Students as designers with Virtual Reality

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8 Students as designers with Virtual Reality

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Abstract

This chapter delves into the role of Virtual Reality (VR) in Technologies education, emphasising its potential to engage students as proactive designers of their educational experiences. The narrative traces the evolution of VR inventions to their contemporary, more accessible forms and, through this historical context, sets the stage for understanding the challenges and growth of VR in educational settings. Aligning VR's capabilities with Constructivist and situated learning theories, the chapter illustrates how VR's interactive environments foster a deeper, hands-on comprehension of complex subjects, where VR enhances learning by enabling students to construct and navigate through historically or scientifically accurate simulations and models. The chapter critically evaluates various VR content creation tools, from simple 360° video platforms to sophisticated game engines such as Unity, focusing on the pedagogical integration of these tools in educational curricula, emphasising the necessity for VR environments to correspond with educational objectives and the need for sustained educator support to leverage these technologies effectively. Lastly, the chapter advocates for the future integration of VR with Artificial Intelligence (AI) to craft more adaptive, personalised learning experiences. This synthesis aims to improve educational methods and practices, transforming students from passive recipients of information to active, engaged participants in their learning journeys.

8.1 Introduction to students designing Virtual Reality

What Virtual Reality (VR) comprises is complex and contested (Kardong-Edgren et al., 2019), but in general terms, it is a technology that creates an immersive, simulated environment that often involves the use of specialised hardware such as VR headsets, which displays 3D

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visuals and track head movements, and devices such as controllers, gloves, or treadmills to interact with a computer generated virtual space – a virtual world. In VR, users can explore and interact with this simulated environment as if physically present within it. This immersive experience is achieved by rendering dynamic, 360° visuals and often incorporating spatial audio, haptic feedback, and other sensory stimuli. VR is commonly used in gaming, education, simulations, training, and various fields such as healthcare and architecture to create experiences that would be difficult or impossible in the real world. This chapter delves into the transformative realm of VR as a technology that not only simulates three-dimensional environments but also empowers students to become creators within these digitally constructed spaces, designing and building VR content. It explores various approaches within technology education, we emphasise VR's profound impact on enhancing educational outcomes and deepening students' engagement with technology.

The evolution of VR development began with Morton Heilig's groundbreaking inventions – the Sensorama (1960) and the Telesphere Mask (1962) – and Ivan Sutherland's visionary 1965 (Sutherland, 1965) concept of digitally crafted virtual environments. Over time, it has advanced to encompass modern headsets, feedback mechanisms, controllers, and movement systems, marking a steady progression from theoretical research to practical applications. Initial exploration of VR's educational potential was hampered by limited accessibility, with experiences confined primarily to game arcades and a few commercially unsuccessful personal VR systems until the transformative launch of the *Oculus Rift* in 2012. Facebook's acquisition of Oculus signified a pivotal moment, heralding a new era of substantial investment in VR technology by leading corporations (Black, 2017).

Many schools are exploring the uses of VR and acquiring devices, but scaling implementation poses challenges, notably high initial costs, recurring hardware upgrades, and difficulties in acquiring or developing suitable virtual applications and environments. While projection caves and economical VR solutions leveraging smartphones can broaden access, deploying fully immersive VR systems in educational contexts remains prohibitively costly for many institutions.

The limited range and open availability of VR environments and content that align with curricular objectives and support varied pedagogical strategies are also challenges. While VR content creation tools have become more user-friendly, their application is frequently limited to producing 360° videos and virtual tours due to ease of creation. Platforms such as *Minecraft* offer interactive building experiences within VR, and tools such as *CoSpaces* and *aframe.io* provide introductory means for employing graphics software to fabricate three-dimensional objects within virtual settings. Although less prevalent in school contexts, online worlds such as *Second Life* and the burgeoning Metaverse afford constructive possibilities, with *Unity* and *Unreal* game engines facilitating more sophisticated development efforts.

Yet, the integration of VR in educational spheres continues to progress, offering diverse approaches and considerations for technology education, including cultivating students' abilities as designers. VR technology, encompassing computing hardware, software, operating systems, user interfaces, and networked environments, presents a comprehensive digital ecosystem for exploration. The array of peripherals – headsets, gloves, wands, pucks, shoes, treadmills, and motion simulators – enriches the potential for technological innovation within both tangible and virtual realms (Merchant et al., 2014).

VR offers unique advantages in education (Makransky et al., 2019) by making learning more engaging and effective. It can enhance spatial reasoning skills as students navigate and interact with three-dimensional environments, which is crucial for subjects such as geometry and science. VR also promotes empathy by enabling students to experience diverse cultural and personal perspectives, enriching social studies and literature lessons. Through realistic simulations, VR facilitates situated learning, enabling students to apply concepts in virtual settings that mimic real-world scenarios, which is especially beneficial in teaching complex scientific principles or historical events. Additionally, VR provides a safe space for students to experiment and learn from their mistakes, fostering critical thinking and problem-solving skills. By integrating these elements, VR can transform traditional educational methods.

Through detailed analysis and examples, this chapter illuminates how VR serves as a cutting-edge educational tool and fosters a new generation of students who are not just consumers of content but designers of their own immersive learning experiences. We explore how these technologies shape students' abilities to innovate and solve problems creatively, preparing them for future challenges in a rapidly evolving digital world.

8.2 Education and the VR content creation process

A multitude of research (Horst & Dorner, 2019; MacDowell & Lock, 2022; Stechert & Vukovic, 2023) have collectively underscored and acknowledged the significance of VR applications in demonstrating knowledge and facilitating learning across diverse educational contexts, ranging from narrative-driven educational storytelling to immersive simulations. However, integrating VR design into classroom instruction presents multifaceted challenges, contingent upon educators' expertise and the accessibility of VR hardware and software infrastructure. Matthews et al. (2020) suggest a growing interest in using extended reality to enhance education, especially by integrating VR and other emerging technologies into educational contexts. Lege and Bonner's (2020) study stressed the growing prevalence of VR applications and the evolving pedagogical approaches associated with them, yet there remain important considerations and challenges unique to the technology. These may include, but are not limited to, the affordances of learning and accessing VR technologies, the difficulty in managing the complexity and process of VR creation, and the rapidly changing development and design process of VR content. There are additional obstacles and challenges for educators and students working with VR and content creation, such as the costs associated with VR and computing equipment/tools, the technical skills and knowledge required to facilitate VR development activities, health-related concerns such as prolonged exposure and misuse of VR devices, and any potential cybersecurity issues related to these emerging technologies, which educational users are less familiar with.

To facilitate educators and students in navigating this complex landscape, a comprehensive understanding of VR formats and the intricacies of content production processes is imperative. As shown in Figure 8.1, educators and students are presented with a spectrum of VR head-mounted devices, ranging from cost-effective options such as mobile device-enabled *Google Cardboard* (left) and high-fidelity setups (right) typically tethered to VR-enabled computer workstations and equipped with specialised Software Developer Kits such as *SteamVR*, *Oculus*, or *OpenXR*, offering creators a diverse array of interactive experiences and content-creation options.

Panoramic virtual 360° still or video content provides an accessible and relatively achievable method for producing photographic-based virtual 360° content that is compatible with

Figure 8.1 Low-cost VR Google Cardboard option (left) and high-fidelity VR Head Mounted Display (HMD) setup (right)

various platforms (Chien et al., 2020; Kuna et al., 2023; Pirker & Dengel, 2021). Such 360° content and materials being used in education can potentially be created using low-cost omnidirectional cameras, with static or video-based 360° content being viewable on a range of personal devices and displays, including tablets and computer screens using widely available web browsers. Figure 8.2 demonstrates a sample virtual 360° work (spherical panorama) that educators and students can produce using off-the-shelf 360° cameras such as the *Ricoh Theta* series or *Insta360* series, showcasing a community forest (the Arcadia Park in Newcastle, NSW, Australia). Such virtual 360° content designed for learning purposes can be uploaded and published online, enabling classroom activities to capture and visualise locations of interest for creating content and learning about topics in Humanities and Social Sciences (HASS) or Science Technology Engineering and Mathematics (STEM) related simulations.

Designing and creating 3D-based VR content and applications using game engines entails a higher level of complexity in terms of software/hardware and knowledge-based requirements (Domingo & Bradley, 2018; Kavanagh et al., 2017; Kuna et al., 2023; MacDowell & Lock, 2022; Stechert & Vukovic, 2023). Currently, commonly accessible industry-recognised digital tools include, but are not limited to, *Unity* and *Unreal Engine*, which are generally available to educators and students as creative and design tools. One of the key prerequisites for getting started is becoming familiar with the process of level design, which involves creating and managing a virtual world, such as a game level or simulated immersive environment. Educators and students can design immersive content and utilise VR for visualising educational materials and content across various subjects, including, but not limited to, STEM and HASS areas. For example, science educators and students can visualise digital anatomy simulations of biological science artefacts; technology students can visualise simulated

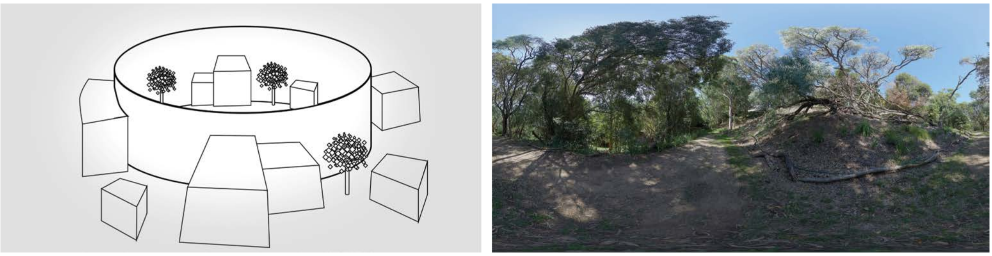

Figure 8.2 An example of virtual 360° content for learning about local places

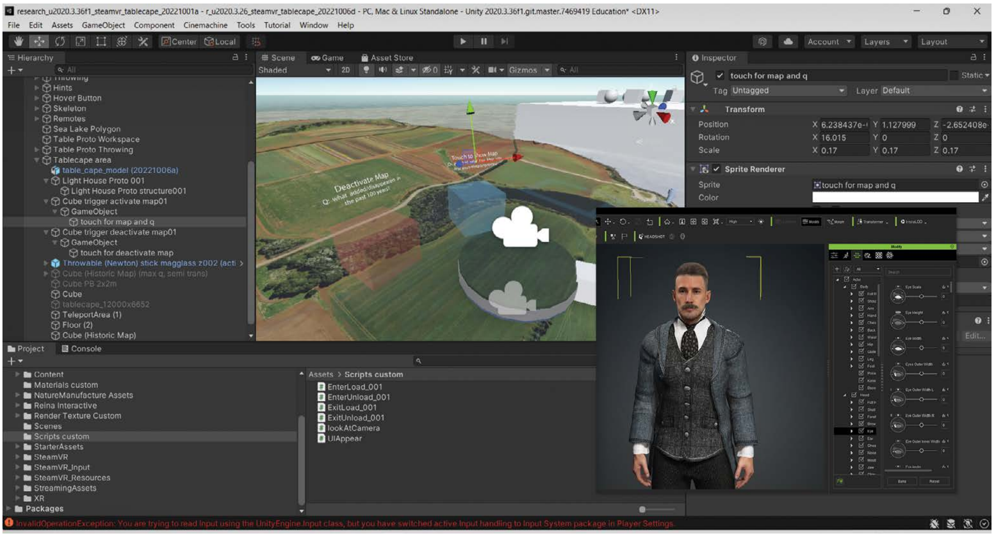

Figure 8.3 Immersive 3D virtual environments created and managed in the Unity platform

computer-aided-design 3D environments; HASS students can digitise and learn about historical artefacts and events as part of a storytelling virtual experience; and arts students can digitise, archive, and showcase their creative works in a virtual gallery space.

In addition to level design and visual programming (graphic user interface assisted programming or drag-and-drop programming), possessing the skill set of 3D modelling and 3D scanning proves highly useful in the creation of VR learning content. For instance, utilising photogrammetry tools such as *Polycam* or *Agisoft* enables the reproduction and preservation of objects from the real world, while applications such as *Blender* and *Autodesk 3Ds Max* facilitate the creation of fully three-dimensional virtual environments. Figure 8.3 showcases an example of 3D assets scanned, produced, and visualised in VR through *Unity* as a digital design tool. It features the photogrammetry 3D terrain reconstruction of Table Cape, part of an educational simulation project, depicting a 13-million-year-old extinct volcano known for its agricultural, cultural, and educational tourism aspects, situated in the northwest of Tasmania, Australia. As AI and other emerging technologies rapidly evolve, hybrid techniques can create AI-assisted content, such as digital characters. Figure 8.3 also illustrates an animated historical character being included in *Unity*, Robert Jackson, the first Superintendent Head Lightkeeper (1888) at Table Cape Lighthouse, recreated for educational storytelling purposes using *Reallusion Headshot AI*.

8.3 Students as designers of VR

The integration of VR offers an approach to learning where students are not just passive recipients of knowledge but active designers of their learning experiences. Given the nature of VR, it can be used in many subjects in both primary and secondary schools. Subjects such as Geography, History, and Science lend themselves to the use of VR as students can immerse themselves in experiences that they would otherwise not have the opportunity to engage in. One example is *Re-Live History*. This learning tool is "designed and developed together with heritage experts and history teachers that can be used in the classroom to help students achieve a number of learning outcomes related to prehistory" (Barbara, 2022, p. 16).

One of the significant principles that underpin the use of VR is the notion of authenticity. This can be considered from two different perspectives. The first perspective relates directly to the use of VR and includes three elements, which are "authenticity of narrative, authenticity of environment, and authenticity of action" (Wang, 2021, p. 2). The authenticity of narrative relates to the users' degree of buy-in for the virtual environment. Authenticity of environment helps students gain accurate mental models of critical topics and helps them to have a sense of presence in the virtual environment. Authenticity of action means that, as much as possible, "the actions available to the player within the game reflect actual techniques available to scientists, the player takes within the game that resemble actions that individuals can do in real life" (Wang, 2021, pp. 2–3).

The second aspect is the authenticity of learning, and this is particularly important when students are taking on the role of designers. Some of the important components of this aspect include authentic contexts, authentic activities (Herrington & Herrington, 2007), and authentic participants. In considering authentic contexts, as well as linking to real-world concepts, VR should encompass a physical environment that reflects the way knowledge will be used. In relation to authentic activities, there should be ill-defined activities that have real-world relevance with the design process sustained over time. An example is when students enter a VR environment where they are urban planners. Their task is to design a city that addresses challenges such as climate change, population growth, and resource management. The notion of authentic participants links partly to the authenticity of actions, where students engage with people involved in the design process as well as undertaking the actions embedded in the VR environment. This might include teachers, other students, teachers, and community members, such as parents, VR designers, and scientists.

A pedagogical approach linked to authentic learning is situated learning. This theory posits that knowledge is best acquired through authentic, real-world experiences (Lave & Wenger, 1991). VR environments provide an ideal platform for this approach, empowering students as designers within these immersive simulations. VR allows students to design environments in situated contexts. This might include environments where they are architects constructing buildings within VR cityscapes, or engineers testing prototypes in simulated factories. By engaging with design problems within these virtual scenarios, students develop a deeper understanding of the practical considerations involved.

Situated learning emphasises collaboration and social interaction (Lave & Wenger, 1991), which are important skills for learners in the twenty-first century (Fiore et al., 2017). VR can facilitate learning by enabling students to design collaboratively within the same virtual space. They can share ideas, test each other's designs, and learn from one another, fostering a sense of community and shared learning. VR design, combined with situated learning, can transform students from passive learners to active designers. By immersing students in realistic situations and encouraging collaboration, VR empowers students to apply design principles in a practical way, fostering both design skills and a deeper understanding of the design process.

Some of the skills that are developed through collaborative VR experiences include "interdependence, thoughtful group formation, individual accountability, and attention to social skill development" (Wang et al., 2021, p. 3). In an environment where students are designers working to design VR spaces, collaboration supports active and agentic learning where students monitor their learning to uncover gaps in their knowledge (Järvenoja et al., 2020). During this process, the teacher is an important resource.

One other important pedagogical approach is Constructivism, where students actively construct knowledge through experience as designers within VR environments, fostering deeper engagement and meaningful learning. Constructivism emphasises the learner's role in building knowledge by interacting with their environment (Jonassen, 1997). Students can manipulate virtual objects, conduct experiments, and explore complex systems in ways traditional learning environments cannot offer. This active engagement allows students to test their existing knowledge, identify gaps, and build new understanding through trial and error (Aiello et al., 2012). The possibilities of VR now provide students the ability to construct visual and manipulable objects to represent knowledge, which traditional learning methods sometimes lack.

8.4 Vignette 1: Culturally responsive learning design

The following vignette outlines case study research conducted in a remote Indigenous Australian schooling context in Central Australia. The case study explored how students and teaching staff experienced VR technologies in a learning design that aimed to generate culturally responsive stories of inquiry. In this case, the term learning design refers to an approach to teaching and learning that strategically positions VR technologies within a culturally responsive pedagogy – one that intentionally invites Indigenous Australians to use their cultural and linguistic assets in the formation of an immersive knowledge product – in this case, the design and creation of a VR story about their school on country. This research was granted full ethical consent by the University's Human Research Ethics Committee. Drawing from Indigenous scholars, we recognised that the research be instrumental in adding value to local knowledge, be preserving local cultural intellectual property, and have had brokered authentic consent from key Aboriginal stakeholders from within that community.

There were 11 Indigenous Australian students involved in this project. Teaching staff comprised one non-Indigenous Australian Teacher, one non-Indigenous Australian Education Support Worker and one Indigenous Australian Education Worker who is a long-term local community resident. Prior to our visit, it was ascertained that students and staff had very limited experience using VR either as a learning technology or as a recreational gaming technology. Consultations with the school community had been in play for 12 months prior to the progress of a mutually agreed understanding of the nature, purpose, and intended benefits of this research.

Whilst on site, *Fruit Ninja VR* – a body-based VR game – was initially used to enable participants to explore the functionality and features of the VR headset and hand controllers. Thereafter, participants progressed to creating a VR story of their school by using a VR authoring tool/editor. Previously, the class undertook a series of learning experiences to identify specific places of interest within the school to create a common storyboard – featured as a sequential mapping of scenes pinned to a large display board – which included – Scene 1: Welcome to our School (Front Office & Entry); Scene 2: The Canteen & Cafeteria; Scene 3: The Art Room; Scene 4: The Basketball Court; and Scene 5: Our Classroom. Whilst onsite, two groups each equipped with a 360° camera affixed to a tripod and synched to a smartphone captured 360° images of the places depicted in their storyboard.

Following 360° filming, a 'noticing' and 'practice' environment was set-up to sequentially onboard participant's mastery of the VR editor. Drawing from Vygotsky's (1986) idea of a more knowledgeable other, teaching staff were invited to take to the driving seat as a 'test pilots' to model how to import 360° images to create scenes – then insert multimedia content such as 2D pictures, text, and digital objects – into each scene. Through visual repetition, deep listening, and collaborative interaction, students and staff collectively developed the requisite skills and routine knowledge which progressed into mastery of the VR editor.

Participants' engagement with storyboarding, 360° filming, and VR authoring clearly highlighted collaborative processes and systems thinking practices at work. Processes of co-design, inquiry, and co-construction were especially apparent in and through aesthetic moments of 360° filming and through the juxtaposition of creative content so assembled when using the VR editor. In particular, the application of the storyboard as a scenographic tool (Hann, 2020) evoked the school's spatiality alongside students' lived experiences. Here, students and staff applied their cultural resources and local funds of knowledge to attach authentic meaning to their school story (Kraehe & Brown, 2011; Parchoma et al., 2020; Vallance, 1996). While the application of VR to storytelling may seem deceptively simplistic, this study provides important insights into how staff and students embraced VR technology in ways that demonstrated their abilities to live and thrive in worlds that are both culturally rich and digitally diverse (MacGill & Unsworth, 2023). Findings from this study confirmed that when VR is used within a learning design approach that values participants' cultural assets and interests, it enables them to engage enthusiastically, capably, and confidently in learning.

A large body of research confirms issues of equity and social justice in Indigenous Australian education in Australia. This study contributes to efforts that speak to advancing equity through the applied use of digital learning technology. As promoted within Red Dirt Education (Guenther & Osborne, 2018), commentators advocate for the implementation of disruptive pedagogies and innovative technologies to foster projects of collaboration, co-construction, and performance in ways that connect the life worlds of learners to learning (Guenther & Osborne, 2018). Research on the merits of VR in education (Gregory & Wood, 2017; Lee & Choi, 2017; Southgate et al., 2018) promotes and amplifies VR's use in projects grounded in digital authorship, confirming that applied use of VR in education can activate deeper engagement when positioned in a corresponding deep learning conceptual framework.

8.5 Vignette 2: Co-construction with supportive Artificial Intelligence

In this example, VR world creation and roleplay have been used to enable pre-service teachers to explore classroom design and teaching approaches. Combining VR and Artificial Intelligence (AI) technologies using *Oculus Quest* VR headsets to access the development spaces *CoSpaces* and *Minecraft*, and the AI tools *ChatGPT* and *Spline* for 3D object creation enabled pre-service teachers to focus less on the building process and more on pedagogy and classroom management roleplay activities in the VR space they were creating. The rapid design, construction, and use of VR spaces supported an improvement cycle as students optimised their virtual classroom spaces to support a range of teaching approaches.

VR use in primary and secondary teacher education has developed (Gregory et al., 2014) from focusing on virtual worlds in the early 2000s (Zagami, 2008) to using VR headsets in the 2010s and AI technologies in the early 2020s. Student teachers currently use a combination of VR and AI technologies to develop and practise constructivist and situated learning theories (Merchant et al., 2014):

- Constructivist Learning Theory (Jonassen & Rohrer-Murphy, 1999), emphasising hands-on, experiential learning, allowed Initial Teacher Education (ITE) students to engage actively with technology by building and manipulating virtual environments in *CoSpaces* and *Minecraft,* constructing knowledge through direct engagement with their learning environment.
- Situated Learning Theory (Lave & Wenger, 1991) focuses on mimicking real-world teaching environments to emphasise the practical application of theoretical knowledge, where students design a virtual classroom and experiment with classroom layouts, educational resources, and student engagement strategies.

The VR project-based design process (Pasfield-Neofitou et al., 2016) began with student teachers identifying the educational objectives of their VR projects. Exploring example projects in *CoSpaces* and *Minecraft* depicting virtual classroom spaces, they experimented with using AI to create virtual objects using *Spline* or *ChatGPT*. Then in groups, they used AI to assist in identifying the needs of technologies classrooms and the possibilities available in designing an optimal space for various pedagogies. Student teachers used AI to develop scenarios of various instructional technologies (including robots and drones), classrooms, lessons, and student projects, and, with the assistance of AI, explored the feasibility of different classroom spaces to accommodate these, deciding as a group which design to focus upon and the tool they would use for its development.

CoSpaces allowed student teachers to drag and drop objects, animate scenes, and script interactions using a block-based coding system akin to *Scratch*. This facilitated the rapid prototyping of VR content for students without extensive programming skills. Conversely, *Minecraft* enabled the building of more complex spaces and automation. Using *ChatGPT* and Spline, AI scripting and model importation supported object development in both spaces. This facilitated co-construction of objects. Roleplay (Figures 8.4 and 8.5) was the primary interactivity within the VR experiences, and students took turns teaching technology lessons to other students who provided feedback on the lesson's effectiveness and the VR classroom space.

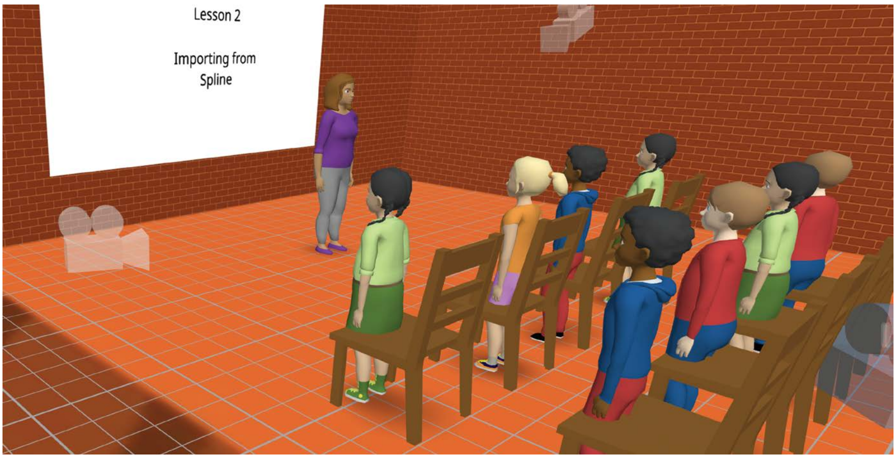

Figure 8.4 CoSpaces Roleplay Example A – a more traditional classroom design

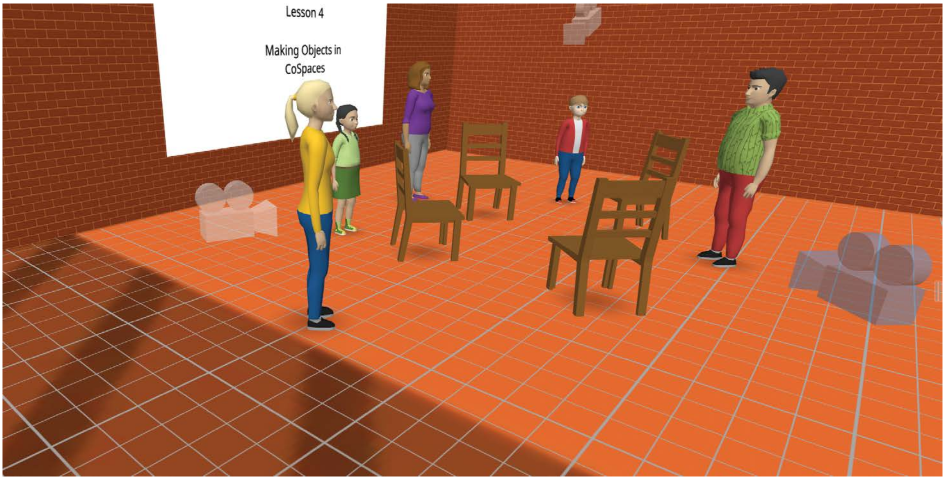

Figure 8.5 CoSpaces Roleplay Example B – a more collaborative classroom design

By incorporating design-based learning (DBL) and co-construction (Ververidis et al., 2022) with the strengths of AI and VR through the tools *CoSpaces* and *Minecraft*, students' learning experiences were enhanced through the construction and use of an immersive, interactive, and adaptive educational environment where they could develop and apply teaching skills collaboratively. This allowed ITE students to visualise and test classroom management strategies, workshop safety considerations, and teaching techniques.

Integrating AI and VR into initial teacher education technologies courses through the application of DBL not only assisted in preparing student teachers to become more proficient in technology education processes but also equipped them with experience in applying innovative teaching tools.

8.6 AI-supported creation

AI's capabilities have expanded to include easy access to creative domains such as VR worldbuilding, AI-enabled avatars, and AI music composition (Urban Davis et al., 2021). This trend significantly affects schools and teaching, including pedagogies and assessment practices (Hao & Yunyun, 2023). These advancements could lead to reimagining traditional teaching methods, where AI and VR are integrated to create more immersive, personalised learning experiences. However, they also raise concerns about equity in access to technology and the potential for over-reliance on AI, potentially diminishing the role of human teachers in critical aspects of education. Technologies, including in student assignments, have always played a crucial role in creative production (Blundell, 2021). However, generative AI within VR environments elevates this support, providing substantial opportunities to generate original content.

The rise of generative AI is changing how we think about creativity in virtual spaces and affecting what students and teachers produce (Mazzone & Elgammal, 2019). AI technologies such as can now create AI-enabled avatars, movies, images, stories, music, and art that seem almost human-like in their creativity. In schools, students can use AI to generate new characters and design worlds, perhaps making the creative process more widely accessible

(Lim et al., 2023). With generative AI, creative content brings opportunities and challenges to creative fields and education at all levels (Creely & Blannin, 2023).

Your AI-enabled virtual guide might lead you through a math problem at your own pace in a virtual classroom, support you in revisiting a complex concept in science, or guide you to a more advanced concept in English class. This personalised approach helps identify areas where students struggle, provide targeted support, or identify strengths and move ahead, optimising learning pathways and outcomes (Bailenson, 2018). In art education, VR can transport students to virtual galleries, where AI-enabled avatars lead them through three-dimensional representations of historical artefacts in situ. Students can also visit the worlds of famous paintings and answer questions. In history lessons, students can virtually experience historical events. AI guides the narrative based on students' responses and questions, perhaps following along with a family of First Nations people as they spend their day, asking questions and gaining insights. Overall, the synergy of AI and VR has the potential to revolutionise educational methodologies by making learning more interactive, adaptive, and enjoyable.

The educational landscape is continually evolving, with significant potential for growth through the integration of AI and VR technologies. AI can enhance VR environments by generating dynamic, interactive scenarios that engage students more deeply and personally than traditional learning methods (Divekar et al., 2022; Qian, 2022). However, it is crucial to view this as a supplement to traditional learning, where teachers guide the technology to support learners rather than delegating their pedagogical expertise to the computer (Selwyn, 2019). This approach ensures that the human element of teaching remains central, with technology enhancing and enriching the learning experience.

The introduction of generative AI is changing how we view creativity and virtual spaces in education and teaching. There is a growing need for thoughtful discussions and research into how human and machine creativity can work together and what it means to 'create' and interact in virtual spaces. This includes rethinking how we assess students when AI is involved and what skills and concepts we seek to evaluate in VR spaces. AI may help make grading quicker and save teachers time (Chhatwal et al., 2023), but we need to ensure these new methods are focused on the learning that is taking place rather than historical notions of ticking boxes of skills achieved.

8.7 Principles for enabling students to design with VR

This chapter has highlighted the capability of VR in educational contexts to foster deep, meaningful learning and develop critical twenty-first century skills (MacDowell & Lock, 2022; Stechert & Vukovic, 2023). To guide educators in effectively using VR in the classroom, the following principles emerge:

Align VR with Pedagogical Objectives: VR activities should go beyond novelty to deeply connect to educational outcomes. VR's ability to enhance spatial reasoning, problem-solving, and computational thinking makes it particularly valuable for STEM subjects, history, and the arts, enabling students to interact with concepts that would otherwise be difficult to grasp in traditional learning environments.

Foster Authentic Learning Experiences: Authenticity is central to the effective use of VR in education and encompasses the realism of the virtual environment and the alignment of learning activities with real-world tasks. Students can perform actions that simulate real-life applications, such as designing architectural models, conducting virtual experiments, or reenacting historical events. This authentic engagement fosters deeper learning by allowing students to apply theoretical knowledge in practical, immersive contexts. For example, learners can be encouraged to think 'historically' by critiquing sources and recreating new knowledge or presenting new arguments (Carretero & Lee, 2014). Authentic learning also involves students owning their educational journey, moving from passive knowledge consumers to active creators. This transition is particularly powerful when students use VR to create their environments and content, promoting design and computational thinking through tasks that mirror professional practices.

Empower Students as Designers: VR can empower students as designers of their own learning experiences, creating virtual worlds, simulations, and models that engage design thinking to iterate their ideas, solve complex problems, and innovate, learning from failures, fostering resilience and adaptability. This active cognitive, emotional, and behavioural engagement is crucial in an educational landscape increasingly focused on developing autonomous learners who are prepared to navigate and innovate within a complex, rapidly changing world (Horst & Dorner, 2019).

Promote Situated and Constructivist Learning: Learning through authentic, real-world contexts using tasks that reflect actual challenges faced in fields such as engineering, science, or history, VR allows students to apply their theoretical knowledge. This hands-on approach promotes constructivist learning through interaction with the VR environment. The immersive nature of VR also facilitates experiential learning, exploring and manipulating virtual objects, conducting experiments, and engaging in complex systems in ways that traditional classrooms often cannot provide.

Encourage Collaboration and Peer Learning: Students can work together in the same virtual space, sharing ideas, testing designs, and providing feedback to each other. This collaborative approach mirrors real-world teamwork, preparing students for the interpersonal and communication skills needed in professional settings. Collaboration also fosters social learning, where students learn by observing, interacting, and reflecting on their peers' work; particularly effective, as students can see and manipulate their peers' designs, offering real-time feedback and suggestions.

Provide Accessibility and Usability: Schools and educators should select VR platforms that match their technical and financial capacities while offering meaningful educational experiences. Tools that are intuitive and easy to navigate enable educators to integrate VR without requiring extensive technical expertise, allowing more time to focus on pedagogical outcomes.

Provide Ongoing Educator Support: As VR technology evolves, educators must be supported with continuous training to understand how to align VR with curriculum objectives, utilise VR tools, and facilitate student-centred learning within VR environments.

Support all students: Educators must be mindful that extended VR use can be physically discomforting, and accessibility challenges exist, even for those needing glasses. Motion sickness, eye strain, and disorientation remain challenges. These effects are typically caused by a mismatch between visual cues and physical motion, making it difficult for some students to focus or fully engage with VR content. Mobility impairments can make interaction using hand controllers or full-body motion difficult, and visual or hearing impairments may lessen VR experiences. Accessibility features, such as closed captioning or voice commands, can help, but these are not yet widespread or standardised across VR technologies. Educators should plan around short VR experiences, with appropriate breaks and close student experience monitoring, to minimise these issues.

8.8 Conclusion

In conclusion, the evolution of VR in education – from early experimental applications to its growing presence as a mainstream tool – marks a significant shift towards technologically enhanced learning environments that empower students. This transformation reflects a broader educational trend where students' agency, creativity, and engagement are prioritised. VR's ability to immerse students in authentic, interactive, and complex learning scenarios can redefine traditional classroom experiences, making abstract concepts more tangible and fostering deeper understanding. By allowing students to participate actively in their learning as designers and creators, VR encourages problem-solving, computational and design thinking, and collaboration skills, which are essential for success in a rapidly changing digital world.

VR is poised to play its role in the continued evolution of educational practices. However, successfully integrating this technology requires thoughtful planning and a commitment to ensuring its use is pedagogically sound and aligned with educational goals. This involves addressing challenges such as cost, accessibility, and teacher training while ensuring that VR is used in equitable and inclusive ways that benefit all students, including those with disabilities. As VR technology evolves, it will be crucial to balance innovation with these educational priorities, ensuring that VR is a meaningful tool in achieving holistic, inclusive learning for all students.

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