive XR technologies lead to two transformative changes in the delivery of learning in higher education (HE) by 2035:

(a) the radical improvement of the online learning experience and corresponding popularity of distance learning

(b) AR, MR and VR being used for experiential and interactive learning far more widely than at present, becoming a standard element of the HE learning experience and leading to a fundamental shift in how intrinsically motivating, inclusive and engaging HE is for students with diverse learning preferences and needs.

These two envisioned pathways of change will be facilitated by predicted innovations in the intervening years. Firstly, it is predicted that the development of VR/AR resolution is likely to have increased to a photo-realist level by 2035 (Durbin, 2017). Secondly, improved devices for interacting with XR, such as high-spec augmented reality glasses, super-light VR headsets and invisible devices such as AR contact lenses, will be available by 2035. There will also be non-wearable technology for interacting with XR such as wraparound monitors, domes, screen walls and holographic displays. See Appendix 1 for images and descriptions of example current technologies that provide a precedent for what can be expected in 2035.

The online/distance learning experience

Our scenario is based partly on the assumption that all IT interfaces become more immersive and sensorily multifaceted over time and, in the intervening 13-year period between 2022 and 2035, interfaces will become less constrained by 2D screens (Valdivia, 2018). We predict that teaching environments for online learning in 2035 will be immersive and three dimensional and may, in some ways, be superior to traditional lecture halls and classroom spaces as learning environments. The two-dimensional platforms currently used by Zoom and Teams will have ceded to navigable 3D online campus environments in which individuals can move, interact and experience being present within a spatial environment designed for learning. Interacting with this online 3D environment will be achievable via screen-based interfaces, such as multi-screen arrays and dome screens, and also by wearable interfaces such as glasses and/or headsets. With this technology, students will feel a connection over a distance that can be lacking within the current 2D platforms. Thanks to live biomotion capture, students and staff may have avatars that have facial expressions, body language and talking movements that are precisely in sync with the physical movements of the individual, allowing for a 3D photorealist avatar rather than a headshot via a webcam.

See Appendix 2 for screenshots from 3D platforms that are currently used for learning and education, which may give an indicator of how future platforms could look.

Learning within an online 3D space has various advantages over lecture halls and classrooms. Students in the physical space they are in, such as being at home, can choose their own chair and their preferred room temperature, instead of being in lecture halls or classrooms that may or may not be environmentally conducive to their needs. A person can choose their exact position relative to the screen, to the lecturer/seminar leader and students can modify the volume of their speaking to suit their auditory preferences. This allows for social communication between peers located next to each other, which in turn facilitates learning, similar to that of a physical lecture hall. There are also potential advantages for individuals with physical disabilities, neurodivergence, physical or mental health problems.

XR-enabled distance learning will create an improved online interface for students who have traditionally found university education that demands physically presence on campus to be challenging, such as students with mobility issues, mature students with children and work commitments or a sensory disability. While current distance learning options are designed to increase access, the 2035 scenario we envisage is one in which a 3D realistic environment creates a more sociable online space for relationship building and a more immersive learning environment.

We recognise the importance of improving physical accessibility to campuses in the intervening 13 years between now and the projected scenario date and envisage improved distance learning via XR technologies to be complementary to such physical developments.

Universities have experimented with 3D virtual world platforms for educational delivery before, such as in Second Life. Second Life is a virtual world platform owned by Linden Labs, and was in some senses a forerunner of the idea of the metaverse – a navigable virtual world in which educational establishments and businesses could set up (Jamison, 2017). There are a number of reasons why Second Life was not successful in the educational sector, and why we predict the next generation of 3D learning enhancement will succeed. Firstly, Second Life emerged in 2003 before most computers had the hardware to manage access to a virtual world and before broadband was common. Even in 2009, when it had its highest user count (Galov, 2022), many computers still struggled with the capacity required for a fluent interaction with Second Life. Also, Second Life is an environment that has a single corporate provider and requires educational users to sign up to that corporate wrapper and model.

In contrast, the digital platforms for distance learning and 3D online campus environments that we envisage will be provided by a range of specialist XR organisations in collaboration with universities, without the need to buy into a single virtual world. This will allow for a greater plurality of technologies and independence of innovation across establishments. Further, the combination of improved connectivity and hardware over recent years, and improvements in digital literacy that have occurred since the Covid-19 pandemic, will lay the foundation for the transformative changes we are predicting by 2035. We set out a bold vision but, of course, we can’t be certain of reaching this destination in 13 years’ time, and so we also consider the drivers and obstacles to our future scenario below.

Experiential and interactive learning

Experiential and interactive learning will be enhanced via XR technologies in a range of different ways. Makransky and Petersen (2021) present a module of immersive learning in virtual reality that emphasises the high levels of presence (feeling fully present in the moment, undistracted) and agency (having a sense of control and volition over learning) relative to other modalities, which in turn leads to increased interest, motivation and self-efficacy, and transferable learning.

The relationship between learning and language is affected by the use of XR technologies. Learning is less reliant on written language to convey ideas, as multisensory experiences can be provided that can bypass language to a degree. This can be beneficial for those with dyslexia (Bentley, 2018; Kalyvioti and Mikropoulos, 2014) Observational learning is enhanced by creating interactive simulacra of phenomena that bypass language and diagrams and reduce the tendency to consider phenomena out of context. For example, there is only so much a two-dimensional diagram with text can explain about photosynthesis. Imagine experiencing photosynthesis from the perspective of a photon or a molecule of water, being directly present within that process. Transcending language by creating these experiences can change our perception of the way we see and hear things, ultimately creating a trans-linguistic experience that includes language but is not completely dependent on it (Zheng et al, 2017).

Virtual reality can also be used for field trips to different parts of the world or to different cultural environments, and the environment conveyed may be a live 3D feed of the actual physical space, rather than a rendered version of that space, making the experience of visiting the environment a close simulacrum of being physically present. For example, a trip through the forest to learn about the mycelium network can be enhanced using an augmented reality overlay of the mycelium networks that are invisible to the naked eye.

Continuing the trend from 2D to 3D, the nature of learning visual aids will have shifted away from PowerPoint towards more 3D-type visualisation platforms. Tilt Brush is a contemporary example of how this can be realised without high levels of technical knowledge (Google VR, nd). We predict that learning visualisation platforms will follow suit by 2035, based on the general trajectory of development towards 3D materials in education (Walia, 2020) Appendix 2 show several examples of how this may look.

While virtual field trips and VR educational simulations have been around for some years now, their use in higher education still remains marginal, or non-existent for most programmes of study (Marks and Thomas, 2022) By 2035, we predict the technology will have moved from peripheral to central. A parallel to this process of disruptive innovation in HE can be seen with the use of PowerPoint. The adoption of PowerPoint started in around 2001, with a few pioneering teachers using it (Guernsey, 2001) By 2009, overhead projectors were still predominant, but PowerPoint rapidly become the default option for adding visual materials to live and recorded lectures, as educators increased in PowerPoint literacy, and software and hardware improved in tandem.

The structure of HE institutions in the 2035 landscape

We project that, by 2035, XR technologies aligned with distance learning platforms will have resculpted the landscape of HE into three types of institution.

1. 'Metaversities': purely virtual universities that deliver immersive distance learning with a central emphasis on XR technologies.
2. Blended XR universities or the creation of a digital twin: universities that integrate a physical campus with an exact virtual online replica campus along with interactive influence between the two using real-time data.
3. Hybrid non-XR universities: establishments that have a physical campus and linked online learning delivery without much use of XR technology.

An example of a current initiative to develop a metaversity is Invact, which has raised $5 million to develop the technologies to support a fully virtual 3D-environment university (Dilipkumar, 2022). Invact was created in India during the pandemic when unemployment was at its peak and online learning was the default mode of teaching for higher education. Invact aims to offer a scalable, immersive university-like experience where students can learn through an experiential combination of virtual and real-world experiences. The platform strives to offer high-quality, socially immersive and affordable education to anyone, no matter where they are located. An example of a planned course is a 16-week virtual business fellowship (Invact, nd). The course offers essential practitioner-oriented job skills, as well as a proof-of-work portfolio that will prepare students for jobs. Invact is one of several early adopters (others include West Virginia University, South Dakota University, California State University, New Mexico State University and Queen Mary University of London) that aim to disrupt the pedagogy in higher education in the hopes of providing effective, socially immersive and inclusive teaching to students who would not be able to participate normally due to location and funding (Lal, 2022). Globally, universities are starting to embrace the blended XR initiative, and the following examples illustrate the potential for the future of education.

1.2 Value proposition

Learners

Facilitated by XR technology, learning in 2035 will be immersive, interactive, flexible and personalised. Learning will be in person and via augmented virtual, and mixed reality, providing genuine choice in mode of learning. Students with physical or sensory diversity as well as those with other competing commitments, can personalise their learning experience to meet their needs, providing enhanced access to an equitable, quality HE for all students.

Teachers

The XR-HE scenario affords a range of benefits to educators. Lessening dependence on campus presence will be of benefit to staff who wish to live in a location that is at a distance from the university campus and makes a daily commute problematic. It also allows for teachers in different countries to contribute their cultural expertise to HE courses without the expense of travel. The Alef Trust has already delivered a number of master's programmes in consciousness studies and transpersonal psychology without any physical campus, including students and teachers from multiple continents (Alef Trust, nd.). Most of the expert teachers who contribute to Alef Trust degree programmes would not be able to if there was the requirement to be present on a physical campus. Immersive and interactive distance learning could benefit both educators and students through increased job satisfaction, student engagement and performance.

Institutions

Immersive, XR-enabled distance learning makes international higher education attractive and accessible to students who do not have the opportunity or funds to travel for study. Institutions who invest in XR-technology will be at a competitive advantage in the global higher education market. Currently, VR headset usage requires about three square metres of empty space, so institutions will need to consider whether this is realistic for the students they hope to attract or consider how they can provide open access to screen-based interfaces (eg multi-screen arrays / dome screens / holographic displays), which will remain an essential option for interaction with virtual environments for many.

The metaversity is already being piloted. Ten universities in the USA are currently delivering courses on virtual campuses, as of September 2022. The virtual campuses are exact 3D replicas of the physical campus. The participating universities include West Virginia University, South Dakota University, California State University and New Mexico State University. The digital campuses are being been built by VictoryXR (see Appendix 2), a virtual world building platform (Kelly, 2022; Whitford, 2022). The courses will be synchronous with live delivery, thus students can attend whether they are learning on campus or remotely. All students are provided with a Meta Quest 2 virtual reality headset, and the 3D environment and materials can also be accessed by screen, without the need for a headset. Within the virtual learning environment, students will be able to interact with other students and staff, while engaging in VR experiences such as delving into the human brain, taking a time machine through history or studying astronomy on a spaceship.

In the UK, medical students from Queen Mary University of London had a lecture delivered within the metaverse, making it the first university in the UK to embrace this approach (Queen Mary University of London, 2022). Sophia Technologies has become the first British online education provider to enter the metaverse, where it will launch its Immersive Learning Discovery Centre in Somnium Space (Shakespeare, 2022). Furthermore, the University of Surrey has recently opened a metaverse academy (University of Surrey, 2022)

Society

XR-HE through remote VR learning conditions offers experiential and affordable university-like space that is accessible to anyone in the world who values an education. This, in turn, can help develop transferable skills and specialisations that can be applied to benefit society; in addition, socialising with a global cohort can stimulate students' worldviews, develop normative competencies and help develop the global citizenship required to reduce prejudice and discrimination and promote open conversations and acceptance of different cultures.

2 Approach

2.1 Research methods

2.1.1 Aims

The aim of the project was to explore a future vision for higher education (HE) that centres on the use of immersive extended reality (XR) technologies as facilitators of new patterns in delivery of higher education that will shape the student experience in 2035. XR technologies encompass virtual reality (VR), augmented reality (AR) and mixed reality (MR). Four key facets of the XR-HE 2035 scenario were explored:

(a) the nature of learning

(b) opportunities and threats to inclusivity, equality and diversity

(c) effects on wellbeing and mental health

(d) the projected structure of HE institutions.

2.1.2 Data collection

Data was collected from a literature search and a search of organisations who are developing relevant technologies, which informed a roundtable online focus group with experts. This was followed by a focused email discussion on the PESTLE analysis with the same group of experts.

Round table online focus group with experts

The online roundtable focus group took place on 5 April 2022. The participants included the project team, plus the following selected experts:

1. Barney Steel, Marshmallow Laser Feast (www.marshmallowlaserfeast.com) – expert in the development of virtual reality technologies for transformative learning experiences (Marshmallow Laser Feast, nd).
2. Lila Moore, Alef Trust – expert in the use of mixed reality for supporting art and dance education
3. Martin Compton, University College London – expert in the use of digital technologies in higher education
4. Miranda McCarthy, Wavelength VR (www.wavelengthvr.com) – expert in the virtual reality for disabled persons (Wavelength VR, nd).
5. Ryan Flynn, University of Greenwich – expert in the use of multimedia games and technologies in education
6. Scott Hibberson, Jisc (www.jisc.ac.uk) – expert in digital solutions for UK education and research (Jisc, nd)

7 Silvia Margarita Baldiris Navarro, Universidad Internacional De La Rioja. Logroño, Spain – expert in the use of augmented reality in education

The focus group lasted two hours and was structured as follows:

1 Welcome and introductions

2 The nature of XR-facilitated learning in 2035 (brief introduction to this section by Oliver Robinson

3 XR opportunities and threats to EDI (brief introduction to this section by Sharon Perera)

4 Effects of XR on wellbeing and mental health (brief introduction to this section by Jazz Rasool

5 Structure of HE institutions and the idea of the metaversity (brief introduction to this section by Carl Smith)

Structured email exchange with experts

Following the online focus group, the experts were emailed with a request to comment specifically on the PESTLE analysis.

Literature review

The literature review encompassed (a) a search of relevant literature on virtual reality, augmented reality, mixed reality and extended reality in education generally, and also more specifically in higher education, and (b) a search of relevant organisations and products that are being developed to facilitate these technologies.

2.1.3 Analysis

Thematic analysis of the focus group allowed themes to be extracted from the transcript, which was produced using Otter.ai followed by several rounds of proofreading. Responses within the structured email exchange were collated and analysed too. These data sources were integrated with data from the literature review to form the report.

3 PESTLE analysis

3.1 Political

Drivers

Investment from government and governmental funding bodies in XR industries and research.

Awareness-building of the future student experience at the political level by organisations such as Advance HE.

Disruptors

If there is **political pressure** on HE institutions to avoid online or distance learning and to continue with on-campus delivery, this could undermine the vision presented in this report. This may occur if politicians and policymakers remain unaware of the potential of XR to add to the distance learning experience and interactive learning, and of the aforementioned pilots that are already being conducted in the USA, which will likely be followed by more permanent metaversity infrastructure.

3.2 Economic

Drivers

Investment by HR institutions in XR technologies and training, which will in turn be influenced by initiatives such as this current project by Advance HE.

Price of technology: virtual reality technologies are coming down in cost despite the current rate of inflation. For example, the Oculus Quest retails at approximately £299 or $350. This is half the price of VR headsets from 2016, so it is realistic to assume that by 2030, headsets will retain for £100 or less or equivalent in other currency. Therefore, the matter of price should not present an issue for inclusion in the future scenario beyond what is currently presented by purchasing a laptop or desktop. Given that Oculus Quest units are currently out-selling Microsoft X-Boxes (Sutrich, 2022), we consider that the price issue is unlikely to present a problem to adoption.

Disruptors

Economic disruption that leads to stagnation and reduction of incomes or savings, such as recession or high inflation, may undermine the market for HE, including via XR-based distance learning. However, there is evidence to suggest that upskilling and reskilling increases during times of recession, suggesting that HE may benefit from individuals seeking to train in a new career (Monear, 2020).

If XR-HE tech evolves along the same lines as platforms operated by large tech companies, the economics underpinning metaverse platforms will be linked to the **capture and commodification of user data** platforms affecting the privacy of individuals (Allen and McIntosh, 2022).

3.3 Social

Drivers

The growth in **working from home** is leading to an increased literacy in remote connection platforms, and domestic investment in relevant technologies.

Partnership with students: students can be key drivers for innovation in terms of creating content for VR/AR and promoting it to other students.

Collaboration across institutions and knowledge exchange with private organisations will help to drive development (Dick, 2021).

A social and organisational focus on **inclusivity and accessibility** will lead to the development of technologies that allow increased access to HE institutions without the need to be on physical campus and with minimal detriment to the student experience.

Disruptors

Challenges and limitations relating to **social interaction in a virtual environment,** eg due to lack of full sensory experience that occurs in face-to-face interaction.

Deploying XR technologies to enrich the diverse experience of students will put **pressure on teaching and support staff** if inadequate training is provided or if changes are implemented too fast. It is necessary to address these dependencies before this experience can happen.

General **lower uptake of XR technology across society** than predicted will disrupt the movement towards this 2035 scenario. This may occur if issues with motion sickness or 'VR dissociation' proves to be a problem as more people use the technology for longer periods, or a cultural shift occurs towards spending less time online.

3.4 Technological

Drivers

Adoption and **integration of XR technologies into popular platforms** such as Zoom and Microsoft Teams.

Developing technologies and training to meet the needs of specific student and staff groups.

As technology improves, processing will take place in the cloud and streamed, meaning very little need for hardware in the devices. **Equipment will become cheaper, lightweight** and, in some cases, as discreet as contact lenses (see Appendix 1).

The **quality of details** such as field of view, depth focus, vision correction, image resolution and luminosity are getting better by the day, with potential for reaching the mass market for providing an inspiring learning experience.

Disruptors

XR technologies update rapidly. For universities to stay agile, they should invest small and strategic, running pilots in specific programme areas/interdisciplinary approaches and review these regularly (Pomerantz and Rode, 2020).

For individuals with arthritis, muscular dystrophy or chronic pain syndrome, **headsets could be a barrier to entry** as they are heavy and can cause discomfort/pain. This will change over the years as technology becomes more lightweight. Nevertheless, the pilot stages of this experience can affect these individuals.

3.5 Legal

Drivers

Universities working with XR technologies that ensure they are **complying with current legislative and regulatory frameworks** will ensure optimal development of XR projects that minimise the potential for legal disruptors, as outlined below (Pryor and Thomson, 2017).

Legality on VR/AR platforms may differ according to a user's home country. A clear **statement of legal jurisdiction** made by HE institutions will help to drive projects forward with minimal potential for cross-jurisdictional disputes.

Disruptors

There are **virtual crimes** that can cause psychological distress to users and cause legal issues. These include virtual groping, stealing of virtual property, cyber assault, illegal betting, identity theft and indecent exposure. The potential for these needs to be addressed before the integration of this technology into HE (Prajapati, 2018).

Intellectual property (IP) rights – usage of IP in VR is still ambiguous. This means things like music, photographs and brand names can be used ubiquitously without permission from the IP owners. This will adversely affect smaller entrepreneurs and brands by not giving them the credit they deserve and need for their business to grow; in the future, legislation must consider measures to define IP laws across different VR platforms as well as individual user rights for a more credible experience (Prajapati, 2018).

Virtual privacy issues: currently, many VR platforms store, process and distribute private data of users to commercialise their business. Data is also sold to third parties to market specific products to target users based on their virtual behaviour and emotions. If an HE institution subcontracts XR technology to a company that engages in data capture, this can also be legally problematic as the digital footprint of the user can be used to identify them in real life. Privacy regulations must take this into account as it breaches the ethical standards of an individual's private life (Prajapati, 2018).

3.6 Environmental

Drivers

The predicted **long-term cost reduction** for education providers offered by these platforms can help the global development of graduate skills and competencies, supporting local communities and countries under-resourced in higher education, without the need to build thousands of 'bricks and mortar' institutions.

Reduced need for international and intranational travel afforded by online communication technologies and XR technologies will **lower carbon emissions.**

Disruptors

Ethical issues, price implications or shortages of parts that result from environment damage due to the growth of technologies required for XR technologies, such as the effects of lithium extraction for batteries in laptops, phones and virtual reality headsets, may disrupt progress towards this 2035 vision.

4 Student experience

Short pen portraits of the student experience

Vignette 1 – pen portrait of a student experience

My name is Erin. I was diagnosed with cerebral palsy at the age of two, a condition which has left my muscles stiff and my movements slow. I spent much of my childhood learning how to walk, going to physiotherapy and correcting for my speech impairment. I now use a walking frame to get around and struggle with pain, for which I take medication. My physical symptoms have improved over time and although I have been able to make some very good friends, I often felt depressed and isolated from society. It was burdensome to do anything social, so I often kept to myself.

Going to university was very daunting for me given my condition, the barriers, and the anxiety I had to overcome. I am now one year into a hybrid XR-HE programme, and it has been absolutely brilliant! I felt liberated attending the virtual campus, going to lectures, socialising with colleagues and even trying some of the virtual sport which I never thought would be possible. This platform has brought university to me; something which I could never have imagined previously. This is a huge plus for the disabled community, and I hope more institutions will adopt this framework and recognise its importance for disability and mental health moving forward.

Vignette 2 – pen portrait of a student experience

My name is Vishal. I come from a small village in the Kurigram district in Bangladesh; one of the poorest places in the country. Education was a struggle for me as I had to help my parents make money from a very young age. However, with the help of my older brother who pushed me and my own passion for studies I was able to finish high school and gained excellent grades. I want to become a surgical oncologist due to personal reasons from my past and my own intrinsic nature to help people. Higher education and enrolling in medical school would be the dream. Unfortunately, my family's financial situation means I'm unable to travel, pay for accommodation or the tuition fees that is required by some of the prestigious universities abroad and locally.

Thankfully for me I recently enrolled in a degree that is delivered by a top UK university via an XR platform. The fees are affordable and I don't incur the costs of travel. All that was required was the purchase of an affordable VR headset. Medical school requires intensive hands-on training and through VR I have been able to learn through immersive experiences what I would have in the real-world, including working with virtual human cadavers. Hands-on surgical training, for example, is limited until the third year but with this technology I can immerse myself in surgeries long before the residency period. With VR I can also explore the central nervous system, cardiovascular system, or skeletal system through an immersive experience; in this environment, myself and other students alike can safely repeat clinical procedures, make mistakes and learn from them, all while also being provided with evaluations. Through meticulous practice we can improve performance in our craft like never before. The learning curve for medicine is very steep and I would have never thought I would progress at this pace if it weren't for AR/VR This technology can definitely help speed up the rate at which students become doctors. As a kid coming from poverty, I would have never imagined I would have the opportunity of training as a doctor. This is truly life changing for myself and my family.

Vignette 3 – pen portrait of a student experience

I'll have to keep this brief as I have a three-month-old that needs feeding. My name is Sharlene, and I am a mature student. The thought of re-entering academia after a decade was quite overwhelming. The process of learning again, reading textbooks, following lectures, making good notes, and constantly trying to overcome the self-doubt was tiring. As well as this, juggling the work-life balance was quite complex while having a baby, a husband and a part-time job to pay the rent. I felt like I would struggle finding time to attend classes and do my assignments.

All these problems disappeared with the introduction of the XR-HE programme at my university. The AR/VR platform made learning fun and something to look forward to as opposed to the 2D Teams platform, and all without having to commute to the campus from my home. I also managed to keep up with the learning curve through immersive experiences and a lot of what I learned got retained in my mind very easily. It was very strange at first. I've seen my nephew use VR headsets for his gaming, but I never thought what a difference it could make in education! This new technology has had such a positive impact in my life. Occasionally I make it to campus to see my friends and do real-world learning. It's great that I have the choice of both.

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5 Appendices

5.1 Appendix 1. Precedent technologies for 2035

Lightweight VR headsets

Bulky VR headsets can be uncomfortable and a hindrance for some people when navigating through the virtual world. To move forward and be accepted by consumers, VR headsets must transition towards becoming lightweight and comfortable to wear, as well as deliver high resolution life-like images (Businesswire, 2022).

Figure 1. MeganeX by Shiftall/Panasonic. The new headset can be worn like a pair of glasses. It is a lightweight, compact headset weighing slightly over eight ounces. Contains 5.2K high-dynamic-Range-VR headset/glasses. Includes Kopin's 2.6K x 2.6K OLED displays as well as All-plastic Pancake optics (Businesswire, 2022).

See

+ www.businesswire.com/news/home/20220104005952/en/Shiftall-Introduces-MaganeX-World%E2%80%99s-First-5.2K-High-Dynamic-Range-Virtual-Reality-Glasses-at-CES-2022-Incorporating-Kopin%E2%80%99s-2.6K-x-2.6K-OLED-Displays-and-All-Plastic-Pancake-Optics
+ https://eu.usatoday.com/story/tech/2022/01/05/meganex-panasonic-vr-ces-2022/9101094002/

High-spec augmented reality glasses

Wearable technology that combines what you see in real life with virtual information, usually overlaid on one of the glasses lenses. This could include mimicking the screens and features found on smartphones, such as map navigation and notification flashing (Lang, 2021).

See

+ https://youtu.be/AuIw5Oe7z1I
+ https://www.roadtovr.com/snapchat-spectacles-ar-glasses-announcement/

Figure 2. Snap Spectacles AR (4th gen). Performance is powered by Qualcomm's Snapdragon XR1 processor, which is designed for AR devices. Although the field of view is only 26.3 degrees, the Snap Spatial Engine provides six degrees of freedom, allowing you to move around and have the visuals overlay in your space. The arms have two RGB cameras and a touchpad, and it weighs only 134 grammes. A lot of information in relation to these glasses are under wraps as they are not for sale and are primarily being offered to developers to experiment with (Lang, 2021).

AR contact lenses

Smart AR lenses can be used by athletes for tracking data of their sport of choice (eg pace of a run), or they can be used by technicians or engineers to see specific structures of machines or buildings. They can also be used to navigate routes and they are a very practical tool for a PowerPoint presentation to display key talking points (Mojo, 2022). All of this can be done without access to a physical device. As such, contact lenses have the power to replace smartphones, smartwatches, augmented reality glasses, and even virtual reality headsets. This technology has the potential to provide faster, non-intruding and accessible AR experience and data delivery compared to traditional methods.

See

+ https://www.mojo.vision/mojo-lens
+ https://www.forbes.com/sites/johnkoetsier/2022/05/18/mojo-visions-smart-contact-lens-ready-for-real-world-testing/?sh=50bf09bb2edf

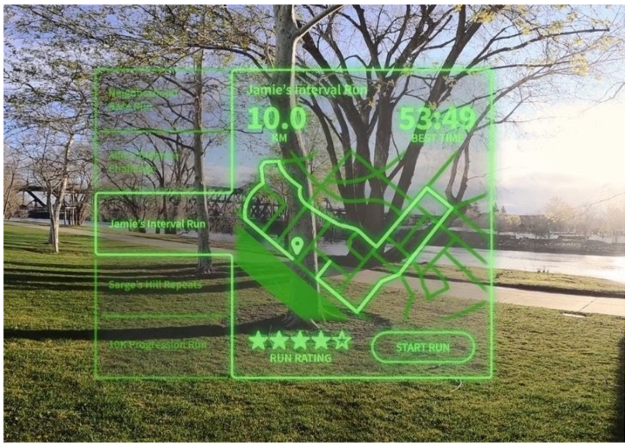

Figure 3. Mojo smart contact. Contains 14,000 pixels per inch MicroLED display at .5mm in diameter (the world’s smallest). It has a 5GH ultra-low latency radio for streaming AR content and an ARMA processor. Includes eye-controlled user interface and eye tracking through custom-configured accelerometers, gyroscopes and magnetometer (Koetsier, 2022).

Holographic displays

Holograms can greatly simplify learning and teaching, especially now that we have accepted the concept of hybrid learning. Holograms can aid in the development of conceptual clarity, the visualisation of abstract concepts and the efficient communication of learners and educators.

See

+ https://www.education2conf.com/blog/holograms-education-key-advantages#:~:text=Holograms%20can%20make%20learning%20and,communication%20between%20learners%20and%20educators.
+ https://www.avinteractive.com/markets/education/new-lifelike-hologram-tech-expands-ucf-students-skills-patient-care-03-08-2021/

Figure 4. Human-sized 4K transparent LCD holoportation system in medical education at the University of Central Florida. Titled “Dr Hologram”, It will be used for patient simulation, allowing students to learn about a broader range of conditions (Campos, 2021).

Dome displays

A virtual reality dome is a 360-degree sphere into which people can enter to interact with the virtual world. This is accomplished without the use of headsets or any other personal connection. Projectors are used in a virtual reality dome to bring the virtual world to life. Using this technology students can experience topics like space, history or geography, and learn from the visualisations.

See:

+ https://fulldome.pro/blog/first-vr-dome/
+ https://lumenandforge.com/step-into-the-future-with-virtual-reality-domes/#:~:text=A%20virtual%20reality%20dome%20is,the%20virtual%20world%20to%20life.

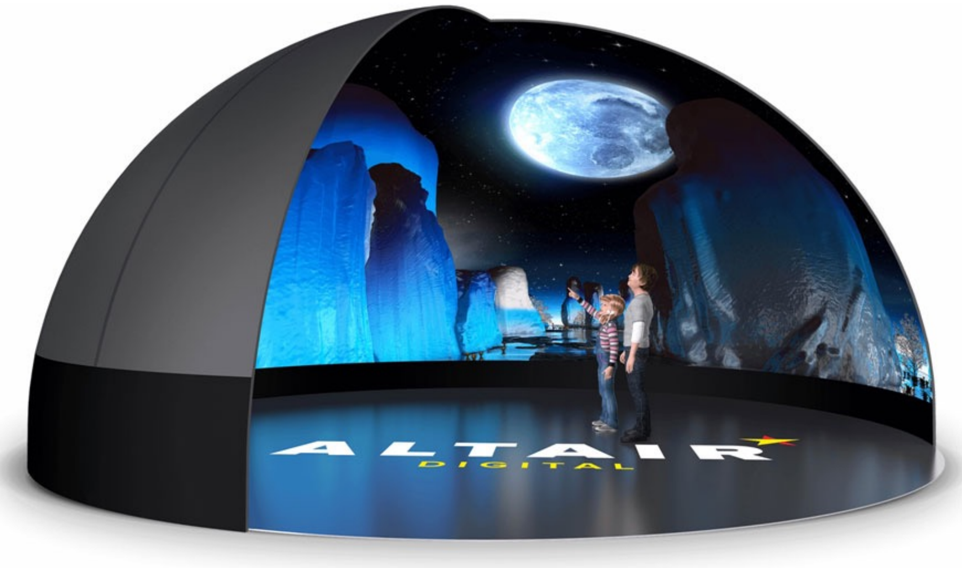

Figure 5. Dome display. Inflatable dome developed by Altair Digital. Consists of spacetouch projection systems including spherical mirrors, multi-channels and fisheyes (Fulldome Database, 2017) , (Altair Digital, nd)

5.2 Appendix 2. Current 3D platforms using AR/VR

zSpace

zSpace uses the one-of-a-kind all-in-one AR/VR laptop with stylus-pen content. When the zSpace glasses are used in classrooms, all students have access to them, allowing for both independent and group learning experiences. With over one million users, zSpace is now available in over 800 school districts across North America. Teachers who use the tool report increased levels of student interaction and engagement with the academic material. Educational leaders also believe that this has led to improvements in student understanding of the material, resulting in higher grades (zSpace, nd).

See

+ https://zspace.com/
+ https://youtu.be/z3KW3YN1ZKA

Figure 6. zSpace AR/VR user interface (zSpace, n.d.)

ENGAGE

ENGAGE simulates a lecture hall in virtual reality, allowing educators to design unique courses and everyone from around the world to participate virtually in a multi-user environment. Through the platform, educators can create their own content, use existing environments, and record or share sessions. In addition, ENGAGE is one of the few platforms that allows for fully embodied conferences, which can be attended by more than 1,000 simulated avatars (Fink, 2021).

See

+ https://engagevr.io/
+ https://www.forbes.com/sites/charliefink/2021/06/22/engage-raises-10-m-announces-oasis-metaverse-for-business/?sh=38efd9f4ae8e

Figure 7. ENGAGE metaverse (Fink, 2021; Hayden, 2021), 2021)

Alchemy Immersive

Alchemy Immersive specialises in developing unique immersive stories using AR/VR and even AI. The platform collaborates in parallel with the world's leading production companies including Atlantic productions. Among the productions are a deep dive beneath the Great Barrier Reef with David Attenborough, an exploration of the Galapagos with Charles Darwin, and even a descent from the International Space Station! These stories are so captivating that one of them won a BAFTA award (Burch, 2019).

See

+ https://alchemyimmersive.com/
+ https://www.wired.co.uk/article/alchemy-vr-launches

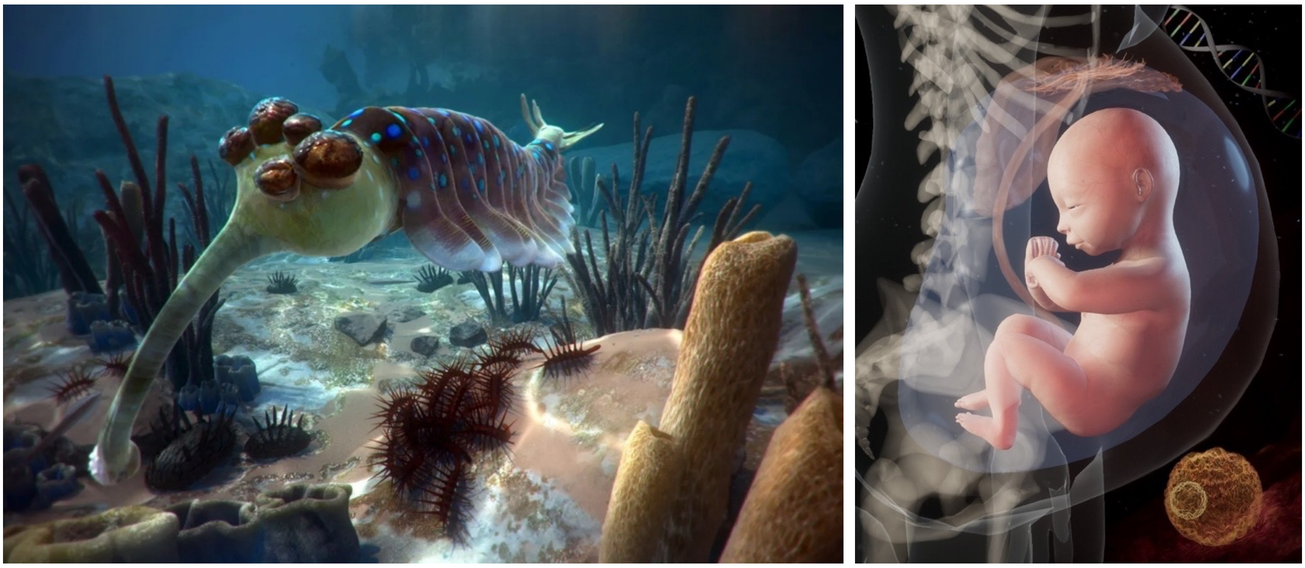

Figure 8. Alchemy Immersive simulated experiences (Alchemy Immersive, nd)

For more VR/AR education platforms see https://touchstoneresearch.com/the-top-10-companies-working-on-education-in-virtual-reality-and-augmented-reality-rebooted/ (Burch, 2019).

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