IMMERSED IN THE FUTURE: A ROADMAP OF EXISTING AND EMERGING TECHNOLOGIES FOR CAREER EXPLORATION

Erica Southgate, Shamus P. Smith and Hayden Cheers

DICE Report Series, Number 3, October 2016

ABOUT THIS SERIES

DICE is a network of scholars interested in digital identity, digital footprint, curation of online presence, and serious games for learning. We investigate new frontiers in digital engagement and education to produce research and resources (e.g. apps and games) for today's learner. The principal aim of the DICE Report Series is to disseminate the research and/or technical output of the network in an easily accessible format.

The opinions or conclusions expressed in the DICE Report Series are those of the authors and do not necessarily reflect the views of the DICE network as a whole.

ISBN 978-0-9945375-4-6 Digital

Visit our website at **http://www.diceresearch.net**
Follow us on Twitter **@Dice_Research**

Cover image derived from images by leungchopan/Shutterstock.com and Lifestyle Graphic/Shutterstock.com

Immersed in the Future:

A roadmap of existing and emerging technologies for career exploration

Dr Erica Southgate
Equity Fellow, National Centre for Student Equity in Higher Education, Curtin University, Australia
School of Education, The University of Newcastle, Callaghan, NSW 2308, Australia
erica.southgate@newcastle.edu.au

Dr Shamus P. Smith
School of Electrical Engineering and Computer Science
The University of Newcastle
Callaghan, NSW 2308, Australia
shamus.smith@newcastle.edu.au

Mr Hayden Cheers
School of Electrical Engineering and Computer Science
The University of Newcastle
Callaghan, NSW 2308, Australia

ACKNOWLEDGEMENTS

This research was funded in part by Dr Southgate's 2016 Equity Fellowship administered through the National Centre for Equity in Higher Education (NCSEHE), Curtin University, Australia.

CONTENTS

SUMMARY

The purpose of this report is to provide an overview of existing and emerging digital technologies and their potential application for K-12 education and career exploration. The report scopes a range of technologies including virtual and augmented reality, haptics, tangibles, and new video media. It aims to provide accessible explanations of these technologies and some examples of how they are or might be used to promote deeper learning in the disciplines associated with different professions and virtual 'taster' experiences of post-school education and the world of work. At the heart of the report is a vision for using these technologies to promote equity of educational outcomes and career opportunities for students facing disadvantage.

TO CITE THIS REPORT IN APA REFERENCING STYLE:

Southgate, E., Smith, S. P., & Cheers, H. (2016). Immersed in the future: A roadmap of existing and emerging technology for career exploration. Report Series Number 3. Newcastle: DICE Research. Retrieved from **http://dice.newcastle.edu.au/DRS_3_2016.pdf**

GLOSSARY

Artificial intelligence (AI)	AI is the theory and development of computer systems that can perform activities that normally require human intelligence such as visual perception, speech recognition and decision-making (Oxford Dictionary, n.d.).
Augmented reality (AR)	AR allows computer-generated virtual objects to be overlayed into the user's physical world. Simpler AR uses apps on smart devices to overlay 2D content onto the real world. More immersive AR (IAR) uses transparent head-mounted display (HMD) technology to project objects into the user's physical world. These objects can be interacted with through gesture and voice, and may have artificial intelligence features. Some types of IAR are called Mixed Reality (MR). This is where digital content dynamically interacts with the real world.
Avatar	The virtual representation of oneself, another user or a virtual agent in virtual or augmented reality environments.
Cave Automatic Virtual Environment (CAVE)	A CAVE is a room or structure that uses projectors, displays and sound to create an immersive virtual environment. The setup can consist of a semi dome-like structure to several walls or a complete room designed to create the virtual environment.
Cybersickness	Motion sickness caused by movement on any display device such as monitors, TVs, smartphones, tablets or HMDs.
Haptics	Haptics allow a user to feel or sense a virtual object or environment. Haptic-enabled devices allow users to feel such things as the shape, weight, texture and temperature of a virtual object through tactile feedback.
Head-mounted display (HMD)	A HMD is a device (googles or a headset) worn over the eyes that displays a virtual or augmented reality environment. HMD range from those that form part of a user's vision without completely obscuring it and that allow digital information to be displayed over the environment (used in augmented reality) to opaque versions that block a user's vision of the real world entirely and replace it with a virtual environment (or those used in virtual reality) (Friedman et al., 2016).

Immersion	Immersion is a state derived from the properties of technologies that have been designed to provide a virtual stimulus to the senses that promote a sense of presence. For example, HMDs provide stimulus to flood the user's visual and auditory senses with realistic 3D graphics and believable sounds (Bowman et al., 2004).
Interactive video	Interactive video includes rich media content such as text, images, links to websites and other videos, and interactive components such as quizzes and polls.
Live streaming	Live streaming allows users to view content (video and audio) over the internet, as it happens in real time.
Massively multiplayer online game (MMOG)	An online game which allows many players anywhere in the world to play in a virtual environment in real time.
Presence	Presence is the feeling of "being there" where a user experiences a replacement of the physical environment with the virtual one.
Tactile feedback	Tactile feedback is a physical response, usually in the form of vibration, generated by a device.
Tangibles	Tangibles are smart objects that have a link to virtual objects. Tangibles give virtual objects a physical presence. By manipulating the tangible object, the virtual representation is also manipulated. A tangible surface allows the user to interact with digital information incorporated into a physical object.
Tethered/Untethered	Tethered refers to the connection of one device to another either physically or through Wi-Fi or Bluetooth. In this report we use the term to refer to physical connection.
Virtual agent	A computer generated character which interacts with and can guide a user.

Virtual reality (VR)	VR transports the user into a 3D computer-generated world which can be a highly imaginative or realistic simulation. Depending on the VR environment, a user can experience the world in the first person (through their eyes or the eyes of a character/avatar) or in a third person (disembodied) perspective or switch between the two. VR can range from 'static' worlds that have limited capacity for user navigation and manipulation/interaction with elements in that world, and more interactive, exploratory environments which allow user autonomy of navigation and interaction. 'Through the window' VR is a virtual world that is displayed and experienced through a computer monitor, smartphone or tablet screen. Immersive VR (IVR) is experienced through a HMD which enhance a 360º sense of presence (or 'being there') in the virtual world. Often in IVR, the virtual world is under the real-time control of user who can navigate and interact with its elements by using controllers, gesture and voice.
360º video	360º video is a recording taken from an 'in-the-round' perspective. This allows the user to look in all directions, similar to real life.

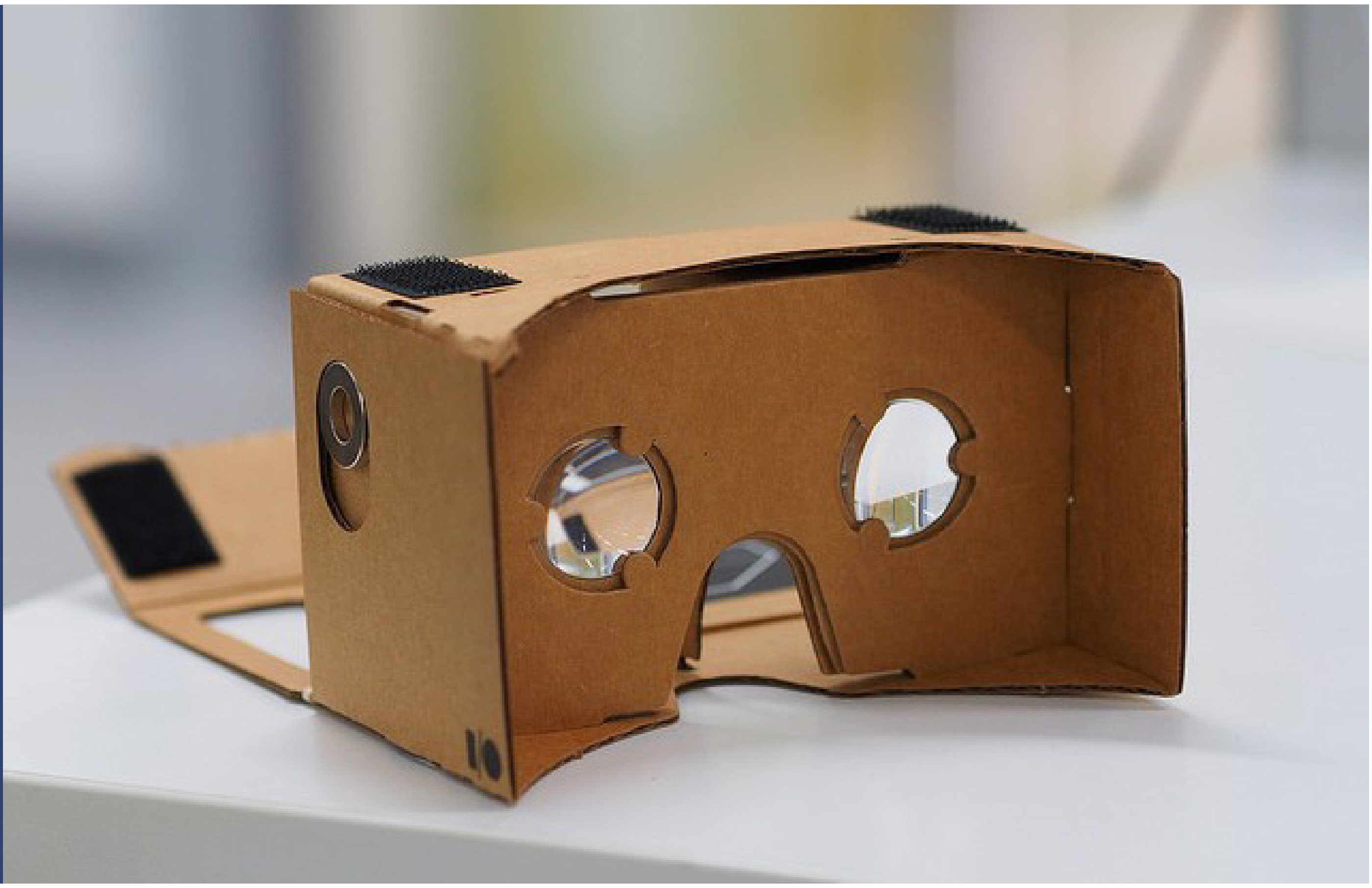

Image: Google Cardboard (by othree, **https://flic.kr/p/o83BwL** Licence at **http://creativecommons.org/licenses/by/2.0**).

1 WHY A TECHNOLOGICAL ROADMAP?

1.1 BACKGROUND

The recent global 'buzz' surrounding the augmented reality game Pokemon Go™ and the release (or imminent release) of head-mounted displays (HMDs) devices such as the Oculus Rift™, HTC Vive™ and HoloLens™, has reinvigorated interest in new digital technologies for leisure, edutainment, and learning. Major technology and entertainment corporations, including those involved in social media, have invested heavily in developing new hardware and software, with today's computers powerful enough to render a highly immersive experience that can create an intensified sense of presence or sense of 'being there' in virtual and augmented worlds. Using a base case scenario, it has been estimated that that by 2025 the virtual and augmented reality market (including HMDs and software) will reach USD 80bn shipment units, annually (Goldman Sachs Group, 2016). While the entertainment, business, military and healthcare sectors will see the most investment and uptake, it has been conservatively estimated that in K-12 and higher education there will be 15 million users with USD 700m spend in shipment units, annually.

The aim of this roadmap is to highlight, in an accessible way, some existing and emerging digital technologies and their potential to create deeper and authentic learning opportunities in school and post-school education (EdTech Mindset, 2016). Deeper learning experiences allow students to engage and respond to real world problems and work situations in an authentic and sustained way and to see the relevance of their learning beyond the classroom (Adams Becker et al., 2016). Like all useful roadmaps, this report does two things. Firstly, it charts some broad directions in the general types of technologies that are currently commercially available and those that are predicted to be available and affordable within a 3-10 year period (Adams Becker et al., 2016; The Goldman Sachs Group, 2016). Secondly, the report provides descriptions of these technologies, their key features and some imaginative examples of their current or possible application in education and for careers exploration.

The purpose of this roadmap is to provoke the imagination of educators in considering how these technologies might be used for education and career exploration, because engaging educators now will be vital if the characteristics (or affordances) of these technologies are to be used in pedagogically sound and curriculum–aligned ways that are duly informed by learning science. Imaginative, 'blue sky' thinking, however, does not take place in a vacuum. Several decades of research on digital technology in education provides ample warning about understanding the difference between the 'state-of-the-art' and 'state-of-the-actual' when technology is deployed in real educational settings:

"(T)he critical study of educational technology seeks to address the use of digital technology in terms of 'state-of-the-actual' as opposed to 'state-of-the-art' questions – i.e. questions concerning what is actually taking place when a digital technology meets an educational setting and, from a historical perspective, how this compares with what has taken place in the recent past. These questions fall broadly into three basic forms, i.e.: What is the use of technology in educational settings actually like? Why is technology used in educational settings the way it is? What are the consequences of what happens with technologies in educational settings?" (Selwyn, 2010, p.70).

Some of the technologies described in this report are new or still in development. It is therefore important that as they are introduced into educational settings that robust evaluations of their learning efficacy and impacts, and equity and ethical implications, are conducted (OECD, 2015). This critical approach does not however preclude 'blue sky' thinking about how the affordances of these technologies might open up new opportunities for educational and career experiences that are not available to all students in real life.

1.2 SOME 'BLUE SKY' THINKING ABOUT EXISTING AND EMERGING TECHNOLOGIES FOR CAREER DEVELOPMENT

Career development for young people might benefit from new and emerging technologies in three foreseeable ways:

a The affordances of these technologies could motivate and engage students in authentic discipline-related learning associated with particular careers and professions. Affordance refers to the characteristics or properties that determine the possible uses for an object or environment (Dalgarno & Lee, 2010). An example of these affordances in virtual reality learning environments include: (a) first order (person) experience that supports social constructivist learning principles; (b) reification or the ability to transform or represent abstract ideas in perceptible representations and interactions; (c) size interaction where users can change their size or the size of objects to experience micro and macro worlds; and, (d) safe and secure exploration where users can have simulations of experience that in real life would be too dangerous or beyond their resources (Mikropoulous & Natsis, 2011). These affordances, coupled with the intense sense of presence created through immersive VR and AR technology, have the potential to motivate students to engage in deep learning in STEAM (science, technology, engineering, art + design, and mathematics) and other disciplines, that can spark interest in pursuing learning through post-school education. Moreover, immersive technologies can provoke educators to re-examine the pedagogical potential within and beyond the physical confines of the classroom (Southgate and Smith, 2016). Moreover, as well as using 'off-the-shelf' educational products, a vital part of element of these technologies will be how they enable students to create, share and customise their own content (Adams Becker et al., 2016; EdTech Mindset, 2016). For example, in the near future, students could collaborate in learning 'raids' to solve problems embedded in massively open multi-player virtual reality games or work together in augmented reality holographic 'escape rooms' to develop a deeper interdisciplinary understanding of and solutions to complex local and global real-world 'puzzles' (Adams Becker et al., 2016).

b New and emerging technologies could afford authentic early connection to experiences of post-school education and the world of work, both of which are limited or unavailable to young people experiencing disadvantage. Many young people are prevented from accessing valuable 'taster' work experience as part of the school curriculum as they are geographically isolated, have lower socioeconomic status, circumscribed social capital networks and/or encounter discrimination based on factors such as gender, ethnicity and cultural background (Hoffman, 2015; Noguera et al., 2015; Southgate et al., 2015). As immersive virtual and augmented reality technologies become spaces for collaboration, authentic learning opportunities will extend students understanding of the purpose of learning beyond the classroom (Adams Becker et al., 2016). For example, immersive virtual reality can allow students to experience authentic simulations of work environments that are either too geographically or socially 'distant' for students to engage in or unsafe for them to visit. Within these virtual worlds, there is the potential for guides from the professions themselves to enter the world in real time (as an avatar) to facilitate career 'taster' experiences. Virtual worlds could be created where students are mentored by engineers, architects, construction specialists, environmental and social scientists, and policy makers, to collaborate and 'deliver' an authentic urban planning project relevant to their community. It is envisioned that augmented reality technology through HMDs could be used by educators to overlay actual classrooms with individual and collaborative learning activities that reflect the types of complex knowledges and experiences of post-school education or work. For example, it will be possible for a teacher to guide a virtual 'magic school bus' journey into the human body where students can explore biology and diagnose health condition. Health professionals might also 'teleport' in and join the virtual field trip.

C New and emerging technologies could create career and post-school education 'taster' spaces where students from diverse socio-cultural backgrounds can envision themselves. To borrow a pithy phrase from Kinnane et al. (2014), it is too often the case that - 'You can't be what you can't see'. There are serious and seemingly intransient equity problems related to fair access to post-school education and many professions. For example, students from equity group backgrounds (e.g. from certain ethnic/cultural groups, of lower socioeconomic status, from rural or remote locations, or with a disability) are under-represented in higher education (Gale, 2013). Similarly, many professions, exhibit stark patterns of limited social diversity, for example, the male dominated nature of engineering (Ayre et al., 2013) or very low rates of access to medical schools for people from lower socioeconomic status backgrounds (Brosnan et al., 2016). Existing and emerging technologies could allow for students from equity groups to interact with virtual agents that are like them and facilitate access to actual professionals in a range of fields who share a common background or set of life experiences. For example, young Indigenous people who are aspiring to become doctors could be mentored by Indigenous doctors in an immersive virtual environment that would allow career exploration to occur within a culturally safe setting. Similarly, immersive virtual and augmented reality experiences could be designed so that first-generation students, particularly those who are geographically isolated, could explore the campuses and learning spaces of vocational or higher education so that these are demystified and less alien.

The remainder of this report provides an overview of some specific digital technologies, their characteristics, and current or potential applications for deeper learning and connection to discipline knowledge, and career development.

Image: Two children in head-mounted displays using virtual reality (by Ars Electronica - PIE Deck/Patrick Proier [AT], **https://flic.kr/p/KeJqch** Licence at **http://creativecommons.org/licenses/by/2.0**).

VIRTUAL REALITY

2.1 WHAT IS VIRTUAL REALITY?

Virtual Reality (VR) refers to a fully 3D computer generated environment in which can be interacted with in a seemingly real manner (Oxford Dictionairies, n.d.). Virtual reality is a self-contained world which generally 'closes' the real world out. VR can be divided into two categories: 'Through the window' virtual reality (WVR) and immersive virtual reality (IVR).

2.2 'THROUGH THE WINDOW' VIRTUAL REALITY (WVR)

Before the advent of mobile devices this type of VR was usually called 'desktop VR': the term 'through the window' VR (WVR) is now sometimes used to more aptly describe the range of viewing devices through which this type of VR is experienced (i.e. computer monitor, television, or tablet and smartphone screens). WVR is 3D viewed from a 2D perspective and allows the user to explore and interact with the virtual world. The user can interact by using a standard keyboard and mouse, touch screen or other input device such as a joystick or game console controller. WVR provides a somewhat immersive experience or the perception of being physically and psychologically present: it requires the user to sit/stand in front of a PC, game console, smartphone or tablet in a fixed position and interact through an input device. However, it is possible to enhance the sense of presence (or 'being there') through the use of 3D glasses where possible (Furht & Borko, 2008). WVR offers both single player and multi-player environments. Multi-player WVR environments are commonly associated with massive multiplayer online games (MMOG), for example Blizzard Entertainment's World of Warcraft (**http://worldofwarcraft.com**) and CCP's EVE Online (**http://www.eveonline.com**). These are applications of WVR intended for online recreation. In these environments, users are represented by a virtual avatar. Users can interact with other people's avatars through an input device. Communication with another user's avatar can be text or voice based; however, this is dependent on the virtual environment. Both the hardware and software used in WVR is commercially available and WVR has been used for training and educational purposes since the early 1990's (Gregory et al., 2014; Merchant et al., 2014). Common commercially available devices such as desktop and laptop PCs, smartphones and tablets are capable of generating WVR environments to varying levels of quality. Higher quality devices will offer a more realistic experience; however, this is also dependent on the simulation software.

Image: Desktop VR (by Trevor Owens - Tj-computer-games-class 11, **https://flic.kr/p/diXTpY**
Licence at **http://creativecommons.org/licenses/by/2.0**).

2.3 IMMERSIVE VIRTUAL REALITY (IVR)

For the purposes of this report, IVR refers to a computer generated world seen from a first or third person point of view which is under the real-time control of the user (Bowman et al., 2004). Moreover, IVR environments have the potential to produce a heightened physical and psychological feeling of presence ('being there') and co-presence ('being there with others'). There are two main technologies used to create IVR environments: Cave Automatic Virtual Environments (CAVE) and head-mounted displays (HMD).

A CAVE is a setup that utilises projectors and displays within a room or similar large scale structure to create an immersive virtual environment. Typically, CAVEs include: rear and side projection walls and down projection on the floor; a range of speakers emitting sound or music; video; and tracking sensors embedded in the walls (Virtual Reality Society, n.d.[a]). In a CAVE, the user can use 3D glasses to enhance the appearance of the environment. The user is often provided with a game pad or has their movement tracked with a wand-like controller or remote. As the user moves within the room, their movement is tracked enabling interaction with a dynamic environment. CAVEs are generally complex and very expensive systems to design, house, make useable and maintain (DeFanti, et al., 2009).

Image: A CAVE (by UCL Engineering **https://flic.kr/p/bAXKsX** Licence at **http://creativecommons.org/licenses/by/2.0**).

Image: Using a head-mounted display with gaming controller (Rommel Canlas/shutterstock.com).

A head-mounted display (HMD) is a device worn over the eyes (Bowman et al., 2004), and in VR the device entirely obscures the user's vision entirely to create a more immersive experience in the virtual environment (Carrozzino & Bergamasco, 2010). In a HMD, the VR environment is in front of the user's eyes no matter where their head is turned (Virtual Reality Society, n.d.[b]). There are a number of methods used to interact with this virtual environment. These commonly include game console controllers, specialised remotes, or motion/body tracking technology. At present, quality HMD offerings start at approximately USD 600 (**https://www.oculus.com**), with commercial game designers such as Sony offering HMDs for PlayStation™ (**https://www.playstation.com/en-au/explore/playstation-vr/**) at AUD 550. Cheaper HMD alternatives exist which utilise smartphones placed in a headset with specialised software (for example **https://vr.google.com/cardboard/**). However, as smartphones are currently not purpose-built for this, simulation quality is often lower than that of a dedicated HMD.

2.4 VIRTUAL REALITY AND EDUCATION

Research has shown that VR can add value to learning particularly in terms of motivating students, but that quality of the learning is determined by the pedagogical theory and learning science that inform the design of the virtual environment (Bannan, 2015; Dalgarno & Lee, 2010; Fowler, 2015). As with all technology there are advantages and disadvantages to consider before adopting VR in education. The benefits of VR in education include:

- An alignment with social constructivist approaches to student learning and pedagogy (Dunleavy & Dede, 2014).
- Its affordances allow for experiential learning in several ways e.g. the ability to explore worlds that are not generally accessible, possible or safe for learners (Dalgarno & Lee, 2010)
- The ability to create active learning experiences in immersive environments, offers new ways for students to engage in deeper learning 'beyond' the immediate classroom.

However, there are a number of issues to consider including:

- At present the cost of IVR can hinder its adoption. For example, Oculus Rift bundles that include the HMD and an optimised PC retail for between US 1400-2600. CAVE systems can cost from 100Ks to millions of dollars. Cheaper HMD devices can cost approximately USD 10; however, these require smartphones to interface with them.
- Cheaper alternatives to HMDs such as Google Cardboard™ raise sanitation issues when used in a shared environment.
- Users can become motion sick or suffer from other physical effects in virtual environments. This is known as cybersickness.
- HMD manufacturers warn that the devices can cause seizures, and impair balance and hand-eye coordination and have specified age limit and immersion time warnings in their user manuals.
- There is a lack of long-term research into the physical, cognitive, social and educational effects of prolonged IVR.
- When VR is used with internet connected devices, users can leave a digital footprint. A user's experience could also potentially be recorded with or without their knowledge, violating their privacy (McPherson et al., 2015).

An example of WVR is the long-running children's game Whyville™ (**http://www.whyville.net**). Whyville™ is an online game-based learning site for students aged 8-14 years. Users can explore, play and interact with each other while engaging in problem-solving in science and mathematics. They have the opportunity to make and spend virtual money, and can even run their own virtual business.

There are also a number of applications of IVR which provide students an immersive learning experience. For example, LectureVR™ (**http://immersivevreducation.com/lecture-vr/**) allows multiple students to be in a lecture room with past historic figures: students could be in a room with Einstein, listening to him talk about the theory of relativity. In Google Expeditions™ (**https://www.google.com.au/edu/expeditions/**) students and teachers can go on virtual field trips to places like museums, world monuments or outer space. IVR content includes 360º panoramas images that are annotated with information. The static virtual worlds could be used to expand student interest. For example, if a student has an interest in marine biology they can explore and learn about underwater worlds. It is envisioned that future educational applications of IVR will be much more dynamic, interactive, creative and collaborative similar to MMOGs.

TABLE 1: SOME FEATURES OF 'THROUGH THE WINDOW' VIRTUAL REALITY (WVR)

Technological Aspects	Characteristics
Hardware	WVR commonly utilises desktop and laptop PCs, television screens, tablets and smartphones, and in some cases requires 3D glasses. Dedicated interaction devices such as game controllers and joysticks can be used.
Environment	WVR creates a virtual environment displayed upon the device and interacted with using a keyboard, joystick or real-time voice relay.
Sense of Realism/Presence	The sense of realism is dependent on the simulation as virtual environments can range from realistic worlds to the fantasy worlds of MMOG. WVR is unlikely to provide the same sense of presence as IVR as the user is required to sit/stand in front of a PC, smartphone or tablet.
Individual/Shared	Both individual and shared experiences are possible with WVR. However, this depends on the simulation.
Users/Players	Avatars of remote users and virtual agents can be present in simulations.
Perspective	WVR can allow the user to view the world from either a first-person or third-person perspective.
Content	Dynamic (highly interactive, autonomously navigated) and static (fixed scene/s) content are both available. With the correct skills, a user can create content, otherwise content is commercially available.
Learning Experience	Individual and shared/collaborative experiences are offered by WVR. These experiences can be autonomous, or guided by an avatar of a remote user or virtual agent.
Connectivity	Both online and offline capabilities are offered, however this is dependent on each application.

TABLE 2: SOME FEATURES OF IMMERSIVE VIRTUAL REALITY (IVR)

Technological Aspects	Characteristics
Hardware	Commonly used hardware includes HMDs, controllers, 3D glasses, smartphones and CAVE systems. At present some HMDs such as Oculus Rift™ require a powerful PC to generate a virtual environment. At present, HMDs are physically tethered to a computer.
Environment	IVR range from highly interactive and cinematic worlds to more static experiences. The difference between WRV and IVR is the ability to surround the user in a virtual world in 360º degree mode.
Sense of Realism/Presence	Depending on the simulation, environments can range from highly realistic worlds to fantasy, gamified worlds. A user can experience a high degree of presence within the world.
Individual/Shared	Both individual and shared/collaborative experiences are possible, however this varies by simulation and device. For example, CAVE environments can allow for multiple users to be present in the environment, while HMDs are single-user but can allow for multiple users in the networked environment.
Users/Players	Physical people are present in CAVEs. Avatars of users and virtual agents can be present in HMD simulations. Most HMD manufacturers recommend users be 13-14 years and over.
Perspective	The user is capable of interacting with the world from a first or third person perspective.
Content	Content can be either dynamic or static. User created content is possible for HMDs; however, this can require significant skills in coding and access to appropriate graphic and sound assets (objects).
Learning Experience	Both individual and shared experiences are offered by these technologies. These experiences can be autonomous, or guided by an avatar of a user or a virtual agent.
Connectivity	Both online and offline capabilities are provided, dependent upon the IVR technology.

3 AUGMENTED REALITY

3.1 WHAT IS AUGMENTED REALITY?

Augmented reality (AR) refers to a real-world environment that is enhanced or overlayed with computer-generated objects or information (Bowman et al., 2004). In an AR environment, the user is capable of interacting with both physical and digital objects. Some types of AR have been called mixed reality (MR). MR is where digital content also interacts with the real world. For the purpose of this report we have used a simplified categorisation and divided AR into two main groups: Viewer-Based Augmented Reality (VAR) and Immersive Augmented Reality (IAR) which includes MR.

3.2 VIEWER-BASED AUGMENTED REALITY (VAR)

In VAR, a viewing device is required to augment the real world. This viewer is commonly a smartphone, handheld PC or dedicated device which uses technology such as GPS tracking and/or a camera to scan the environment and overlay virtual objects and information onto the real world (Kipper & Rampolla, 2012). VAR technology is commercially available to varying degrees of quality. The use of smartphones is the most common method of creating a VAR experience (Kipper & Rampolla, 2012); however, the quality of the device will impact upon the quality of the simulated objects. For example, high-end devices with greater processing and display power are capable of displaying a more realistic experience compared to low-end devices. A recent popular example of VAR is the game Pokémon Go™ where a user is able to explore the physical world using their mobile device in order to find and capture virtual representations of fictional Pokémon characters.

3.3 IMMERSIVE AUGMENTED REALITY (IAR)

IAR is the enhancement of the physical world with digital information usually seen from a first-person perspective. Digital objects and information are readily available to the user, and can be interacted with using voice and gesture. IAR requires the use of a transparent HMD which overlays 2D and holographic digital objects on top of the user's physical environment (Bowman et al., 2004). Some types of IAR are described as mixed reality (MR) as the digital content dynamically interacts with the real world. In order to interact with digital objects, the user's environment is scanned and their hand/body movements tracked and interpreted by the HMD. IAR technology has recently become available but is in limited supply or in the 'developer kit' stage. The technology is currently expensive, with headsets ranging between USD 600-3000 (see **https://www.epson.com.au/microsite/moverio-bt-200/** or **https://www.microsoft.com/microsoft-hololens/en-us**). It is expected that this technology will become more affordable within the next 3-10 years, which will allow for wider scale utilisation.

Image: IAR with Microsoft's HoloLens (by Microsoft Sweden **https://www.flickr.com/photos/microsoftsweden/16153485657/**
Licence at **http://creativecommons.org/licenses/by/2.0.**)

3.4 AUGMENTED REALITY AND EDUCATION

AR has been shown to have some benefits to learning such as increased motivation, attention, collaboration and interactivity although there are questions about student engrossment in the technology at the expense of engagement with the learning tasks (Cuendet et al., 2013; Dunleavy et al., 2009; Diegmann et al., 2015). Research on VAR has identified that some learners concentrate more on the technological novelty than on undertaking learning activities, and that there can be safety issues with students moving around physical environments when they are engrossed in the device (Dunleavy et al., 2009; Sabelman & Lam, 2015). Anecdotally, new transparent HMDs for IAR are reported to decrease the likelihood of cybersickness because they allow the user to see their physical surroundings even when digital objects are overlayed onto the real world (this requires further investigation). It is estimated that it will take between 3-10 years for IAR to become affordable. As with internet connected VR, AR can have privacy and digital footprint management issues (McPherson et al., 2015).

Quiver™ (**http://www.quivervision.com/apps/quiver-education/**) is one example of an application of VAR for education for young children. Quiver™ allows students to print and colour-in pages from its website and then view the drawing through a smart device and watch it come to life. For example, a volcano viewed through a device erupts and is annotated with information. Educational content covers science, geography and mathematics.

While IAR is still in the development phase, Microsoft's HoloLens™ project has signalled the educational potential of the technology and educators are beginning to envisage its uses for learning. For example, one educator has speculated that students interested in automotive trades or engineering could learn to identify machine components, take apart virtual machines, or test original mechanical design through interaction with holographic elements (**http://www.digitaltrends.com/computing/is-hololens-the-future-of-education/**).

Image: Example HoloLens Minecraft experience
(by Microsoft Sweden **https://www.flickr.com/photos/microsoftsweden/15716942894/**
Licence at **http://creativecommons.org/licenses/by/2.0**).

TABLE 3: SOME FEATURES OF VIEWER-BASED AUGMENTED REALITY (VAR)

Technological Aspects	Characteristics
Technology	Smartphone, tablet, PC, or dedicated mobile devices are used for VAR. These devices require a camera and/or a GPS.
Environment	Real world, with digital virtual elements overlayed.
Sense of Realism/Presence	Virtual elements can appear to be realistic or highly imaginative. However, the quality of the generated elements is dependent on the mobile device with higher quality devices capable of better quality simulations.
Individual/Shared	Depending on the simulation, the user can either have an individual or shared experience. Playing VAR games can allow for shared experiences.
Users/Players	Virtual agents can be present in a VAR environment.
Perspective	Users can have either a first-person or third-person view of the environment observed and interacted with through a device.
Content	Generally dynamic. With correct skills, a user can create content, however content is also commercially available.
Learning Experience	Individual experiences can be autonomous, or guided by a virtual agent.
Connectivity	Online or offline, depending on the simulation.

TABLE 4: SOME FEATURES OF IMMERSIVE AUGMENTED REALITY (IAR)

Technological Aspects	Characteristics
Hardware	Transparent HMD. Some applications require a camera to scan the environment. Recent IAV technology includes systems where the user is not tethered – the HMD does not need to be attached by a cord to a computer in order to operate.
Environment	IAR is in the physical world, enhanced with virtual objects and information.
Sense of Realism/Presence	Virtual elements can appear to simulate real objects, or be distinctly computer generated. They can appear as manipulable 2D (screen display) or 3D (holographic object or animation) objects.
Individual/Shared	Both individual and shared experiences are possible with IAR.
Users/Players	Physical people, avatars, and virtual agents can be present when using IAR.
Perspective	Users have an immersive first-person perspective of virtual objects.
Content	Content is dynamic and is intended to be interacted with through gesture and voice. As this technology is still developing, the ability for easy user-created content is not yet available.
Learning Experience	Individual experiences can be autonomous, or guided by a virtual agent. It is predicted that in the future, there will be shared experiences guided by a physical person, avatar or virtual agent.
Connectivity	Different AR applications have different connectivity requirements. For example, many available applications of HoloLens™ allow the enhancement of the physical world with virtual objects and information based on data from the internet.

HAPTICS

4.1 WHAT ARE HAPTICS?

Haptic devices allow a user to sense and manipulate 3D virtual objects (McLaughlin et al., 2001). With haptic devices users can feel the shape, weight, texture and temperature of a virtual object. Haptics aim to provide tactile feedback so that virtual objects have a physical presence. This is accomplished by simulating sensory features and providing the user with a deeper level of feedback interaction.

4.2 USES FOR HAPTICS

Haptic technology is rarely used alone; rather, it is used to enhance other technologies. The most common application is that of force feedback on game controllers or mobile phones. For example, the game controller used for the gaming console Xbox™ One provides vibration feedback to the user during game events. A basic application is where the user is able to drive a vehicle in the game through the controller. Haptic feedback through the controller can be used to simulate different road surfaces in the game. Off-road or dirt road surfaces often provide a high degree of sensory feedback to deliver a sense of roughness, while smoother tarred roads will typically offer little or no sensory feedback.

More advanced applications in AR and VR include expensive haptic bodysuits that allow users in these environments to feel sensory experiences such as touch, wind, and temperature across their whole body (Heinrich, 2016). Haptics are commonly used in medical training simulations in order to aid a practitioner to learn and practice a procedure. For example, Xia and Sourin (2012) describe an application of haptics for venipuncture which allows students to experience sensory feedback while practicing inserting a needle into a virtual representation of an arm. In this simulation haptic feedback allows students to feel physical resistance similar to a real procedure.

Image: 3D medical simulator with a haptic device (Courtesy of Shamus Smith).

4.3 HAPTICS AND EDUCATION

Haptics are currently commercially available in a number of applications. Dedicated haptic devices such as bodysuits and styluses that provide more in-depth feedback are available, however can have a large cost associated with them and are usually application-specific. For example, the Tesla Haptic Bodysuit™ (**http://www.teslastudios.co.uk/teslasuit**) is reported to start at AUD 2000, while the GeoMagic Touch™ **http://www.geomagic.com/en/products/phantom-omni/overview**) (a low-cost haptic stylus) retails for USD 600. However, most smartphones, tablets and some smart watches offer haptic feedback at a much lower price.

A significant issue regarding haptics is the cost, as quality specialised devices can cost from hundreds to thousands of dollars. Personal preference can be an issue with some users reporting a dislike of haptic feedback (Martin, 2013).

Haptics can allow learners to experience a heightened level of perception in a simulated environment. This creates an in-depth sensory component to learning experiences. For example, in high school physics education, researchers have developed haptic based simulations to allow students to learn scientific concepts in a hands-on way (Flinders University, n.d.). In their simulation concepts such as the difference between weight and mass are taught by allowing students to feel the weight of objects under the gravity of different planets in virtual reality incorporating the latest precise force-feedback haptic technology. As objects are moved into different parts of the screen, the gravity changes from the low gravity of the moon, through to the extreme gravity of Jupiter (where the same mass weighs three times the amount as here on Earth).

While there are currently only a very few dedicated applications of haptics in education, haptic technology provides a means to engage students experientially in the learning process. By providing a physical or sensory component to learning, students learn using multiple sensory channels in a more natural fashion (Hamza-Lup & Adams, 2008). This can have the added benefit of aiding students to learn difficult concepts and enhance their engagement of students in learning (Hamza-Lup & Adams, 2008).

Image: Haptic body suit (by Mitch Altman - Science Hack Day San Francisco, October 2012 **https://flic.kr/p/dpP6dB/** Licence at **http://creativecommons.org/licenses/by/2.0.**)

TABLE 5: SOME FEATURES OF HAPTIC TECHNOLOGY

Technological Aspects	Characteristics
Hardware	Joysticks, controllers, mobile phones, gloves, smart watches and bodysuits are examples of devices that can contain haptic elements. Most haptic devices rely on the use of a PC, visual display and/or HMD in order to function, and are rarely user alone. Devices using haptics can be tethered or untethered. Haptic devices such as bodysuits and gloves are commonly tethered to a PC. Mobile devices such as smartphones, tablets and smart watches offer an untethered experience.
Environment	Haptics can be used within VR, AR, and PC desktop environments.
Sense of Realism/Presence	Haptics can simulate realistic sensory feedback in interaction with virtual objects.
Individual/Shared	Applications of haptics can be for individual or shared experiences. Devices such as mobile phones, tablets, and smart watches can allow for shared haptic experiences. For example, Apple Watch (**http://www.apple.com/au/watch/**) allows users to share touches or even their heartbeat through the device. Many multiplayer online games allow for the sharing of haptic feedback through events in a game, for example, controller vibration during a vehicle collision.
Users/Players	Haptics allow users to experience environments with additional sensory feedback which is tactile and kinaesthetic.
Content	The ability for content to be static or dynamic is dependent on the haptic technology that is used. For example, when used with console video games, content is generally dynamic. Mobile applications utilising basic haptics can be created by users; however, more advanced applications do not generally allow users to easily create content.
Learning Experience	Applications can be individual and self-directed. Haptics can be used to guide a learner in an activity.
Connectivity	Haptic applications can be both online or offline.

5 TANGIBLES

5.1 WHAT IS A TANGIBLE USER INTERFACE?

A tangible user interface (TUI), often referred to as 'tangibles', uses real-world objects to perform actions in a virtual environment (Bowman et al., 2004). Tangible User Interfaces (TUIs) give physical form to digital information and computation by allowing using to directly manipulate the digital with embodied action (Ishi, 2008). The idea behind TUIs is that a physical object will have a direct link with a virtual object in an environment, and by manipulating the physical object in the real world, the virtual object will also be manipulated. These physical objects are known as tangible objects, and may or may not bear any resemblance to the representation of the virtual object. Tangibles have a number of uses. The most common example is that of the PC mouse. Moving the physical object of the mouse causes a virtual object (the pointer) to be moved. There are advanced TUI applications used in VR and AR environments (Kipper & Rampolla, 2012). In these environments, a tangible object can be used to enable interaction with virtual objects, providing a sense of physical presence to these objects. The experimental potential of TUIs can be viewed at the MIT Lab – Tangible Media Group (**http://tangible.media.mit.edu/**).

5.2 SOME TYPES OF TUIs

There are a number of variations of TUIs. Each variation modifies the purpose of use, or the method of interaction within the virtual environment. Three notable variations of TUIs are:

a **Token and constraint based TUIs:** These rely on physical objects (tokens) and defined locations on a work surface (constraints). Tokens can be moved upon a work surface in order to interact with a virtual environment, and by doing so the associated virtual object is manipulated (Ishii, 2006). Constraints are controls which have pre-defined uses (Ishii, 2006), and are interacted with by placing tokens on/within them. For example, a user can control a computer's volume by placing a square token inside a rectangular control area.

b **Interactive tangible surfaces:** Interactive surfaces are digital surfaces powered by a display or projector which allow for the use of tangible objects to manipulate virtual objects displayed upon this surface (Ishii, 2006). On these surfaces, a tangible object can be placed upon and moved freely in order to update the environment presented on the display. A common example of a tangible surface is the Smart Board. A Smart Board™ allows the user to utilise tangible objects representing pens and erasers in order to draw upon a projected surface. However more advanced tangible surfaces allow for greater interaction with a display surface. For example Reactable™ (**http://reactable.com**) is a tabletop TUI which allows for tangible objects to be placed on a display surface in order to synthesise music. By manipulating cubes representing musical instruments, the pitch and tone of the music that is generated changes, along with a visual representation of the music.

c **Tangible augmented reality (TAR):** TAR is a combination of tangible interfaces with AR. In TAR, computer generated AR objects are linked with physical objects. By manipulating a physical object, the associated virtual object is also manipulated (Billinghurst et al., 2008). For example, using VAR (through a smartphone) it would be possible to overlay animations of virtual flowers over pictures of a real flower in a real book. Moving the book could trigger the virtual flower animations. In this case the TUI is the physical book.

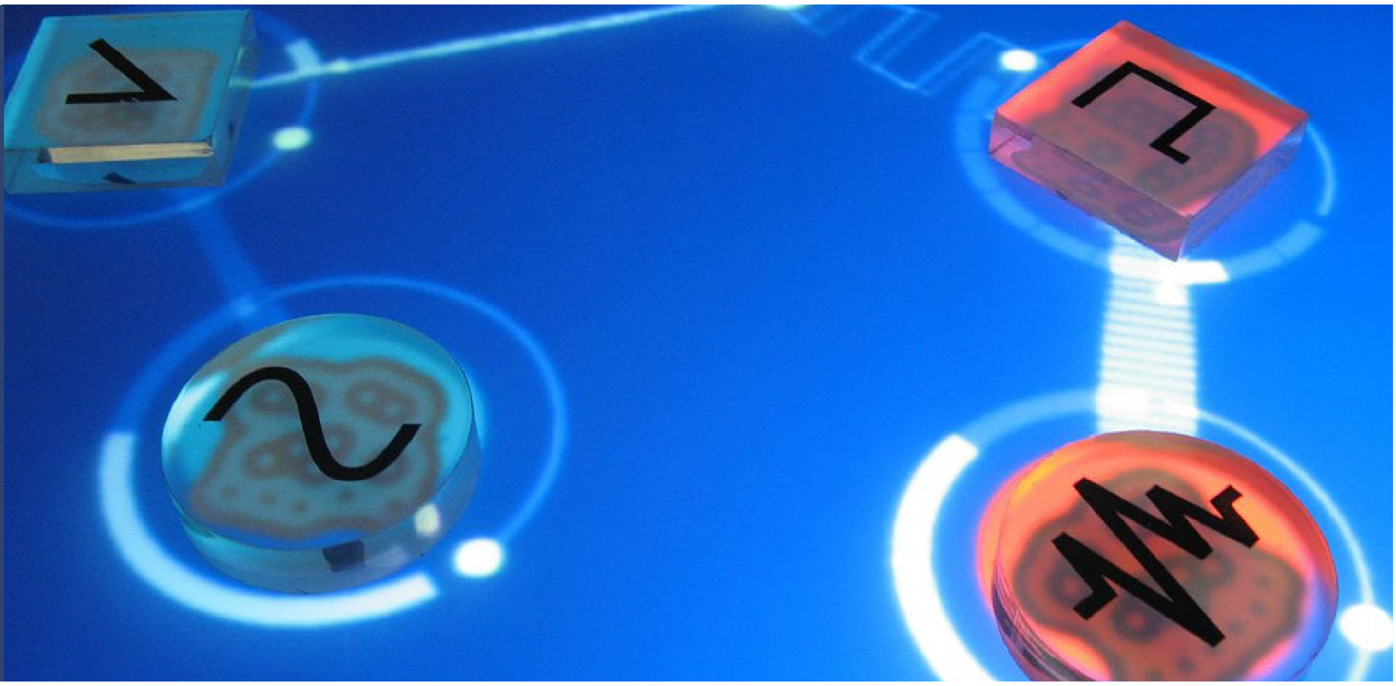

Image: Physical tokens on an interactive surface with projected virtual symbols in the Reactable system (by Luis Leao **https://flic.kr/p/4rMupe** – Licence at **http://creativecommons.org/licenses/by/2.0**).

5.3 TUIs IN EDUCATION

Applications of tangible surfaces and TAR are currently commercially available with Smart Boards a feature of most schools. Applications such as Reactable™ are commercially available; however, can be expensive. The cost of Reactable™ is approximately USD 6000, while HP Sprout™ – explained below – retails for AUD 4000 with an extra AUD600 for the 3D scanning platform. Some issues have been identified with TUIs especially for use in collaborative educational activities. At present, tangible objects tend to have a single associated action, and as such having a TUI with many actions would require having many different tangible objects (Bowman et al., 2004). In complex activities this could require having many objects to conduct the interaction with a tangible interface, thus creating potential confusion during learning.

Sin and Zaman (2009) have detailed an application of Tangible AR in astronomy through a learning tool that allows learners to interact with virtual representations of planets through the use of tangible tokens. These tokens are in the form of paper cards and cubes printed with QR codes (Quick Response codes are square machine-readable barcodes). A HMD with special software recognises what each card or cube is intended to represent. Users are able to rotate and move the tokens which create a similar action in the corresponding virtual planet. By touching the tokens, users display information about the planet, which includes other media such as images and video.

The all-in-one computer scanner HP Sprout™ (**http://www8.hp.com/au/en/sprout/home.html**) has been used in US schools. Sprout™ is a PC setup consisting of a 23" touchscreen computer, a 20" touch sensitive mat, and a camera/scanner/projector system. A 3D scanning platform or 'stage' is also available. One study exploring the educational potential of Sprout™ (Piehler, 2015) documented high school working together on a telemedicine scenario whereby a person in a remote area without medical facilities had a broken hand or finger. Students scanned the hand or finger and made a 3D print of a custom cast or splint for it. Students expressed a high degree of enthusiasm for the learning activity and the collaboration it entailed.

TABLE 6: SOME FEATURES OF TANGIBLES (OR TUIs)

Technological Aspects	Characteristics
Hardware	Physical objects with a virtual representation are used for interaction. A HMD, digital surface, or projector can be used to display the environment; however, this is dependent on the type of the TUI. This interface may be tethered or untethered. For example, an interactive surface is generally tethered to a specific physical location; however, tangible AR/VR can be either tethered or untethered depending on the device used.
Environment	TUIs can be used in both physical and VR/AR environments. Tangible objects are associated with a virtual representation when used in either environment.
Sense of Realism/Presence	As TUIs require manipulating physical objects, applications enhance the sense of realism for the user i.e. when used in AR/VR environments, TUIs increase the overall level of realism by allowing physical interactions to manipulate virtual objects.
Individual/Shared Experience	Both individual and shared experiences can be provided. Tangible objects can, in some cases, be shared between users.
Users/Players	Physical users manipulate tangible objects that interface with virtual objects.
Content	Content is dynamic, as users are intended to interact with generated content. Content is not generally able to be created by users without extensive software development and coding expertise.
Learning Experience	The user is free to interact with the environment as they wish. However, there is the possibility of guided learning with TUIs.
Connectivity	Both online and offline capabilities are available. This depends on the TUI application.

6 VIDEO MEDIA

6.1 INNOVATIONS IN VIDEO MEDIA

This section describes some video technology that has interactive qualities, with some examples of how these might be used for education. This type of video media includes:

a **360º video** is a video recording taken from a 360º perspective (in-the-round). Compared to a standard video which only captures activity in front of the recorder, a 360º video records everything surrounding the recording device. 360º video is typically viewed using a standard PC, smartphone, tablet or HMD. When watching a 360º video the user is afforded the ability to change their viewing perspective of the world, either with a keyboard or mouse input (on a PC), touch (with a smartphone or tablet) or through head movement in a HMD. Compared to some VR or AR simulations, a 360º video recording is static: although the content can be viewed from differing perspectives, it is not interactive, nor does it change. It is an affordable technology with many software applications available at low cost, and it is accessible as 360º video can be viewed with common devices. For example, the site 360Cities™ (**http://www.360cities.net/**) offers a collection of free 360º videos and images which can be used on PCs, smartphones, tablets, or HMDs. Devices for 360º video creation such as GoPro Omni™ and 360Hero™ (**http://www.360heros.com/**) are commercially available. As 360º video has the potential to allow learners to control their view of environments from different perspectives it can allow for a more interesting and immersive experience. For example, students interested in geology or earth science could pay a free visit to an Icelandic geyser (**http://video.360heros.com/website/users/webplayer/videodetails.php?vid=56**).

b **Interactive video** allows users to interact in the video often through a non-linear structure, with alternative playback paths, choice elements and even the influence on the order of scenes (Meixner et al., 2014). These videos play like regular video files, but can include rich media such as text, images, interactive questions and polls, links to websites or even other videos. Interactive videos are commonly created and viewed within a web browser which could be on a PC, smartphone or tablet. Applied to education, interactive videos have the potential to offer students an interactive and immersive learning experience, allowing for educational discovery, discussion and assessment to occur on a single platform (Gan et al., 2015). Interactive video is readily available in platforms such as TED-Ed (**http://ed.ted.com/**).

c **Live streaming** is the broadcasting of real-time video and audio over the internet, which allows users to view content in real time. Video stream can allow for some sense of connection, interaction and collaboration between users. Live streaming generally requires the use of a desktop or laptop PC with a webcam, smartphone, or tablet, and has been used in education, most notably for distance education involving rural or isolated students. However, in recent years there have been many new applications of live streaming in education (Mazza, 2012). A notable application is the ability to connect remote classrooms to allow for virtual excursions. For example, with the common occurrence of interactive whiteboards in classrooms, students can witness in real time educational experiences from experts in the field without having to leave the classroom. A two-way live feed can be broadcast between the expert and classroom, allowing for a remote expert to guide and interact with students from any location. A notable provider of this is Dart Connections (**http://dartconnections.org.au**), a NSW government site which organises virtual excursions for schools.

6.2 VIDEO AND EDUCATION

All technologies in this section are commercially available. 360º video recorders and Interactive video creation platforms such as TED-Ed™ and EdPuzzle™ (**https://edpuzzle.com/**) offer free tools for education-focused content creation and there are also paid alternatives available. Live streaming technology is commonly used with many free applications available. Free apps such as Google's Cardboard Camera™ allow users to take 360º photos with their smartphones that can be used in inexpensive HMDs.

However, the use of these technologies requires consideration. Live streaming, when used in primary or secondary schools, records and broadcasts students undertaking activities. Recording and live streaming may require the consent of students and their parents or carers. Considerations such as privacy are paramount. In regards to the use of interactive videos, many creation platforms record analytics of their users' usage, particularly when a video enables a student to answer a quiz or tracks their progress at a task. As such it is important to consider the ownership, security and privacy of this data.

Interactive video can allow educators to blend knowledge and skill content with assessment in a single presentation, with the advantage of using embedded learning analytics to assess student mastery (and also allow students to self-assess learning progression). For example, the platform EdPuzzle™ allows teachers to upload any video to the site, and turn it into an interactive presentation. This video can be edited, and have content such as quizzes and questions embedded to assess students on their understanding of learning material.

While not offering the same level as interaction or sense of presence as IVR or IAR, 360º video is commonly available and provides users the opportunity to both view and create content. Students have the opportunity to view a wide range of freely available pre-recorded experiences of others from a completely different way of life, or even create and share their own experiences with others. 360º video can provide students both an engaging and entertaining method of visualising locations that are geographically distant or impossible to get to in real life. For example, on the site 360cities.com, students can view the surface of Mars through high resolution panoramic 360º images created by the Curiosity rover. Furthermore, the integration of live streaming in social media platforms creates the potential to expose students to work places in real time where they can have genuine career conversations with professionals in a range of occupations.

Image: Example 360º video (Courtesy of Shamus Smith).

TABLE 7: SOME FEATURES OF INNOVATIVE VIDEO MEDIA

Technological Aspects	Characteristics
Hardware	360º cameras, 360º video cameras, HMDs, smartphones, tablets, televisions, and laptop and desktop PCs are all associated with these video technologies. All of these technologies are commercially available. The viewing or use of these video technologies is commonly associated with a PC, smartphone or tablet.
Environment	Video technologies are displayed upon a PC monitor, smartphone, tablet, television or smart board. 360º and interactive video can be interacted with through touch, keyboard, mouse or controller input. Some variations of 360º video allow for display with a HMD, which affords the user the ability to interact with it through head/motion tracking.
Sense of Realism/Presence	In 360º video the user interacts by changing the viewed perspective of the environment. When using a HMD with 360º video, the sense of presence is increased, as the user has a first-person immersive perspective of the captured environment. Interactive video and live streaming can evoke a good sense of immediacy; the former relies on user direct engagement, while the later relays actual events in real time.
Individual/Shared	Both live streaming and interactive video can be targeted towards groups or single users. 360º video can be viewed by groups but only a single user can change the perspective of the image at a time.
Content	Content is both available and user-creatable for all three mentioned technologies, with many common devices and applications capable of creating content. For example, the creation of interactive video presentations is readily available through free (or paid) online tools. While 360º video does require a specialised video camera such as the GoPro Omni™, many smartphones can capture, view and share 360º panorama video and images.

Learning Experience	Interactive videos provide a pre-defined guided learning experience, often set by a producer or instructor. Live streaming can provide an interactive experience which is guided remotely by a local user. 360º videos provide the opportunity for self-directed viewing of a captured environment.
Connectivity	Both interactive video and video live streaming requires internet connectivity to view and create content. 360º videos do not commonly require an internet connection to capture content.

Image: Woman with head-mounted GoPro (by Robert Couse-Baker - First person perspective **https://flic.kr/p/GVEUbA** - image lightened - License at **http://creativecommons.org/licenses/by/2.0**).

A CALL TO ACTION

While this report provides a technological snapshot in time, its intent is to call on school teachers, university educators, policy-makers, and students of all ages to not only ‘watch this space’ but to actively participate in developing ideas and applications for using new and emerging technologies, to create deeper disciplinary and interdisciplinary learning and more authentic connection to post-school education and world of work. This is a call for all those involved in education, to act now. Educators and students, alike, need to ‘dream-up’, sand-pit, prototype, create proof-of-concept and rigorously apply existing and emerging technologies as tools to ensure fairer educational outcomes and futures.

Image: The authors of this report, in the lab at the University of Newcastle (Australia), from left to right - Erica Southgate in HTC Vive™, Shamus Smith in Microsoft HoloLens™ and Hayden Cheers in Oculus Rift™ (Courtesy Jake Fountain).

REFERENCES

Adams Becker, S, Freeman, A., Giesinger Hall, C., Cummins, M. & Yuhnke, B. (2016). NMC/CoSN Horizon Report: 2016 K-12 Edition. Austin: Texas. The New Media Consortium. **http://cdn.nmc.org/media/2016-nmc-cosn-horizon-report-k12-EN.pdf** Retrieved 10/10/16.

Ayre, M., Mills, J., & Gill, J. (2013). 'Yes I do belong': the women who stay in engineering. Engineering Studies, 5(3), 216-232.

Bannan, K. J. (2015). Is virtual reality for everyone? EdTech Magazine: **http://www.edtechmagazine.com/higher/article/2015/08/virtual-reality-everyone** Retrieved 17/10/16.

Billinghurst, M., Kato, H., & Poupyrev, I. (2008). Tangible augmented reality. ACM SIGGRAPH ASIA 7.

Bowman, D. A., Kruijff, E., LaViola, JR, J. J., & Poupyrev, I. (2004). 3D User Interfaces: Theory and practice. Boston: Addison Wesley.

Brosnan, C., Southgate, E., Outram, S., Lempp, H., Wright, S., Saxby, T., ... & Kelly, B. (2016). Experiences of medical students who are first in family to attend university. Medical Education, 50(8), 842-851.

Carrozzino, M., & Bergamasco, M. (2010). Beyond virtual museums: Experiencing immersive virtual reality in real museums. Journal of Cultural Heritage, 11(4), 452-458.

Cuendet, S., Bonnard, Q., Do-Lenh, S., & Dillenbourg, P. (2013). Designing augmented reality for the classroom. Computers & Education, 68, 557-569.

DeFanti, T. A., Dawe, G., Sandin, D. J., Schulze, J. P., Otto, P., Girado, J., ... & Rao, R. (2009). The StarCAVE, a third-generation CAVE and virtual reality OptIPortal. Future Generation Computer Systems, 25(2), 169-178.

Dalgarno, B., & Lee, M. J. (2010). What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology, 41(1), 10-32.

Diegmann, P., Schmidt-Kraepelin, M., Eynden, S., & Basten, D. (2015). Benefits of augmented reality in educational environments: a systematic literature review. 12th International Conference on Wirtschaftsinformati, Conference Proceedings, 1542-1556. **http://www.wi2015.uni-osnabrueck.de/Files/WI2015-D-14-00036.pdf** Retrieved 11/10/16.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In Handbook of research on educational communications and technology (pp. 735-745). Springer: New York.

Dunleavy, M., Dede, C. & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. Journal of Science Education and Technology, 18(1), 7-22.

EdTech Mindset. (2016). Virtual reality promise: a contemporary version of 'The emperor's new clothes'? **http://www.mindcet.org/wp-content/uploads/2016/06/VREducation.pdf** Retrieved 09/10/16.

Flinders University. (n.d.). Haptics for high-schools. Flinders University, School of Computer Science, Engineering and Mathematics **http://www.flinders.edu.au/science_engineering/csem/research/programs/human-computer-interaction/ghs.cfm**

Friedman, M., Friedrich, K., Queisner, M., & Stein, C. (2016). Editorial introduction: conceptualizing screen practices: how head-mounted displays transform action and perception. Media Tropes, 6(1), i-v.

Fowler, C. (2015). Virtual reality and learning: where is the pedagogy? British Journal of Educational Technology, 46(2), 412-422.

Furht, & Borko. (2008). Desktop Virtual Reality. In Encyclopedia of Multimedia (pp. 150-151). Boston, MA: Springer US.

Gale, T. (2013). Widening participation in Australian education. **https://www.deakin.edu.au/__data/assets/pdf_file/0006/365199/widening-participation.pdf** Retrieved 24/09/16.

Gan, B., Menkhoff, T., & Smith, R. (2015). Enhancing students' learning process through interactive digital media: new opportunities for collaborative learning. Computers in Human Behavior, 51, 652-663.

Goldman Sachs Group (2016). Virtual and augmented reality: understanding the race for the next computing platform. **http://www.goldmansachs.com/our-thinking/pages/technology-driving-innovation-folder/virtual-and-augmented-reality/report.pdf** Retrieved 10/10/16.

Gregory, S., Gregory, B., Reiners, T., Fardinpour, A., Hillier, M., Lee, M., ... & Hearns, M. (2013). Virtual worlds in Australian and New Zealand higher education: remembering the past, understanding the present and imagining the future. **http://eprints.qut.edu.au/64096/2/64096.pdf** Retrieved 17/10/16.

Hamza-Lup, F. G., & Adams, M. (2008). Feel the pressure: e-learning systems with haptic feedback. 2008 Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, (pp. 445-450).

Heinrich, A. (2016, 01 07). Teslasuit offers full-body haptics to VR users. Retrieved from Gizmag: **http://www.gizmag.com/teslasuit-full-body-virtual-reality-stimulation/41206/** Retrieved 17/10/16.

Hoffman, N. (2015). Let's get real: deeper learning and the power of the workplace. Jobs for the Future Series. **http://www.hewlett.org/sites/default/files/Lets-Get-Real-final.pdf** Retrieved 11/10/16.

Ishii, H. (2006). A.2 Tangible User Interfaces. What is the Next Generation of Human-Computer Interaction? Workshop, CHI 2006 Workshop Proceedings. Quebec.

Ishii, H. (2008). Tangible bits: beyond pixels. In Proceedings of the 2nd International Conference on Tangible and Embedded Interaction (pp. xv-xxv). ACM.

Kinnane, S., Wilks, J., Wilson, K., Hughes, T., & Thomas, S. (2014). Can't be what you can't see'.The transition of Aboriginal and Torres Strait Islander students into higher education. **http://www.nd.edu.au/__data/assets/pdf_file/0018/122364/OLT-ID-SI11-2138-Lit-Rev-Final-14-March-2014.pdf** Retrieved 6/10/16.

Kipper, G., & Rampolla, J. (2012). Augmented reality: an emerging technologies guide to AR. Amsterdam: Elsevier.

Martin, T. (2013). Why I hate haptic feedback. **http://pocketnow.com/2013/07/16/why-i-hate-haptic-feedback** Retrieved 08/12/16.

Mazza, R. (2012). Live stream school events to boost community outreach. **http://www.edutopia.org/blog/live-streaming-schools-joe-mazza** Retrieved 12/10/16.

McLaughlin, M. L., Sukhatme, G., & Hespanha, J. (2001). Touch in virtual environments: haptics and the design of interactive systems. New Jersey: Prentice Hall.

McPherson, R., McPherson, J., Vitaly, S., & Vitaly, S. (2015). No escape from reality: security and privacy of augmented reality browsers. Proceedings of the 24th International Conference on World Wide Web (pp. 743-753). Florence: ACM.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis . Computers & Education, 70, 29-40.

Mikropoulos, T. A., & Natsis, A. (2011). Educational virtual environments: A ten-year review of empirical research (1999–2009). Computers & Education, 56(3), 769-780.

Meixner, B., Matusik, K., Grill, C., & Kosch, H. (2014). Towards an easy to use authoring tool for interactive non-linear video. Multimedia Tools and Applications, 70(2), 1251-1276.

Noguera, P., Darling-Hammond, L., & Friedlaender, D. (2015). Equal opportunity for deeper learning. Deeper Learning Research Series. Jobs for the Future. **http://www.jff.org/sites/default/files/publications/materials/Equal-Opportunity-for-Deeper-Learning-100115a.pdf** Retrieved 17/10/16.

OECD. (2015). Students, computers and learning: making the connection. OECD Publishing. **http://www.oecd.org/publications/students-computers-and-learning-9789264239555-en.htm** Retrived 11/10/16.

Oxford Dictionairies. (n.d.). Virtual reality and artificial intelligence. **http://www.oxforddictionaries.com/definition/english/virtual-reality?q=virtual+reality** & **https://en.oxforddictionaries.com/definition/artificial_intelligence** Retrieved 07/07/16.

Piehler, C. (2015). A new platform for connecting the physical and digital worlds. The Journal. **https://thejournal.com/articles/2015/08/13/a-new-platform-for-connecting-the-physical-and-digital-worlds.aspx** Retrieved 08/12/16.

Sabelman, E. E., & Lam, R. (2015). The real-life dangers of augmented reality. IEEE Spectrum, **http://spectrum.ieee.org/consumer-electronics/portable-devices/the-reallife-dangers-of-augmented-reality** Retreived 12/10/16.

Selwyn, N. (2010). Looking beyond learning: notes towards the critical study of educational technology. Journal of Computer Assisted Learning, 26(1), 65-73.

Sin, A. K., & Zaman, H. B. (2009). Tangible interaction in learning astronomy through augmented reality book-based education tool. Visual Informatics: Bridging Research and Practice, 302-313.

Southgate, E., Kelly, B. J., & Symonds, I. M. (2015). Disadvantage and the 'capacity to aspire' to medical school. Medical Education, 49(1), 73-83.

Southgate, E. & Smith, S.P. (2016). Pedagogical theory and embodiment: provocations for virtual and augmented reality in education. Paper presented at the IEEE Virtual Reality 2016 Workshop on K-12 Embodied Learning through Virtual & Augmented Reality (KELVAR), Greenville NC. **https://sites.google.com/site/vrkelvar/** Retrieved 17/10/16.

Virtual Reality Society. (n.d.[a]). Cabe fully immersive virtual reality. **http://www.vrs.org.uk/virtual-reality-environments/cave.html** Retrieved 07/08/16.

Virtual Reality Society. (n.d.[b]). Head mounted displays. Virtual Reality Society. **http://www.vrs.org.uk/virtual-reality-gear/head-mounted-displays/** Retrieved 07/08/16.

Xia, P., & Sourin, A. (2012). Design and implementation of a haptics-based virtual venepuncture simulation and training system. Proceedings of the 11th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and Its Applications in Industry, 25-30.