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# PLAYABLE EXPERIENCES THROUGH TECHNOLOGIES: OPPORTUNITIES AND CHALLENGES FOR TEACHING SIMULATION LEARNING AND EXTENDED REALITY SOLUTION CREATION


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| Zi Siang See* | University of Tasmania, Tasmania, Australia | zisiang.see@utas.edu.au |
| Susan Ledger | University of Newcastle, NSW, Australia | susan.ledger@newcastle.edu.au |
| Lizbeth Goodman | University College Dublin, Dublin, Ireland | lizbeth.goodman@ucd.ie |
| Benjamin Matthews | University of Newcastle, NSW, Australia | ben.matthews@newcastle.edu.au |
| Donovan Jones | Charles Sturt University, NSW, Australia | donojones@csu.edu.au |
| Shanna Fealy | Charles Sturt University, NSW, Australia | sfealy@csu.edu.au |
| Wooi Har Ooi | Queen Victoria Museum and Art Gallery, Tasmania, Australia | haireena.ooi@launceston.gov.au |
| Manisha Amin | Centre for Inclusive Design, NSW, Australia | manisha.amin@cfid.org.au |

* Corresponding author

## ABSTRACT


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| Aim/Purpose | This paper describes a technologies education model for introducing Simulation Learning and Extended Reality (XR) solution creation skills and knowledge to students at the tertiary education level, which is broadly applicable to higher education-based contexts of teaching and learning. |
| Background | This work is made possible via the model's focus on advancing knowledge and understanding of a range of digital resources, and the processes and production |


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| | skills to teach and produce playable educational digital content, including classroom practice and applications. |
| Methodology | Through practice-based learning and technology as an enabler, to inform the development of this model, we proposed a mixed-mode project-based approach of study within a transdisciplinary course for Higher Education students from the first year through to the post-graduate level. |
| Contribution | An argument is also presented for the utility of this model for upskilling Pre-service Teachers' (PSTs) pedagogical content knowledge in Technologies, which is especially relevant to the Australian curriculum context and will be broadly applicable to various educative and non-Australian settings. |
| Findings | Supported by practice-based research, work samples and digital projects of Simulation Learning and XR developed by the authors are demonstrated to ground the discussion in examples; the discussion that is based around some of the challenges and the technical considerations, and the scope of teaching digital solutions creation is provided. |
| Recommendations for Practitioners | We provide a flexible technologies teaching and learning model for determining content for inclusion in a course designed to provide introductory Simulation Learning and XR solution creation skills and knowledge. |
| Recommendations for Researchers | The goal was to provide key criteria and an outline that can be adapted by academic researchers and learning designers in various higher education-based contexts of teaching and inclusive learning design focused on XR. |
| Impact on Society | We explore how educators work with entities in various settings and contexts with different priorities, and how we recognise expertise beyond the institutional interests, beyond discipline, and explore 'what is possible' through digital technologies for social good and inclusivity. |
| Future Research | The next step for this research is to investigate and explore how XR and Simulation Learning could be utilised to accelerate student learning in STEM and HASS disciplines, to promote knowledge retention and a higher level of technology-enhanced learning engagement. |

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| Keywords | augmented reality, virtual reality, user experience study, extended realities, interactive media, human-computer interaction, simulation learning, serious games, digital media, higher education, virtual learning, education technologies, inclusive design, ethical design, digital technologies, design and technologies, digital literacy, technologies education, transdisciplinary, multidisciplinary, science technology engineering and mathematics (STEM), humanities and social sciences (HASS) |

## INTRODUCTION AND BACKGROUND

Extended Reality (XR) based content and Simulation Learning applications have become increasingly distributed and employed as both professional communication tools and everyday consumer products, demanding a rapid improvement in digital literacy in this domain. This trend has generated the requirement for introductory teaching and learning in XR in higher education, which has emerged as a priority across a significant proportion of disciplinary areas of tertiary education-based institutions and external professional contexts given XR now meaningfully applies to diverse industry sectors. This flexible model is proposed as a suitable approach to determining the scope of content for students from any program and level of study and is deemed adaptable for non-enrolled learners as part of community-based education, professional learning, and certified-professional development (CPD) where micro-credentialing plays a vital role. In this paper, we outline the technical and social background of Simulation Learning and XR teaching and learning and make suggestions with the goal of attaining a more accurate, flexible, and gender-aware vocabulary for such projects in the future. We propose learning components and a rationale for exclusions based on difficulty level guided by observations of student learning efficacy before commenting on the ethical implications of a practice-based approach to course delivery, indicating directions for future research. The main contribution of this paper is to provide the key criteria for an outline of a course/unit of study that can be adapted to various higher education-based contexts of teaching and learning design, with a focus on teaching Technologies with the key components of Learning Simulation and XR solution creation.

This paper outlines introductory skills and knowledge for creating solutions through Simulation Learning and XR and identifies where these skills are fostered through teaching and learning in digital technologies. The work is structured into multiple sections, beginning with an introduction and background of the educational context relevant to simulation learning and XR, followed by a practice-based approach that describes the key aspects of: (i) Screen-based Simulation Learning Serious Games Applications; (ii) Extended Reality including Augmented and Virtual Reality; and (iii) Dome-based Digital Content. A scholarly discussion with a list of learning outcomes is also provided, along with the rationale, key challenges, and new questions raised. A series of original work samples are included to ground the discussion in examples, followed by a conclusion and implications section that provides an overview summary of the work.

In defining and locating these, an argument is presented promoting and supporting the development of digital literacy, of learners in tertiary education contexts, for programs and courses focused on Information and Communications Technology (ICT), Computing, Design and Digital Media, and the facilitating, training, and learning (FTL) of F-10/K-12 educators (foundation to year 10/kindergarten to year 12). This includes but is not limited to the Australian Curriculum Technologies context where teachers will teach Technologies as one of the main areas at school (ACARA, 2022), where it was described that "Digital Technologies explicitly supports the development of Digital Literacy across the curriculum. Digital Literacy and Digital Technologies give students the opportunity to become discerning users, productive creators, critical analysts, and effective developers of digital solutions". In a broader perspective, for instance, technology-based subjects are being introduced in various curriculum settings (Gov.UK, 2022; Ministry of Education Singapore, 2022; National Council for Curriculum and Assessment Ireland, 2022), where educators are expected to upskill and reskill regularly, in an area of growth focused on working with advanced and emerging digital tools confidently.

Our suggested approach may be applicable to three contexts:

- Introducing Augmented Reality (AR) and Virtual Reality (VR) skills and knowledge in a higher education setting (unit or course design);
- Introducing AR and VR skills and knowledge in a professional learning setting (training or short courses); and
- Introducing AR and VR skills and knowledge in school settings (mainly for the training of pre-service teachers, and the reskilling/upskilling of existing educators).

The literature chosen for inclusion in this paper may include, but is not limited to, department of education documents related to curriculum design and peer-reviewed academic research articles. We can see that there is an increasing demand for simulation and XR applications in the education space (Fischetti et al., 2022; Gu & Blackmore, 2015; Horst & Dörner, 2018; MacDowell & Lock, 2022; Matthews et al., 2020), with a focus on immersive education and designing for learning. However, the course content and teaching approach for developing these skills and production processes are not yet well-established. Informed by a creative and practice-based approach (Candy, 2006; Gray & Malins, 2004), the work described in this paper provides an overview of multimodal applications in the recommended teaching and learning plan so that educators can collaboratively work with students to develop digital literacy and work with emerging technologies in a growing area of simulation learning and XR digital content creation. To provide context, technology acts as an enabler for STEM (Science, Technology, Engineering, and Mathematics) educators and students, enabling them to visualize data and technical content through various simulated and XR experiences. Mathematics students, for example, can use mathematical modeling to solve practical problems involving proportion and scaling of 3D objects/models and conduct simulations using digital tools. Science students can visualize earth and space simulations and interact with biological and health sciences learning content virtually and intuitively. HASS (Humanities and Social Sciences) educators and students can explore how technology-enhanced content can deepen their knowledge and understanding of places and humanities topics. This may include, but is not limited to, the use of VR to visualise the settlement of local places, and to improve the understanding of both the historical and geographical contexts of the subject matters.

The ongoing development of emerging digital technologies continues to provide educators and learners opportunities to develop skills as end-users of the technologies, but also opportunities to be creators of future technologies. Much debate, however, centres on the use of educational technologies (EdTech) and pedagogical technologies (PedTech), which inform or direct the other (Aubrey-Smith, 2021). Choosing the right tool to support the pedagogy that shapes practice lies at the heart of preparing students for a technological future. However, before such choices can be made, one must ask how and where students 'learn' these technologies and pedagogies. Systems such as schooling and higher education provide a unique opportunity for students to be aware of and exposed to new and emerging technologies. State, national, and international policies including the OECD (Organisation for Economic Co-operation and Development) and The Future of Education and Skills 2030 project, all acknowledge the fast rate of technological developments driven by accelerating globalisation and the need to equip learners with the competencies they need to shape their own lives and contribute to the lives of others (OECD, 2018, p. 2). Despite this recognition of the significance and need in the education policy and vision statements, little detail or exemplars are offered as to cohesive whole-of-government or whole-of-nation approaches to support enactment and implementation. For example, Gary Waters (2021), a director of the Integrated Institute for Economic Research, calls on the government to develop a "sovereign ICT capability framework that would enable Australia to adopt an integration-by-design approach". We argue that current ICT policies from schools to higher education are disjointed, using language that prescribes pedagogical practices reliant on teacher experience and expertise. We support Waters' (2021) call for a more holistic approach to ICT education and digital literacy training policies to help shape the preparedness of current Australian students to consume and create future EdTech innovations.

Australia currently has a technology skills shortage and is predicted to require a 79% increase in the current number of qualified individuals (Technology Decisions, 2022). Technology-based education and training are contextualised within Australian higher education policies through the Higher Education Standards Framework (Australian Government, Tertiary Education Quality and Standards Agency, 2021) and the TEQSA Act (Tertiary Education Quality Standards Agency Act) (Australian Government, Tertiary Education Quality and Standards Agency, 2011), all of which lack detail pertaining to a nationwide enactment or implementation strategy as outlined below. A similar lack of clarity around ICT and associated ethical practices is evident in Australian policy documents for schools (Southgate et al., 2017). This certainly needs to be a consideration, and it is likely to have a negative impact on higher education courses seeking to offer new and emerging technologies to students. With higher education budgets being continuously reduced, growing tension exists between the need to balance course costs against providing innovative student experiences. In response to this our flexible model endeavours to incorporate low-budget or free technologies within its design. The lack of reference to Technologies in core policy documents is concerning. This contradicts current policy discourse about the significant need for Australia to develop a strong technological skill base to meet the predicted technology skills shortage noted above. The requirements of Technologies as part of the teaching and learning process within the Higher Education sector are somewhat scarce and rely on individual institutes to frame their own approach and these are often influenced by international policies and technology companies themselves.

The reliance on individual institutions to frame their own approach to ICT delivery has opened the door to large EdTech companies pitching to universities and schools as clients with creative, integrated platforms and a plethora of applications (Berger, 2019). From 2021 to 2025, the global Edtech space is expected to grow by $112.39 billion with an annualized growth rate of 17.85% (Technavio, 2021), making it a powerful influencer driving change in education. In this environment, without clear policy direction from the government the approach of educational institutions will likely be shaped by EdTech rather than PedTech solutions.

The silence on technologies in policy documents in Australia is representative of a global lack of clarity in this space. The OECD recently presented a global Learning Framework to guide their predictions for future needs in schools, and technology was also missing from this global educational influencer (see Figure 1).

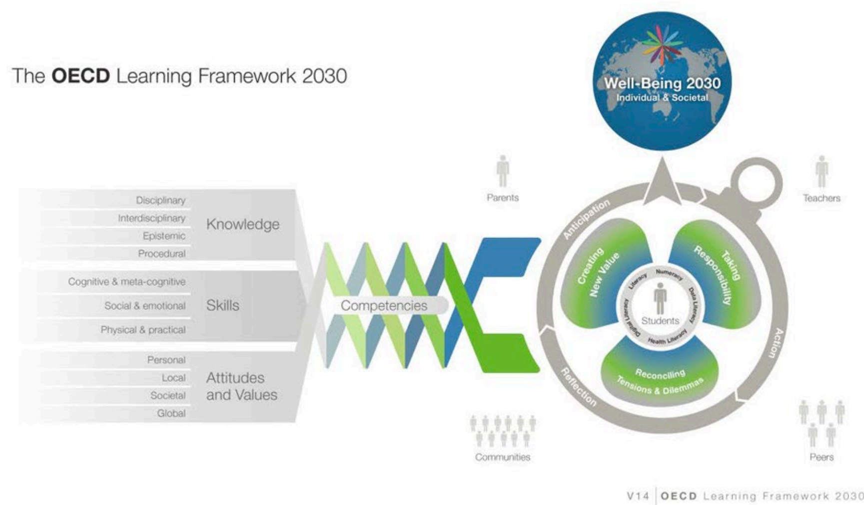


**Figure 1. The OECD Learning Framework 2030: Work-in-progress (from OECD, 2018 - The future of education and skills Education 2030)**

This conflicted backdrop of limited policy direction is counterbalanced by examples of good pedagogical practices using and creating technologies for higher education contexts. A focus on PedTech has been evident within higher education, where over a decade ago a framework for technological pedagogical content knowledge (TPACK) was adapted by Koehler and Mishra (2009) using Lee Shulmans' construct of pedagogical content knowledge to include Technologies. Both models highlight the interactive and interconnected bodies of knowledge derived from both theory and practice. However, introducing students to emerging technologies has significant ethical implications given the way these technologies impact cognition, behaviour, and social dynamics, particularly via human 'virtuality' (Southgate et al., 2017). These require further consideration, especially in the context of the use of immersive virtual and augmented reality technologies by school-aged children and young people. We propose the inclusion of ethics in the TPACK framework (eTPACK) as we move toward addressing the competencies and outcomes of the OECD 2030 model (Figure 1) and consideration of how to meet the well-being of individuals in society as they learn to interact with and create emerging technologies.

Ledger et al. (2021) framed the use of simulation in preparing preservice teachers for placements within Grossman et al.'s (2009) pedagogies of practice-representations, decomposition, and approximations of practice. Bower et al. (2020) noted the increasing accessibility of immersive virtual reality (IVR) in education due to the proliferation of affordable applications and hardware. The COVID-19 pandemic has further accelerated interest in digitally enhanced approaches to teaching and learning (Matthews et al., 2020). VR offers fully immersive experiences while AR provides digitally overlaid enhanced content (Billinghurst, 2011; Concannon et al., 2019; Morie, 2007; Ohta & Tamura, 2014). Technical developments in AR and VR are focused on immersion, usability, interactivity, and display techniques (Azuma et al., 2001; Billinghurst, 2011; Sherman & Craig, 2003). In Simulation Learning and XR for education, specialized design elements are crucial to prototyping the user experience, as illustrated in the 'Playable Experience' domain of knowledge diagram we present in Figure 2.

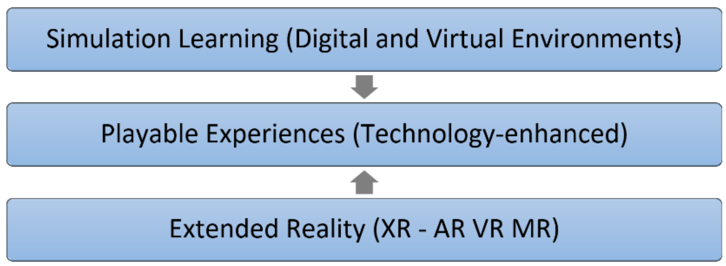


**Figure 2. Playable Experience domain of knowledge informing the proposed teaching-and-learning model**

We are interested in how knowledge retention and improved engagement can be promoted through playable experiences using Simulation Learning and XR. These technologies form part of a media ecology with strong educational applications in the setting of highly inclusive pedagogy (Concannon et al., 2019; Dey et al., 2018; Domingo & Bradley, 2018; Fernandez-Antolin et al., 2021; Goodman, 2017; Horst & Dörner, 2018; Yang & Wang, 2023). Play-based learning contexts (Edwards et al., 2017; Edwards & Cutter-Mackenzie, 2013; Vygotsky, 2004) could be enhanced with technology-enabled playable solutions and activities, such as promoting learning exploration of new concepts or co-developing understandings of concepts between teachers and children by drawing on a range of information resources. Aligned with TPACK (Koehler et al., 2013) and SAMR (Bartolotti, 2021; Puentedura, 2010) for enhanced teaching and learning through technologies, XR allows Simulation Learning content to be recreated and made playable in a classroom and various experiential learning conditions (Alonso-Fernández et al., 2019; Australian Government, Department of Education, 2022; Victoria State Government, Department of Education, 2022). It is suggested that students be engaged in the ethical dimension of XR technology by implementing universal design and inclusive design principles in their projects (Amin, 2019; The Center for Universal Design, 1997). This includes working with digital solutions that are diversity friendly. Diversity is the range of human differences, including but not limited to race, ethnicity, gender, gender identity, sexual orientation, age, social class, physical ability, or attributes, religious or ethical values system, national origin, and political beliefs. We offer some comments on how these developments might inform the ethical dimension of XR pedagogy in our Discussion section.

The field of Inclusive Design also underpins this study, as the co-design of educational content and delivery modes must be developed in tandem and with (not only for) the groups of learners who will ultimately engage with the materials. To simplify the 'Playable Experiences' application of these frameworks, we have employed pragmatic criteria highlighted by Everyone Can Play A Guideline to Create Inclusive Playspaces (NSW Government, 2019). They provide detailed criteria, but it is broken into three key areas that can be applicable to our context of XR research-creation and user experience design:

1. Can I get there (the journey to access the activity, do I have the resources, the social understanding, and the support to access the equipment and the schools and environments where the equipment works)?

2. Can I play there (is it usable, and accessible? Both the WCAG Pour principles (W3C, 2016) as well as the Heuristics good design principles, and focusing on what if I have difficulty with reality, seeing, hearing, smelling, moving, and dexterity or thinking)?
3. Can I stay there (this relates to safety and experience and feelings of inclusion)?

## PRACTICE-BASED APPROACH

We have observed that peer-to-peer learning and peer-assisted learning (social way of learning) are some of the effective approaches for developing skills and knowledge in these design and technologies contexts, especially in the higher education FTL space. At present, there is no standardisation in some of the digital workflows or solutions required for creating and managing the development of XR and Simulation Learning content. We recommend a co-design approach that allows students to engage with users, collaborators, and experts in a work-integrated process in order to achieve the optimum teaching and learning outcome. In this section of the paper, we take the approach of introducing multimodal applications in the recommended teaching and learning plan, which allows students to work with the creative development process of (i) Screen-based Simulation Learning Serious Games Applications, (ii) Extended Reality including Augmented and Virtual Reality, and (iii) Dome-based Digital Content. The following sections describe possible learning activities that cover essential elements of these areas toward achieving research-creation in the context of Simulation Learning and XR.

### *ESSENTIALS OF INTRODUCTORY SIMULATION LEARNING SERIOUS GAMES APPLICATIONS*

The essential elements of introductory Simulation Learning serious games require learners to work with level design, a set of skills, and the design thinking process to create and manage a virtual environment (VE), which may include working with processes and the production skills of managing system and user interfaces (UI), conventionally using the visual programming and/or game design approach of authoring a digital world. Essential elements of Simulation Learning serious games literacy include:

- Level design
- Working with design and technologies
- Basic 3D modelling and 3D scanning

The purpose of having the students work with level design is to develop their understanding of gameplay research-creation and the process of authoring a virtual environment (for creating playable interactive digital solutions), whilst engaging in industry-standard activities. Malliet (2007) suggested students/learners as creators or developers engage a scheme of seven topics of interest: audiovisual style; narration; the complexity of controls; game goals; character and object structure; the balance between user input and pre-programmed rules; and spatial properties of the game world. Learners may use the suggested topics of interest to analyse any existing digital playable resources or simulation content or use the scheme as a guideline for the planning and development process of creating a digital playable project, whilst working alongside the process with various design and technologies components. These may require students to work with basic visual programming or managing in-game interactive elements. In this case, student projects may involve work-integrated or research-integrated learning opportunities. Fundamentally students should be able to communicate an understanding of game types, gameplay history, and culture, develop digital content and game aesthetics, and create multimedia assets and simulation content in their own specialism - this is applicable to various simulative and storytelling applications in both STEM and HASS spaces. For example, Figure 3 shows the level design development process of students being guided to create precision 3D models in a game engine, and Figure 4 illustrates the 3D scanning process required to digitise a heritage artefact (example of an artefact found in Cessnock, New South Wales, Australia, in 2019) using a photogrammetry mathematical reconstruction approach (Schindler, 2015).

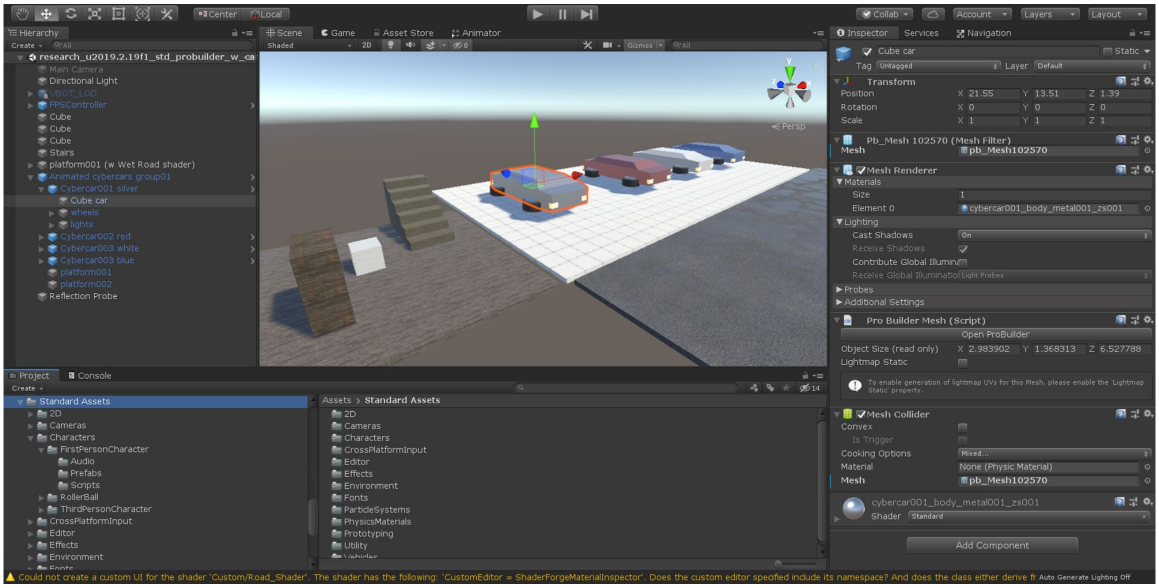

**Figure 3. Level design with basic 3D modelling**

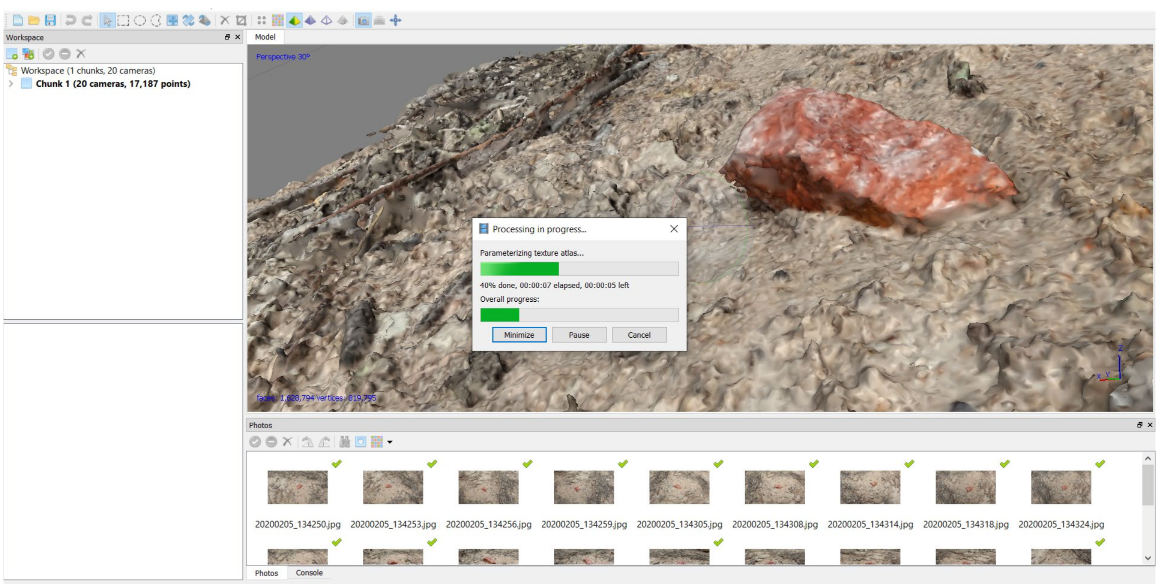


**Figure 4. 3D scanning using the photogrammetry approach for combining multi-angle photographs**

## *Essentials of Introductory Extended Reality (XR)*

The key areas of XR at the present time include AR and VR, and we focus on a discussion defining elements of related skills and knowledge for each, sorting these into two categories of learning goals: essential, and high level. It is intended that this simple taxonomy can inform other educators from a range of disciplinary backgrounds, and to this end, we begin with a discussion that seeks to examine AR, before covering VR, then the learning outcomes of our model can be translated to achieve if utilized to inform a broad-based, fully-fledged academic unit of study. The main focus here is to provide the rationale, key criteria, and outline for a course that can be adapted to various higher education-based contexts of teaching and learning design focused on XR (and Simulation Learning) in the context of Technologies.

## Introductory of AR

The essential elements of introductory AR are outlined here, along with a rationale for their inclusion, followed by the high-level areas of AR literacy that are excluded, and the reasons for doing so. Essential elements of AR literacy include:

- Image-based AR tracking
- Authoring multimedia content
- Interaction and graphic user interface (GUI) design

Image-based AR tracking is essential because it allows AR content to be overlaid on a 2D surface (see Figure 5). Some of the AR Software Development Kits (SDK) provide features such as overlaying text, image, and video. Such scenarios can be seen in some of the Museum and Art Gallery based AR applications (Chan & Maxwell, n.d.; Kyriakou & Hermon, 2019). Authoring multimedia content (See, Lee, et al., 2018) is essential as it involves a range of production processes including image and video editing, creative design processes, sound montage composition, colour management, file compression, web-based content development, and server hosting. Interaction and GUI design are fundamental because hand gesture input (by the users) is central to any mobile-based AR experience. It allows everything from simple buttons to be pressed (to do things like creating hyperlinks leading to social media or video hosting services) to scaling or rotating a 3D object. To demonstrate, in Figure 5 we can see the authoring process of preparing a simple user interface with interactable elements.

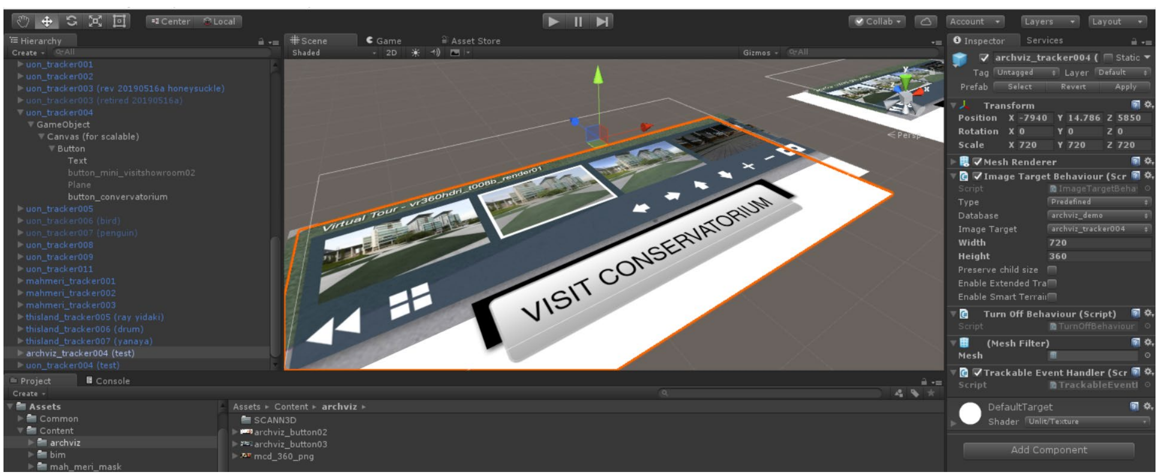


**Figure 5. Authoring basic AR content in the Unity Engine editor**

High-level goals for an introductory course would include:

- 3D object tracking
- Markerless tracking
- Authoring AR-optimized multimedia
- Customizing mechanics in AR

3D tracking of a real-world object is an essential part of AR experiences and can be readily explained, however, it is considered high level because it's relatively difficult to implement as a practical, task-oriented skill in an introductory course. This is because no technology exists to permit this process to be executed reliably and easily. Such minimal interference as a shadow cast on a 2D single image, for instance, will confuse most existing tracking systems. In the context of a 3D object, with many details and possible lighting conditions, this problem is drastically elevated. This points toward the next high-level exclusion, Markerless tracking like SLAM (Simultaneous Localization and Mapping), which is commonly utilised to understand the physical world through feature points. This makes it possible for AR applications to recognise 3D objects and scenes, as well as to instantly track the world, and to overlay digital interactive augmentations. However, such actions are considered high level because they require hardware with faster computing power, and at present only devices such as 'flagship' mobile phones are able to support them. Therefore, whilst markerless tracking is vital in the current or next stage of AR experiences, it is only functional in high-end mobile devices, and lower-range devices tend to suffer from a lack of computing power and cannot render the required content and perform environment tracking (e.g., Google's Android ARCore platform, and Apple's ARKIT platform). Authoring AR-optimized multimedia is considered high-end because currently there are no standardized ways to develop AR-enabled content. On the one hand, new versions of authoring platforms continue to rapidly emerge (e.g., Unity 5 vs Unity 2023), and on the other, the major platforms - Android and Apple - have very different Standard Developer Kit (SDK) requirements. Customizing mechanics in AR, such as creating interactable interfaces that change colour or scale, has been categorized as a high-level goal because some AR features of this kind need specific computing and mathematical requirements to function (see Figure 6). These emerging media experiences may only be suitable for resourceful organizations or creative projects. A more detailed discussion of AR curriculum design with a focus on Information and Communication Technologies (ICT) can also be found in the work of Fominykh et al. (2020).

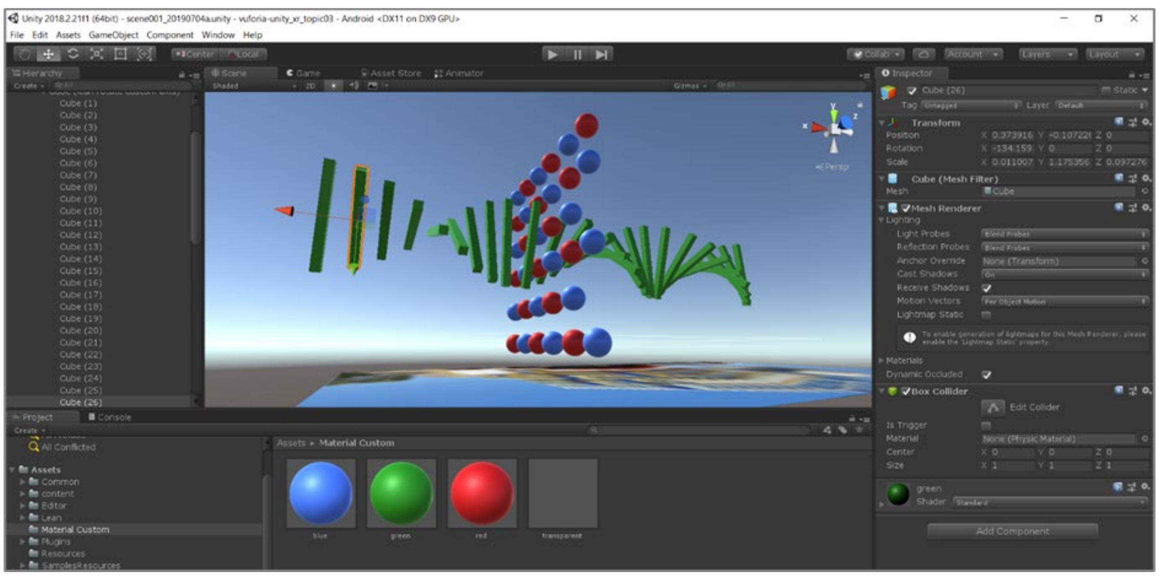

**Figure 6. Customizing complex AR-optimized content and interactivity**

## Essentials of Introductory VR

Now we turn to the essential elements of introductory VR, which are outlined here, along with a rationale for their inclusion, followed by the high-level areas of VR literacy that are excluded, and the reasons for doing so. Essential elements of VR literacy include:

- Environment simulation
- VR360 (Spherical Panorama) videos and photographs
- Locomotion and interactions
- Authoring conventional multimedia

Environment simulation is an essential visual programming creation process that underpins VR - also commonly known as "level design" in the game development context for managing and creating an interactable virtual environment (VE). It involves a number of key skills, and the creation process assists in the acquisition of core technical knowledge around 3D modelling, visual programming, and managing shading and textures (see Figure 7). VR360 (Spherical Panorama) is another core area of computational photography and probably one of the earliest forms of VR. It has its roots in the early 19th-century practice of panorama painting where the artist's goal was to reproduce the world so realistically that onlookers believed what they were seeing was real (Benosman & Kang, 2001). VR360 is considered essential for introductory VR because of the usability, affordability, and efficacy of consumer-level 360 cameras, and the wide availability of platforms that support and deliver this content including Facebook and YouTube. Locomotion and interaction are essential elements of VR. Locomotion describes the capacity for users to "walk around" in virtual reality (3 Degrees of or 6 Degrees of Freedom), while interaction describes the ability of users to perform actions with objects in virtual scenes. This is a rapidly evolving aspect of VR technology and the various consumer products and platforms offer a wide range of functionality. SteamVR SDK and Meta/Oculus SDK in Unity, for instance, can allow users to have a room-scale locomotion experience. Some of these virtual applications can be seen in the study conducted by Tatlı et al. (2023). Authoring conventional multimedia working with text, image, animation, video, and sound is also an essential part of introductory VR. These processes are a common part of the skillset possessed by multimedia-ready students or media-industry professionals, but for most beginners involve a range of technical knowledge and contextual understanding that must be provided here.

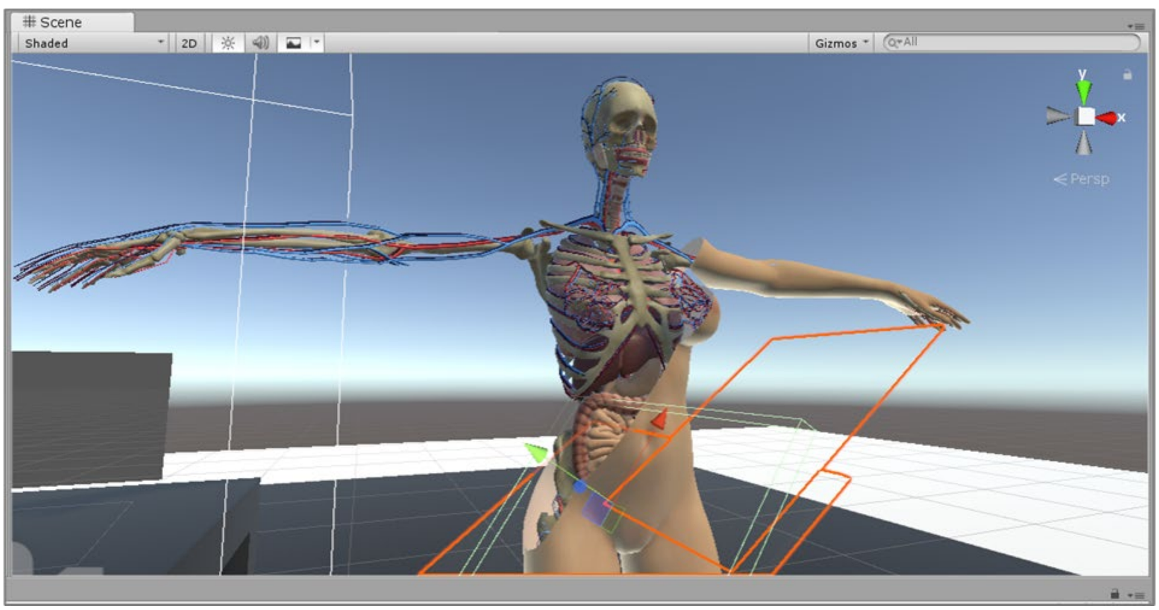


**Figure 7. Authoring basic VR content in the Unity Engine editor**

High-level goals for an introductory VR course would include:

- Presence/Immersion
- Hands or Avatar (self-realisation)
- Ambisonic and 3D audio
- Authoring hyper-realistic VR scenes

Presence is a defining feature of VR and a top priority in VR experience development. However, it can be extremely challenging to import various "real-world" elements into a VR world that enhance presence, often requiring specialized hardware and software, and non-standardized knowledge, and so should be regarded as a high-level learning goal. The manipulation of visible hands or an avatar (self-realisation) is a high-level learning goal that strongly relates to the issue of improving a sense of presence. The process involves a number of complex hardware and software elements and is a key area of scholarly and industry-level research. Hands in VR and the use of an avatar for self-realization are features developers can introduce to a VR experience, however, students with limited hardware access will experience too many barriers. Ambisonic audio (full-sphere surround sound) allows the user to hear what they see as their gaze wanders about. It is a specialized area in VR360 video or VR content development and production that should be regarded as a high-level learning goal that demands knowledge of a rapidly shifting area of most software environments. The newer version of Unity (2018 onwards), for instance, supports an ambisonic audio decoder, which only functions effectively once a range of specialized settings is applied. Finally, authoring hyper-realistic VR scenes is a high-level, key area of VR, and involves importing almost any real-world element, and attempting to implement it as part of the virtual environment (see Figure 8). This may include such complex development tasks as managing lighting, shadow, plants, terrain, water, wind, texture, dynamics, and physics, and will not form part of the skills acquisition in introductory-level VR.

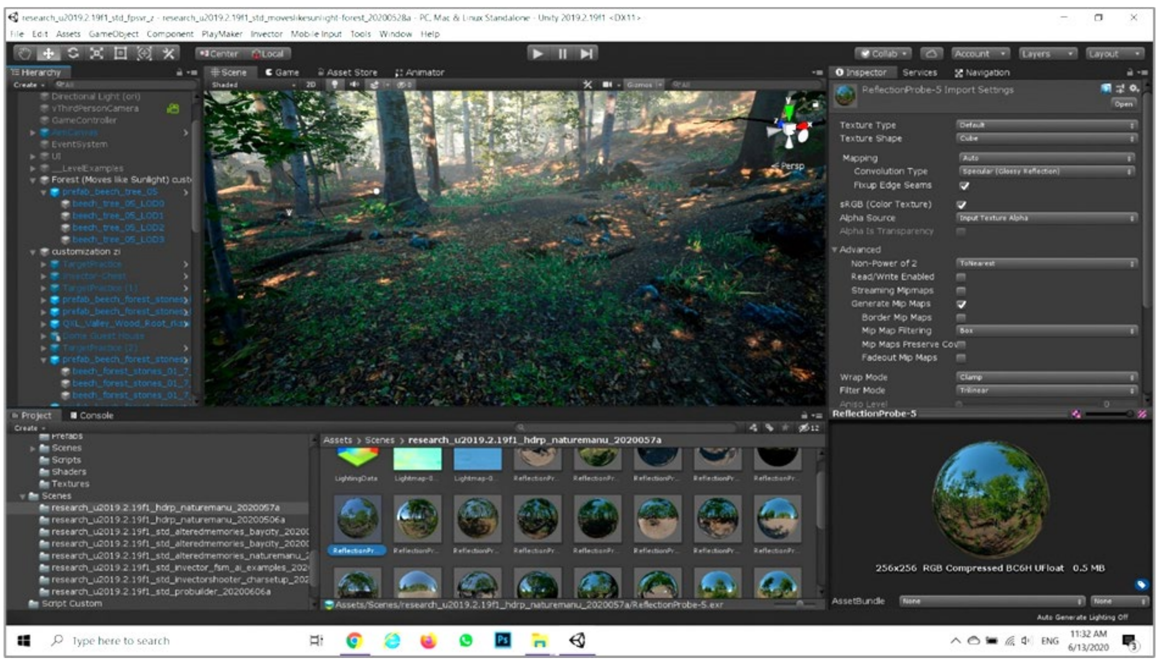

**Figure 8. Customising hyper-realistic VR content**

## *Essentials of Introductory Dome-based Digital Content and Experiences*

Dome-based digital content and experiences transform an existing physical space into an immersive environment, usually institution-owned due to its size, cost, and large-scale configuration. An industry-recognised solution is the Igloo system (Figure 9), which is a user-friendly solution for realistic, intuitive, interactive, and immersive experiences. Creating and managing content that can be operable using a dome may include:

- Both standard and VR360 (Spherical Panorama) videos and static photographs.
- 3D software integrations.
- Web and applications.
- External feeds, creative tools, and digital technologies.

The nature of the curve screen projection system in a dome configuration allows 360-content to be projected and played intuitively by the users - in this context, it is essential for students to be able to identify suitable 360-capturing solutions for generating high-resolution operable content. This workflow can be used for capturing community stories, citizen journalism, creating virtual tourism activities, and digital health activities. For example, patients with limited physical mobility can now enjoy VR360 and various virtual reality experiences as a mode of 'virtual travel' - providing a new level of inclusive experience, enhanced in terms of presence, active engagement, and immersion. As described in the previous sections, the dome platform will allow the integration of 3D software and digital content (e.g., level design of a virtual environment) to be visualised with intuitive interactions. For example, architectural building information modelling (BIM) and engineering simulation content and materials can be visualised and interacted with using the dome intuitively. The dome platform will also support online web-based content, which allows different content in various forms to be displayed simultaneously with few limitations. One of the most powerful aspects of the dome-based configuration is that it permits users (including instructors, students, and external collaborators) to communicate and collaborate remotely, requiring students to be familiar with various industry-standard tools and digital technologies. The dome provides the opportunity for a shared immersive experience with students, facilitating real-time discussion, reflection, and questioning. Moreover, if joined with a commonly available teleconference interface (e.g., Zoom), real-time connections with experts or context-specific personnel beyond the immersive space can occur. For example, a day in the life of a teacher in a remote indigenous school, or a day in the life of a teacher working with children with severe disabilities opens up insight and experiences that most mainstream higher education students may typically not be exposed to. Figure 9 shows digital health Simulation Learning content projected on an Igloo dome, which allows spontaneous interactions and conversation to take place in this collaborative and hybrid learning space.

**Figure 9. Example of digital health Simulation Learning content projected on an Igloo dome platform**

## DISCUSSION

The model of conventional Universal Design wherein a 'universal solution' is proposed to be possible and maximally efficient by design is problematic. Rather, we insist on what Treviranus (2018) frames as a '1 size fits 1' model of Inclusive Design, precisely because 'One size does not fit all', either in terms of students/teachers/users of systems or in terms of systems themselves, since it is difficult to migrate content created in an enterprise authoring system (e.g. Unity, Unreal, Zappar) and adapt it for use in other environments.

On successful completion of a course/unit/program based on the inclusions outlined above, students will be able to demonstrate some of the following attributes (without being limited to them):

- Apply digital solutions and investigate approaches of Technologies as an enabler across disciplines and implement inquiry-based pedagogy demonstrating a focus on a growth mindset and cross-curriculum integration.
- Critically reflect on teaching and learning in your own specialism through digital technologies (which may inform and evaluate the implementation of the Australian Curriculum Technologies using an integrated approach at schools, if applicable).
- Research and identify emerging digital tools and advanced features to create and communicate interactive content for a diverse audience.
- Develop, design, and prototype the user experience of a digital system, which reflects how innovative digital solutions can be introduced.

The challenges learning designers might face during the creation, coordination, and delivery of such an XR course in local conditions would include:

- Lack of costly specialised equipment and software (e.g., VR-enabled workstation);
- The time-consuming process required for students to produce adequate and usable XR content; and
- A lack of opportunity to distribute and share the student-created content on platforms with cross-compatibility, meaning student-created XR content is difficult to test in "real-life" scenarios for authentic learning.

In terms of the impact of technology on learning, and the impact of technologies on social well-being, here are some of the challenges and new questions raised:

- What are the learning benefits but also distractions from a learning perspective of technology and at what age? For example, we won't put comics or chocolates on a desk and tell children to avoid them, but we do this with tech all the time.
- With AR VR and Simulation Learning, what are the positive consequences but also the unintended negative ones? For example, cyber and virtual bullying, dissociation from the real world, inappropriate behaviour, and more - so how do teachers and others moderate this in an appropriate way? We need to ensure that learning is at the right type and level, and we increase social cohesion, ways of connecting and negotiating differences, and solving conflict in the real world.

Despite these challenges, Simulation Learning and XR technologies can be useful in aiding knowledge-based demonstrations and educational experiences (Dey et al., 2018; Domingo & Bradley, 2018; Horst & Dörner, 2018; Marsh & Costello, 2012), which can be applicable to a wide range of non-gaming scenarios and settings. XR applications have also been explored in terms of how they can be used in a variety of therapeutic, well-being, and social good contexts (Blum et al., 2019; Guillén et al., 2018; Roche et al., 2019; Rose et al., 2018; Valtchanov et al., 2010).

"Creating solutions for preferred futures" is the overarching core concept described in the Australian Curriculum, Assessment and Reporting Authority (2022), and besides exploring the innovative use of XR, educators, and students can also work with other digital tools and emerging technology projects to this goal. These include but are not limited to working with digital application prototyping (Ferreira et al., 2019), 3D Printing (Makerbot, n.d.; Nemorin & Selwyn, 2017), and computer programming (Digital Technologies Hub, 2022; Micro:bit Education Foundation, n.d.; Raspberry Pi Foundation, 2022; Tseng & Chu, 2017). So, what does this mean for education? In sum, the strong relevance of Simulation Learning and XR technologies to the goal of 'social good' allows students opportunities to consider how a range of user communities can be assisted through such approaches as serious games and knowledge demonstration applications. Here, a particular emphasis on the principles of Inclusive Design is clear and distinct from the previous model of Universal Design. The latter assumes a 'norm' from which some learners might 'deviate', rather than envisioning each and every learner as a unique individual capable of co-designing their best learning content and methods of learning. This approach permits a strong ethical dimension to be introduced during course delivery and offers open doors and flexibility in approach to the learner as an individual. This can be achieved by exploring a number of approaches, and we encourage our students to adopt a practice-based approach to their learning (Technologies processes and production skills in the context of the Australian Curriculum), experimenting with the strength of XR in its versatile applicability as a transformative technology. These may include but are not limited to projects in STEM and HASS education.

To further this research, we aim to explore the potential of XR and Simulation Learning in accelerating student learning in STEM and HASS disciplines, facilitating greater knowledge retention, and promoting enhanced engagement with technology-enabled learning. We are interested in exploring ways to enhance educators' awareness and understanding of current and emerging digital technologies, as well as their ability to effectively use these technologies in their teaching practice.

## SIMULATION LEARNING AND XR WORK SAMPLES AND ONGOING INITIATIVES

With XR and Simulation Learning technologies, educators and students are finding new ways to explore, experience, and visualise data, particularly in the areas of STEM and HASS. Learning activities and storytelling ideas can be communicated and visualised using immersive experiences in various forms. This paper provides opportunities and insights to run Technologies related subjects in a higher education context or facilitate conversations to link it to other subjects that can be informed by technologies-based curriculum through innovative use of EdTech and emerging digital resources. The study by Bower et al. (2020) suggested that the use of immersive virtual reality in education has the potential to enhance immersion, improve spatial capabilities, promote empathy, increase motivation, and possibly improve learning outcomes. Figure 10 shows classroom sessions of teaching programs focused on Simulation Learning and XR. In this section, we demonstrate the researcher's existing multidisciplinary research-creation collaborative projects and ongoing initiatives focused on Simulation Learning and XR to ground the discussion in examples - as we stress the importance of looking at inclusive design as one of the key aspects of a sustainable human-centred thinking process, and some of these initiatives investigate early exploration of the use of AR VR for simulation in facilitating inclusive practice while research and industry have started to explore the conversation based around inclusion and accessibility which is often missing in digital projects.

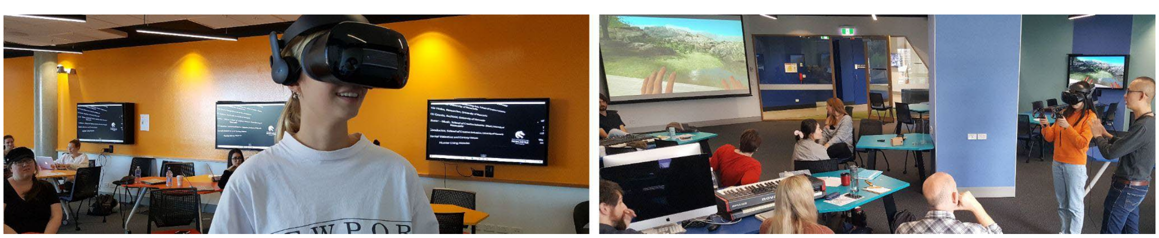

**Figure 10. Classroom sessions teaching the programs focused on Simulation Learning and XR**

In relation to research initiatives focused on using VR and immersive technologies for education, Figure 11 shows the work on 'The Development of the Compromised Neonate' (Jones et al., 2022). This project demonstrates an enhanced learning environment that makes use of technology and innovation. This XR simulation has two experiential learning options - "Guided" and "Unguided" modes - through which students work on preparations, checking equipment, clinical assessment, temperature control, neonatal stimulation, airway and breathing controls, target oxygen saturations, medications, and communicating with medical professionals and family. Figure 12, the 'Road to Birth' (Jones et al., 2021), presents the development of a collaborative, multi-modal, digital anatomy program, aimed to provide undergraduate midwifery students with a novel, visual, interactive, and accessible, pregnancy education tool. Users (undergraduate health students) of the program have the opportunity to observe, interact and manipulate detailed three-dimensional models and visualise the growth of a foetus and maternal anatomical changes simultaneously. With birth consideration provided as part of the visualisation process, the XR Simulation Learning program includes detailed foetal and placental three-dimensional models that display both normal and pathological birth positions. For reproductive anatomy being introduced in the teaching and learning scenarios that relied on the protected cadaveric materials and the conventional scientific illustrations, such an approach is not afforded to visualise the effect caused to the structure of the human body and morphological changes (Jones et al., 2021; Pottle, 2019; Visser et al., 2011). Therefore, the innovative use of VR (Fealy et al., 2019) will then provide accessible learning experiences to medical and health science students, operatable in an immersive, guided, and safe environment. Such advancements will also make learning simulation content customisable and accessible, which would be ideal for rural and remote health education. Clearly, the teaching and learning of clinical procedures such as neonatal resuscitation and reproductive anatomy in medical education, nursing, and midwifery present a context where the adoption of digital technologies can facilitate learning beyond what is currently possible.


**Figure 11. The development of the compromised neonate (Jones et al., 2022)**

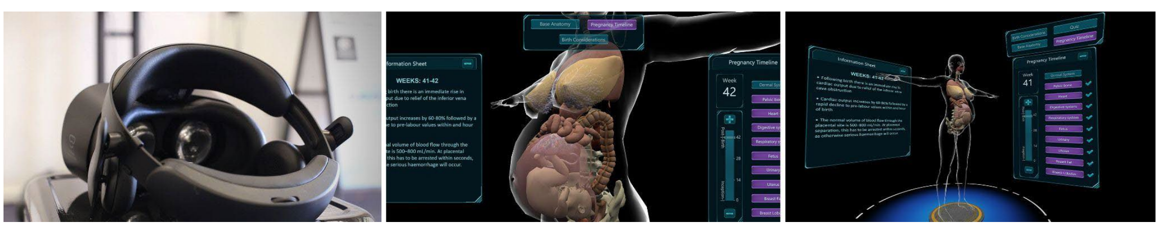

**Figure 12. Roads to birth (Jones et al., 2021)**

In collaboration with the Centre for Inclusive Design, Figure 13 shows an XR user experience research project focused on inclusive augmented reality and virtual reality (See et al., 2020), one of the original projects developed by some of the authors. An early design of the 'Extended Reality Interactive Wall' was tested several times in a university setting during academic events designed to demonstrate STEM-based learning content. The prototype was fully interactable and playable as part of the user experience design development of the project, which has considered various factors in terms of accessibility for users which different physical requirements. To facilitate a culturally respectful place-making initiative, Figure 14 demonstrates a research project collaboration with Akur Meta Torres Strait Islander Corporation (Australia) and Newcastle Art Gallery (New South Wales, Australia), through which was developed the 'This Land Augmented Reality' installation. Guided by people from the community, the project embraces cultural and social perspectives and related contemporary discourses within the Australian context. Another practice-based Simulation Learning research project with significant educational relevance to the context of HASS is the 'The Sultan Hussin Shah

Tomb VR Museum Experience' - This was demonstrated at the Digital Heritage 2018 3rd International Congress & Expo IEEE in San Francisco, USA, October 2018 (See, Santano, et al., 2018) (Figure 15).

**Figure 13. Extended reality interactive wall: User experience design research-creation (See et al., 2020)**

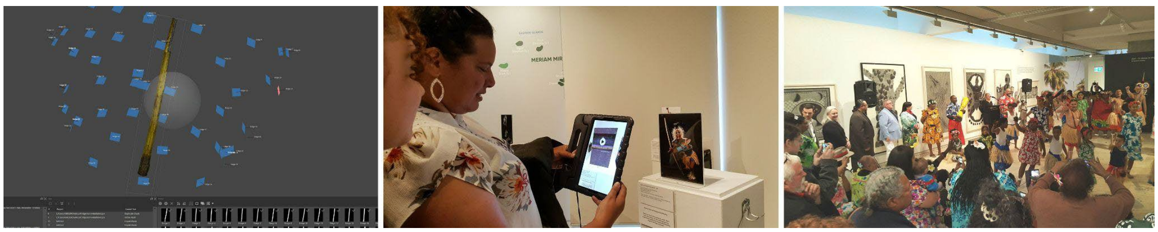

**Figure 14. This Land AR: An Australian music and sound XR installation (Matthias et al., 2019)**

**Figure 15. Tomb of a Sultan: A VR digital heritage approach (See, Santano, et al., 2018)**

## CONCLUSION AND IMPLICATIONS

In this paper, we provide a flexible Technologies teaching and learning model for determining content for inclusion in a course designed to provide introductory Simulation Learning and XR solution creation skills and knowledge. Playable experiences through Technologies, the model is designed for students at the tertiary education level, which is also applicable to student-teachers who are studying and will be teaching Technologies, though with a wider aim of achieving the goals of inclusive design in education (with regard to gender, ability, geographic location, nationality, age, and other diversity factors). To promote the development of digital literacy and the preparedness of a future-ready workforce, all students become consumers and creators of content within this FTL model.

The goal was to provide key criteria and an outline that can be adapted by learning designers to various higher education-based contexts of teaching and inclusive learning design focused on XR. The next step for this research will be to provide responses to the challenges raised in the discussion section and outline a fully realized learning design model that does so, whilst being capable of being delivered as a transdisciplinary unit of study for students from the first year through to the post-graduate level. This fully-fledged academic unit of study should be able to respond to extra-institutional demand and be available for adaptation for non-enrolled learners as part of community-based education and certified-professional development (CPD) where micro-credentialing provides accessible learning opportunities.

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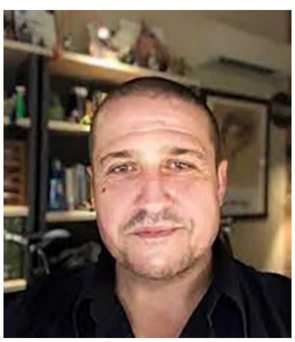
## AUTHORS

**Dr Zi Siang See** has specialised over the past 10 years in the design, use and integration of interactive media, including but not limited to augmented reality (AR) and virtual reality (VR) research-creation. Zi has over 15 years' experience of working within the field of interaction design and digital media in both industry and within university institutions, nationally and internationally. These include collaborations with multinational corporations such as McDonald's, Lafarge Cement, Servier, Leo Burnett, DDB and Saatchi & Saatchi Arachnid. As an early career researcher, he has been part of various MOOC projects and been actively involved in scholarly research and international collaborations. His work has contributed to new systems, theory and studies in human-computer-interaction, education technologies and inclusive design. Some of these technical research papers were published at specialised venues such as SIGGRAPH, IEEE Virtual Systems and Multimedia (VSMM), and Springer's Virtual Reality.

**Professor Susan Ledger** is Head of School - Dean of Education at University of Newcastle. Susan is an advocate for the teaching profession and committed to exploring education policies and practices relating to teaching and preparing to teach diverse students and diverse contexts. Susan has a broad experiential base in rural, remote, and international school settings and university contexts. Her recent endeavours focus on the affordances of emerging technologies to prepare graduate teachers for successful practicums and the development of teacher professionalism. Her recent publications explore how rural and international fields of study complement and compete with each other. In 2017, she introduced SimLab@Murdoch (Mursion), an immersive platform that simulates classrooms into the preparation of initial teacher educators. Newcastle has introduced three technology platforms to support ITE students: Sim School; SimTeach (Mursion) and SimCAVE. These platforms are used as diagnostic tools to target different areas of development for our future teachers. Susan provides a global to local perspective on the teaching profession, leading reform by implementing simulation into the initial teacher education program at University of Newcastle.

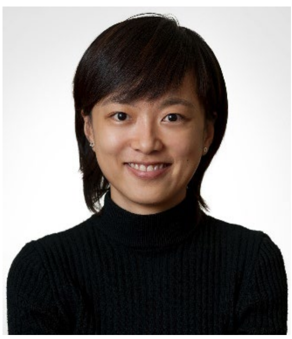
**Dr Benjamin Matthews** is a Lecturer in the School of Humanities, Creative Industries and Social Sciences at the University of Newcastle, with an interest in design, spatial media, the post-industrial circumstances of media work, emergent network cultures and media art. His scholarly approach is transdisciplinary, and includes collaboration with STEMM based researchers with the goal of addressing problems with tangible end users and translational outcomes. His interests include organised networks, media work, communication design, celebrity, collaborative cultures, urban/street cultures, visual culture, emergence and synthetic biology.

**Professor Lizbeth Goodman** is Chair of Creative Technology Innovation and Full Professor of Inclusive Design for Education at University College Dublin (Ireland), where she directs the Inclusive Design Research Centre of Ireland at UCD (IDRC) within the College of Engineering and Architecture, in collaboration with SMARTlab. She is Programme Director for the Thematic PhD in the College of E&A. She has held a Personal Chair in Creative Technology Innovation, with a focus on practice-based research into the future of Inclusive Interdisciplinary Research and Education, since 2005. She is also Director of Equality, Diversity and Inclusion for MME at UCD. She currently Chairs the Women in Science, Technology and Innovation taskforce for the AERAP programme of the European commission and parliament. She recently served as Academic Chair of the Marie Curie ASSISTID Programme for the DOCTRID Research Institute: the first top tier research institute bridging the Republic and Northern Ireland. Also, on behalf of UCD and the national universities network, she was elected to Chair the Social Sciences Panel of the Royal Irish Academy in 2012.



**Dr Donovan** started his nursing career as a theatre nurse before moving into midwifery, becoming interested in teaching and research. Donovan has been involved with the Bachelor of Midwifery program at University of Newcastle as a lecturer since 2010. Having held the position of deputy program convenor Donovan was actively involved in the development of new midwifery curriculum starting in 2016 for the bachelor of midwifery at the University of Newcastle. Additionally, Donovan was the program convenor for nursing and midwifery honours at the University of Newcastle, before joining Charles Sturt University in 2019 as a senior lecturer in the School of Nursing, Midwifery and Indigenous Health. As an early career researcher Donovan's PhD "mindfulness for men with pregnant partners" has attracted international recognition receiving international publications and has gained him a position as a board advisor on the international forum for wellbeing in pregnancy ww.ifwip.org. In Addition, Donovan's PhD is being run in the UK in 2019 through the University of Leeds.

**Dr Shanna Fealy** has over 15 years' experience as a Registered Nurse and Midwife. Completing a Bachelor of Nursing Degree at the University of Western Sydney in 2001, Shanna gained extensive experience working in various health facilities in Australia and the United Kingdom. Shanna began a career in midwifery in 2005 completing a Graduate Diploma in Midwifery at Charles Sturt University. Shanna then progressed into nursing and midwifery education upon completion of her Master of Midwifery studies in 2008 at the University of Newcastle. Shanna is current PhD candidate at the University of Newcastle, investigating the influence of psychosocial factors on gestational weight gain. Shanna is an early career researcher, member of the Hunter Medical Research Institute (HMRI) and maintains research and teaching collaborations across the Mid North Coast Local Health District. Shanna has experience in both honours and PhD supervision and is member of the CSU XRC.



**Wooi Har Ooi** (Haireena) has technical interest in emerging technologies and user experience design for Augmented Reality (AR) and Virtual Reality (VR). Haireena is currently with the Queen Victoria Museum and Art Gallery (QVMAG), Tasmania, Australia. She has nearly 20 years of contribution and experience in SAP and IT-based implementation projects, roll out projects and operational support environment in various SAP modules (HR, FI, CO, SD, MM, WM, GTM, Warranty, PS). She previously worked in international consulting firms, including Deloitte Consulting (SEA) and ABeam. She also worked in a number of multi-national corporations - SGL Carbon and Averis. She specialized in system development and database management. In terms of professional contribution and involvement in SAP and enterprise project management, she is certified Lean Six Sigma Green Belt, and familiar with Lean Six-Sigma (LSS) methodology for improving performance of a subject matter by systematically removing waste and reducing variation.

As CEO, **Dr Manisha Amin** is the chief strategist and visionary at Centre for Inclusive Design. With a background in strategic marketing, communication, transforming cultures and creativity she is a thought leader in the power of thinking from the edge. Manisha has a unique talent for seeing beyond the horizon to emerging trends, defining them and building powerful communities to bring them in to being. Manisha previously worked in the technology sector and with various government departments in environmental advocacy. With over 20 years' experience in strategic marketing, communication, transforming cultures and creativity, she brings together an impressive team of industry experts and global partners to focus on the areas ripe for disruption where we can make the greatest impact. She is passionate about social justice and business growth, and believes that when we combine the two, we get gold. She has a PhD in Arts and Social Science, a Masters in Professional Writing, and a Bachelor of Business (Marketing), from the University of Technology, Sydney. Manisha is also on the Board of ADHD Australia and is a published novelist.