Jl. of Technology and Teacher Education (2021) **29**(3), 417-447

Teaching in a 3D Virtual World - Defining Teacher Practices

SARAH PRESTRIDGE
Griffith University, Australia
s.prestridge@griffith.edu.au

BERYL EXLEY
Griffith University, Australia
b.exley@griffith.edu.au

DONNA PENDERGAST
Griffith University, Australia
d.pendergast@griffith.edu.au

MIA O'BRIEN
Griffith University, Australia
mia.obrien@griffith.edu.au

DENIESE COX
Griffith University, Australia
deniese.cox@griffith.edu.au

MIRJAM SCHMID
Griffith University, Australia
m.schmid@griffith.edu.au

With the increase in distance and online teaching for mainstream schooling contexts, the advocacy of using a virtual world as a teaching and learning place has accelerated. Currently, there is no empirical evidence revealing the pedagogical elements defining teacher practices in virtual settings. This article reports on an exploratory study which contributes to defining virtual pedagogy. Six pre-service teachers and

two researchers spent 20 hours exploring a three-dimensional virtual platform for its pedagogical appropriation. The pre-service teachers were asked to conduct a learning challenge. An observation protocol was developed from an analysis of literature on the use of digital technologies and virtual worlds to identify specific teaching practices. Using video recordings of the learning challenges, a process of deductive and inductive categorisation occurred. Findings indicate that virtual teaching practices can be categorised by virtual world environment; technology function; use of technology in/with virtual worlds; pedagogical approach; classroom organisation; teacher role; learner action; feedback type and modality; and quality dimensions. The appropriation of the virtual place plays a role in defining teacher practices in the virtual classroom. These findings begin to represent and guide virtual teaching that has the potential to impact the quality of distance learning and learning in a classroom.

Keywords: Virtual worlds; virtual teaching; remote schooling; distance teaching

INTRODUCTION

Background

Distance learning has been common and is well established in Australia due to the geographic remoteness and rural environment (Kato & Wong, 1993). However, in recent years, there has been an increase in the use of online digital tools to connect students and discipline experts in mainstream classrooms as a response to teacher shortages. For example, there is an emergence of a hi-flex (highly flexible) classroom where the teacher teaches students in the classroom and at the same time students who are in a number of other geographical locations. This approach, for example, enables students to access a physics or language class when there is no teacher available at their school. Yet there has never been such a rush to online education as there was in 2020 due to COVID-19. This period has shown, at the very least, that schooling can happen without being in a classroom (Starkey et al., 2021). In Australia and worldwide, many different digital tools were used to support children's learning online, and this trend continues into 2021 as around half of the world's schools remain impacted by closures and alternative delivery well into the year (UNESCO, 2021).

During the pandemic, frequently used platforms such as Microsoft Teams or Zoom offer students and teachers the opportunity to share real-time webcam feeds and thus also show real facial expressions and body language. However, users in such platforms do not represent themselves moving around in a visual learning space as they can do in a virtual world. Currently, immersive and non-immersive VR platforms are reportedly becoming more frequently utilised for student learning in the schooling settings because of their ability to actively involve students (Stavroulia et al., 2019). Virtual worlds have had long history in education, see for instance Bronack et al.'s (2006) AET Zone in Active Worlds or exploration of Second Life by Kluge and Riley (2008). These examinations, like most in the online and distance realm, have occurred in a tertiary context. What we are seeing now and needing to examine is teaching virtually in a schooling context. This paper begins to examine what teachers' pedagogical practice looks like when teaching in a virtual world for primary and high school students.

Virtual Worlds in Education

Currently, immersive and non-immersive technology and its related concepts are increasingly emerging in schools and gaining greater access (Stavroulia et al., 2019). Immersive technology is defined as a "technology that blurs the line between the physical, virtual, and simulated worlds, thereby creating a sense of immersion" (Suh & Prophet, 2018, p. 79). A further distinction can be made between augmented reality (AR), virtual reality (VR), or mixed reality (MR), some of which can be immersive or non-immersive. For example, in non-immersive VR, content is displayed via a computer screen and traditional media such as keyboard and mouse are used for interactions rather than special equipment (Suh & Prophet, 2018, p. 79). These environments, likened to Second Life and Minecraft, use avatars, real-life objects, and scenes in which the individual has free movement and action. Avatars are visually represented entities that are controlled by a human user, whereas agents are visually represented entities that are controlled by a computer program (Felnhofer et al., 2018).

Originally, virtual worlds were used particularly in higher education, where students who are at a distance, meet in a virtual campus (see Angel et al., 2005), where they present a pitch to the industry as part of an assessment task (see Lee et al., 2016), or where they gain access to a situation that they cannot physically visit (see Freina & Ott, 2015). Furthermore, another purpose of these technologies is to mitigate the time constraints, safety con-

cerns, or accessibility and other challenges of onsite work integrated learning (see e.g., Male et al., 2017; Quinn et al., 2019). The simulations recreate a virtual environment (Rubio-Tamayo et al., 2017) for students to engage with and, as such, could be considered technology-blended online work integrated learning.

Regarding the effectiveness of VR-based learning, there have been mixed findings (Lee & Wong, 2014). A study by Merchant et al. (2014) found that game-based learning yielded better learning outcomes than a simulated virtual world learning space. Furthermore, although VR is promoted for its facilitation of constructivist pedagogy (Formosa et al., 2018), there are many examples in education of VR being utilised to facilitate independent, asynchronous engagement with an activity (e.g., Lee et al., 2010). However, non-immersive VR, such as Second Life, has reportedly been used to demonstrate for students "things that are impossible to do in real life such as conducting harmful experiments, going on virtual tours, and working collaborative teams" (Gregory & Bannister-Tyrrell, 2017, p. 5). In this study, the students reported being highly engaged in the learning happening within Second Life. Different from those applications of VR, González-Yebra et al. (2019) have reported on the design of a 3D virtual campus for synchronous teaching with remote university students. The authors proposed that what a non-immersive VR campus can offer over other online education or eLearning strategies is the feeling of belonging for members because of the visual contact between users and serendipitous engagement.

These and other previous studies show that we are still examining and using virtual worlds at an entry level adoption where the virtual world is a meeting place or delivery mechanism afforded by distance (Ertmer & Ottenbreit-Leftwich, 2013; Loveless, 2011). Furthermore, there is little to no empirical studies that examine the use of virtual worlds in schooling for teaching or as a learning tool.

Digital Learning Environments in Teacher Education

Within teacher education programs, there is an acknowledged need for pre-service teachers to gain experience in real-world classrooms (Stavroulia et al., 2019). According to Graziano and Feher (2016), such experiences offer pre-service teachers the opportunity to "test theories, knowledge, pedagogy, best practices, and classroom management techniques" (p. 496) that have been learned in their formal study. In response to changing teaching practices where more technology is being utilised in schools, it has been

suggested that there is a need for teacher education to also evolve (Curtis et al., 2019; Mabunda, 2013). Thus, already in the 1980s and 1990s, teacher education dealt with virtual learning environments, initially with a focus on, for example, MS Office software or specialist educational software (Clarke, 2013). As technology has evolved towards complex, virtual environments with multiple users, teacher education has also steadily changed in recent years. This evolution in teacher education includes expanding concepts of practical experience to incorporate not only face-to-face classrooms but also wholly online teaching contexts (Allen et al., 2019; Le Cornu, 2015; Luo et al., 2017).

However, currently, there is little in the way of education or professional learning for teachers who are exploring these new ways of teaching. Additionally, most teachers have been prepared for a traditional classroom context and thus the requisite mindset and skill set for shifting into a distance learning mode is wanting (Albion et al., 2015; Scherer et al., 2021). To exacerbate the problem, we also know that simply transferring traditional instructional practices from the classroom to the online environment are doomed to fail (Peltier at al., 2007) evidenced by student disengagement during the remote schooling period based on online teaching approaches (Ewing & Cooper, 2021). We know that this problem of shifting online is fundamentally grounded in the disconnect between *how teachers* use digital tools for online delivery and *how students* use digital tools for engagement practices (Ellis & Bliuc, 2019). Thus, learning frameworks are needed that provide a useful counterbalance to the permanently changing technologies and thereby offer constancy and orientation (see Clarke, 2013).

Quality Teaching in an Online Environment

Uncertainties about how to teach in online classrooms stem from a dearth of understanding of how to teach effectively online in the schooling context. Online teaching at a schooling level is different to online coursework at a tertiary level, with a shift away from transmission models of teaching where tasks, videos, or quizzes are sent to students to complete. Instead, pedagogies that focus on active student engagement (D'Agustino, 2012; Veletsianos & Navarrete, 2012) where students are enabled to take greater control working with their peers is considered more beneficial (Bain, 2004). A systematic review by Sun and Chen (2016) revealed that educators are still challenged when designing effective student-centred delivery methods. Teaching online is more than simply knowing how to use technol-

ogy or transferring materials to an online platform (Palloff & Pratt, 2013), it requires different pedagogies and new ways of engaging and communicating with students (Jensen et al., 2019; Philipsen et al., 2019; Rodrigues et al., 2019). This idea is also reflected, for example, in the widely used TPACK framework (technological pedagogical content knowledge): In order to teach effectively today, teachers need knowledge about different technologies, but also about how a certain subject can be taught in a pedagogically and technologically meaningful way (Koehler & Mishra, 2009). Thus, an interplay of different, even *new* areas of knowledge is necessary, such as technological pedagogical knowledge (TPK). Importantly, Yen et al. (2018) have contended that teaching online is not instinctive for many educators. As such, we are faced with the problem that empirically grounded school-based pedagogical paradigms have not matched the proliferate growth in the online teaching and learning domain.

As a foundation to effective teaching online, the notion of *technology enabled learning* needs to be examined. Teaching online typically necessitated the use of a learning management system (LMS) as well as the incorporation of other digital tools to support the student engagement process. However, providing the environment does not mean that students will engage. Knowing which technology to use at a given time in the learning design process for a particular learning purpose, in relation to the content and the learner's needs is required for the effective appropriation of technologies (Koehler & Mishra, 2009; Prestridge, 2017). This means that teachers need to know how to use an LMS but more importantly how to engineer the student engagement with the online digital tools. This has been described as Technology Enabled Learning (Ertmer & Ottenbreit-Leftwich, 2010), which emphasises constructivist pedagogical practices where the use of digital tools are centred on active learning, participation in inquiry, discussion, collaboration and reflection to support learners to turn *information* into *knowledge* as a social, co-constructed process (see Hsu, 2016; Looi et al., 2014; Prestridge, 2017). A virtual world is one such digital tool.

The Present Study

Teaching online is different to teaching in a classroom. There is a disconnect with how teachers use digital tools to teach and how students use digital tools to engage in learning. We are moving rapidly into blended, hybrid and fully online modes of teaching in classrooms and virtual worlds are being adopted. However, there are currently no empirical studies that exam-

ine how to teach in a virtual world and there is little pedagogical preparation of pre-service or in-service teachers. This exploratory study responds to these complex challenges by exploring the pedagogical elements of teaching in virtual worlds. It is guided by the simple but clearly positioned research question: What are the pedagogical elements for teaching in a virtual world and their relationship (if at all) to classroom teaching?

METHOD

Study Design and Data Collection

This study was concerned with investigating the potential for, and characteristics of, pre-service teacher professional experience situated within wholly online teaching and learning spaces. The study was designed as a collaborative project in which two experienced researchers in online pedagogy worked with six pre-service teachers to experiment with virtual pedagogy and reflect on what opportunities exist for professional experience in digital spaces. The two researchers were supported by an experienced teacher who took on the role of a professional experience supervising teacher during pre-service teacher mock classroom experiences held in iSeeVC, a non-immersive virtual world environment.

Three types of data were collected: (1) pre-service teacher written self-reflections, (2) recordings and transcripts of focus group meetings held in Microsoft Teams, and (3) video recordings of pre-service teacher and researcher actions in the iSeeVC platform (e.g., participant-led mock classroom experiences). Data were collected during a 20-hour intensive project broken into six sessions with follow-up interviews conducted in subsequent weeks.

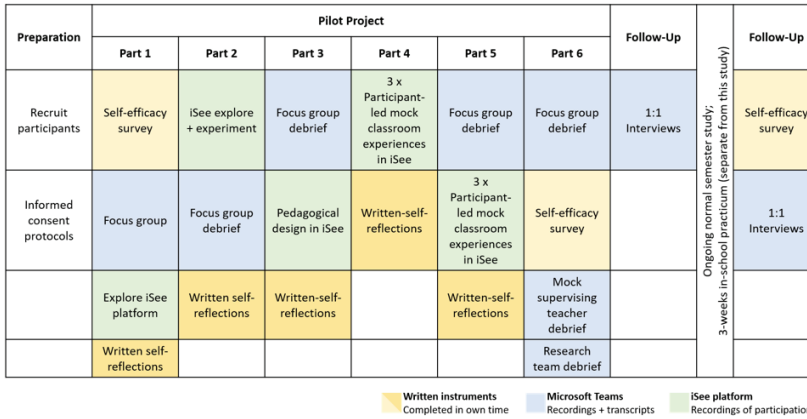

Figure 1. Overview of Study Design.

In this paper, we investigate the recorded participant-led mock classroom experiences. Each pre-service teacher was required to lead a *learning challenge* for the other active participants who acted as students. The learning challenge was presented broadly to the pre-service teachers. Guidelines for the learning challenges were (1) 30 minutes in length; (2) any discipline and curriculum outcomes; (3) use any feature and element of the virtual world and any other digital tool. The pre-service teachers were invited to then imagine, plan and deliver a school@home experience in the iSeeVC virtual world working space. All pre-service teachers planned learning experiences that could be aligned to the Australian Curriculum.

Collecting data in a virtual world workspace is a relatively new undertaking. As each participant create their own entry and exit points and their own journey through the virtual world platform, collecting comprehensive screen capture data on each and every interaction across each learning challenge was both time-consuming and cumbersome. For data economy reasons, we chose to screen the learning experiences from the perspective of one participant, in this instance, one of the researchers. This researcher consciously and strategically roamed around learning activities to gloss a variety of experiences and conversations taking place using screen-capture software.

The virtual world iSeeVC comprises of a number of different zones that represent different *real* spaces such as a social zone which is an outdoor area; a classroom zone that has a central room with connected *breakout* rooms; a lab zone; a dynamic room where the room dimension can increase; and a holodeck where a 3-dimension image can be featured. iSeeVC

is a virtual world that uses live streaming of video so that the user is represented by a floating window rather than an avatar. An additional feature is the directional use of sound relative to the user's position, that is, volume is louder when you are closer to another user (see https://iseevc.com.au/).

Sample

To recruit six pre-service teachers for this project, an advertisement was distributed at a major Australian teacher education institution to all third-year Bachelor of Education students who intended to participate in an in-school professional experience placement that semester. Applicants had to be interested in technology-enhanced teaching, showed evidence of being pedagogically creative, conceived potential within the desktop virtual reality platforms, were able to communicate ideas, and indicated ability and willingness to work as a team. Interested students applied through an online portal where they answered a series of written pre-screening questions. Following a telephone interview process to identify qualified and motivated participants, two pre-service teachers from the primary school stream and four from the high school stream (English and Drama, History and Biology, Sciences) were selected (see Table 1). Informed consent procedures included the public use of participants names, images, and materials created within the project. However, as the works of these pre-service teachers are examined, pseudonym are used. Pre-service teachers were paid 20-hours at an entry-level research assistant rate. Detailed lesson descriptions are provided in the findings.

Table 1

Overview of Participating Pre-Service Teachers and Their Lesson

Participant	Study stream	Lesson focus and learning zone
Gabrielle	High school (English, Drama)	Art gallery excursion in the dynamic zone
Henry	High school (History, Biology)	World War I trench in the holodeck
Lee	High school (English, Drama)	Drama improvisation in the social zone
Sam	High school (Sciences)	Classifying species in lab zone
Patricia	Primary school years	Mrs Gren classification strategy in lab zone
Ruth	Primary school years	Art elements in dynamic zone

Development of the Observer Protocol

Since no observer protocol exists to date that examines teaching in digital environments, the goal was to adopt an exploratory approach to develop a protocol in a multi-step procedure. To help answer the main research question the first step involved two researchers review of existing literature that examined the pedagogical use of digital tools in a schooling context. Heitink et al.'s (2016) overview of observed digital learning environment characteristics was determined to be an appropriate basis for our goal as it provided an observation protocol that was used to examine teachers' lesson plans specifically for the use of digital tools in schooling.

In a second step, this existing observer protocol was adapted over a longer period based on the incorporation of literature in the field of virtual worlds and online learning theory. In total, there were seven major modifications: (a) The protocol was supplemented with an overview of technology functions (Heitink et al., 2016). At the same time, guided by the authors' first experience with iSeeVC, a dimension with the possible functions of iSeeVC was added (i.e., classroom space, replica space, meeting space). (b) Instead of *Curriculum Characteristics*, we use the term *Pedagogical Approach* for the sub-dimension, we changed the item *authentic lesson* to *authentic emersion* and added the item *task-based* activities (Reisoğlu et al., 2017). (c) In the sub-dimension *Classroom Organisation* we additionally distinguish whether it is learning in a teacher-directed small group or in a learner-initiated small group (Hew & Cheung, 2010). (d) To better reflect the teacher's role in iSeeVC, the four original items for the sub-dimension *Teacher Role* were replaced by the steps of Cognitive Apprenticeship which is dominant in the literature on virtual world teaching (Brown et al., 1989; see also Lai & Yen, 2018). (e) The sub-dimension *Student Role* has been renamed into *Learner Action* with a stronger focus on, for example, agency (Brown et al., 1989; Hillman et al., 1994). (f) The sub-dimension *Assessment and Feedback* was refined by also taking into account who gives feedback to whom (e.g., teacher-to-learner, learner-to-learner). (g) And finally, a whole new dimension was added to consider the quality of teaching based on Praetorius et al.'s (2018) dimensions of teaching quality. (h) In addition to these content-related modifications, the response scale was also adapted. Unlike in Heitink et al. (2016) we only distinguish whether a feature was observed or not, without considering whether with or without technology. The sub-dimension *Learner Action* was differentiated into a scale from 1 (never) to 5 (very often).

In a third step, the adapted observer protocol was applied to one video of a pre-service teacher (Gabrielle) where two researchers applied the pro-

tocol independently. After coding, the two researchers met again and, in a fourth step, further developed the observer protocol based on their experience with the video: (a) A first modification concerned the sub-dimension *Function of Platform iSee*, which was renamed to *Virtual World Environment* and was placed first in the protocol. Since the environment offers vast potential, we have also added the item *other*. (b) Directly after that, the new sub-dimension *Functions* was added, which is strongly oriented towards use (i.e., use of furniture, boards, audio, spaces, tools). (c) The sub-dimension *Technology Function* was renamed *How Technology Is Used in/with Virtual Worlds*. At the same time, the item *instruction tool* was removed in this sub-dimension. (d) In the sub-dimension *Classroom Organisation*, two of the items have been renamed (i.e., learner small group (teacher initiated) and learner small group (learner initiated)). (e) The learner-to-learner feedback was deleted again, as it is unlikely to appear and is not the focus of interest of this study. (f) Also, some clarifications have been made to the *Quality Dimensions* (e.g., item *cognitive activation* becomes *cognitive complexity*). (g) The last change concerned the response scale. In the discussion, the two researchers decided that the sub-dimension *How Technology Is Used in/with Virtual Worlds* should distinguish not only whether a particular technology is used in/with a virtual world, but also whether it was used by the teacher or the students (see e.g., Schmid et al., 2021). The sub-dimension *Quality Dimensions* was also differentiated into a five-point scale (i.e., never to very often).

In a fifth step, two researchers independently coded all six pre-service teachers' videos using the newly revised observer protocol. Subsequently, in a sixth step, the researchers met again and discussed the coded videos in detail and paid particular attention to dimensions and items with little or no agreement. In addition, cases were constantly compared and contrasted to remain consistent. Through discussion, the items were further refined and defined. For example, the two researchers decided that good collaboration within a group should be coded with a *3*. If, in contrast, the collaboration also takes place beyond the group, the code *4* can be assigned. Or, for the item *skilling/functional* it was important for the teacher to explain, for example, how a technology works within iSeeVC (e.g., laser pointer) or outside of iSeeVC (e.g., Kahoot). Besides the discussion of the six cases, two last modifications were made in the observer protocol based on the coded videos: First, the item *metacognitive strategies* in the dimension *Pedagogical Approach* was deleted because metacognitive strategies are already included in *problem solving* for example. Second, the item *role play* was added because it emerged in the data (see e.g., Reisoğlu et al., 2017).

RESULTS

Observer Protocol

The final observer protocol contains 9 sub-dimensions with a total of 53 items (see Table 2). This represents the pedagogical elements identified and existing based on the literature in virtual worlds and the use of digital tools online.

Table 2
Observer Protocol for Teaching in a Virtual World

DIMENSIONS AND ITEMS			CODING			
Technology						
	Virtual World Environment		**No**	**Yes**		
		Classroom space[a]				
		Replica space (e.g., museum, trench)[a]				
		Meeting space[a]				
		Other[a]				
	Functions		**No**	**Yes**		
		Use of furniture (e.g., tables)[a]				
		Use of boards[a]				
		Use of audio (e.g., megaphone, broadcasts)[a]				
		Use of spaces (e.g., breakout rooms, rooftop)[a]				
		Use of tools (e.g., raise hand, laser pointer, chat)[a]				
	How Technology Is Used in/with Virtual Worlds		**No**	**Yes, by teacher**	**Yes, by learner**	
		Information processing tool (e.g., Word)[b]				
		Drill and practice tool (e.g., software for practising vocabulary)[b]				
		Information source (e.g., website, YouTube clip)[b]				
		Presentation tool (e.g., PowerPoint)[b]				
		Evaluation tool (e.g., computerized test)[b]				
		Communication tool (e.g., blog)[b]				
		Learning process support (e.g., mind maps)[b]				
		Simulation (e.g., software simulating physical or societal phenomena)[b]				
		Collaboration support (e.g., cloud software)[b]				
		Other (e.g., administration, stopwatch)[b]				

DIMENSIONS AND ITEMS		CODING				
Teacher						
Pedagogical Approach		**No**	**Yes**			
	Authentic emersion[c]					
	Problem solving[d]					
	Drill and practice[d]					
	Inquiry learning[d]					
	Task-based[a]					
	Role play[a]					
Classroom Organisation		**No**	**Yes**			
	Individual[d]					
	Whole classroom teaching[d]					
	Teacher directed small group[c]					
	Learner small group (teacher initiated)[a]					
	Learner small group (learner initiated)[a]					
Teacher Role		**No**	**Yes**			
	Instructional[e]					
	Modelling[e]					
	Coaching[e]					
	Scaffolding[e]					
	Articulation[e]					
	Reflection[e]					
	Exploration[e]					
Learner						
Learner Action		**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**
	Learning activity controlled by learner[c]					
	Pacing controlled by learner[c]					
	Agency for movement[a]					
	Agency for interaction with others[a]					
	Choice with tasks[a]					
	Playtime actions (e.g., bouncing, thumbs up)[a]					
Feedback						
Feedback Type and Modality		**No**	**Yes**			
	Formative assessment[b]					
	Summative assessment[b]					
	Teacher-to-learner feedback[a]					
	Learner-to-learner feedback[a]					
Quality						
Quality Dimensions		**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**
	Learner support/differentiation[a]					
	Cognitive complexity[a]					
	Collaboration (teacher-learner, learner-learner)[a]					
	Learning processes (e.g., supporting how to collaborate)[a]					
	Building relationships[a]					
	Skilling/functional[a]					

Notes. [a] Developed by the authors. [b] Heitink et al. (2016), p. 78. [c] Adapted from Heitink et al. (2016), p. 79. [d] Heitink et al. (2016), p. 79. [e] Adapted from Brown et al. (1989).

The results of the observations are presented firstly by dimension and secondly by learning challenges. This procedure makes it possible to obtain indications of the quantitative results and then to look at them qualitatively in terms of each learning challenge.

Findings on Observer Protocol

The newly developed observer protocol was used to code the six videos of the pre-service teachers. The following Table 3 provides the results of the observed virtual teaching elements in the six learning challenges and gives some examples of practice.

Looking at the technology dimension, it shows that half of the students have used the virtual world as a replica space (e.g., Trench in World War I). The remaining three pre-service teachers have used it either as a classroom or the social space. There are hardly any differences, however, in the functions used in iSeeVC. All of them have used furniture, boards, audio, spaces or even different tools. Interestingly, different rooms were used in all lessons. In a *normal* classroom, this is more time-consuming organisationally due to movement times. However, in a virtual world, transporting to a new location is quick. Within iSeeVC, different digital technologies were used for teaching purposes or used by the learners in the learning challenges. Presentation tools (n = 5) and information sources (n = 4) were observed most frequently by the teacher. Similar results were obtained by Heitink et al. (2016), who found presentation tools and information sources as a technology function also among the most frequently observable technology functions. Additionally, we distinguished whether the technology was used by the teacher or the students. Here we found that in the learning challenges students were encouraged to use different technological tools for information processing, presentation, evaluation or communication.

With regard to the dimension of teacher, it emerged that learning challenges were designed mainly as task based activities (n = 4). Two pre-service teachers chose an authentic emersion and one also organised a role play. All learning challenges contained common sequences of whole class then group work, with half of lessons requiring students to work individually. Interestingly, it was observed twice that teachers allowed students to initiate their own formation of the group. The study by Heitink et al. (2016) also observed a large number of lessons with these different class organisations. Over the implementation of the learning challenge, the pre-service teachers adopted very different teacher roles, mostly focused on articulation. Scaffolding and exploration were not observed.

Table 3

Results of the Observed Virtual Teaching Elements

DIMENSIONS AND ITEMS		CODING			
Technology					
Virtual World Environment		**No**	**Yes**	***Notes***	
	Classroom space[a]	4	2		
	Replica space (e.g., museum, trench)[a]	3	3	Trench in World War I (Henry)	
	Meeting space[a]	6	0		
	Other[a]	5	1	Social Space (Lee)	
Functions		**No**	**Yes**	***Notes***	
	Use of furniture (e.g., tables)[a]	0	6	Use of tables as a part of the art exhibition (Gabrielle)	
	Use of boards[a]	0	6		
	Use of audio (e.g., megaphone, broadcasts)[a]	0	6		
	Use of spaces (e.g., breakout rooms, rooftop)[a]	0	6		
	Use of tools (e.g., raise hand, laser pointer, chat)[a]	1	5		
How Technology Is Used in/with Virtual Worlds		**No**	**Yes, by teacher**	**Yes, by learner**	***Notes***
	Information processing tool (e.g., Word)[b]	4	1	1	Boards are Word documents, which can be annotated by the students (Sam)
	Drill and practice tool (e.g., software for practising vocabulary)[b]	6	0	0	
	Information source (e.g., website, YouTube clip)[b]	2	2	2	Students searched for evidence on the Internet (Sam)
	Presentation tool (e.g., PowerPoint)[b]	1	4	1	Teacher presented content (Sam)
	Evaluation tool (e.g., computerized test)[b]	5	0	1	
	Communication tool (e.g., blog)[b]	5	0	1	
	Learning process support (e.g., mind maps)[b]	6	0	0	
	Simulation (e.g., software simulating physical or societal phenomena)[b]	5	0	1	
	Collaboration support (e.g., cloud software)[b]	5	0	1	Teams shared space (Ruth)
	Other (e.g., administration, stopwatch)[b]	3	1	2	

DIMENSIONS AND ITEMS		CODING		
Teacher				
Pedagogical Approach		**No**	**Yes**	***Notes***
	Authentic emersion[c]	4	2	
	Problem solving[d]	6	0	
	Drill and practice[d]	6	0	
	Inquiry learning[d]	6	0	
	Task-based[a]	2	4	
	Role play[a]	5	1	Students invented and played a short scene starting with a given sentence (Lee)
Classroom Organisation		**No**	**Yes**	***Notes***
	Individual[d]	3	3	Students are asked to individually classify given species on different boards (Sam)
	Whole classroom teaching[d]	0	6	
	Teacher directed small group[c]	6	0	
	Learner small group (teacher initiated)[a]	3	3	
	Learner small group (learner initiated)[a]	4	2	Students chose their own group (Patricia)
Teacher Role		**No**	**Yes**	***Notes***
	Instructional[e]	2	4	
	Modelling[e]	4	2	Teacher modelled how to make a scientific claim supported by evidence and reasoning (Sam)
	Coaching[e]	2	4	
	Scaffolding[e]	6	0	
	Articulation[e]	1	5	Students were encouraged to speak about learnings and ideas (Gabrielle)
	Reflection[e]	3	3	At end of lesson teacher focused on supporting student reflections (Gabrielle)
	Exploration[e]	6	0	

DIMENSIONS AND ITEMS			CODING					
Learner								
	Learner Action		**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**	***Notes***
		Learning activity controlled by learner[c]	0	0	5	0	1	Students were completely free to move around the museum and get information (5) (Gabrielle)
		Pacing controlled by learner[c]	5	0	0	0	1	Teacher-controlled time (1) (Patricia)
		Agency for movement[a]	0	1	3	1	1	
		Agency for interaction with others[a]	1	1	1	1	2	Students had to talk to any group (4) (Patricia)
		Choice with tasks[a]	5	0	0	0	1	
		Playtime actions (e.g., bouncing, thumbs up)[a]	0	2	0	2	2	Students were asked to do thumbs up, move around (4) (Sam)
Feedback								
	Feedback Type and Modality		**No**	**Yes**	***Notes***			
		Formative assessment[b]	5	1				
		Summative assessment[b]	6	0				
		Teacher-to-learner feedback[a]	0	6				
		Learner-to-learner feedback[a]	2	4	Teacher asked students to respond after another students skit (Lee)			
Quality								
	Quality Dimensions		**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**	***Notes***
		Learner support/differentiation[a]	0	3	1	2	0	Teacher checked if all students understood and identified those who needed more help through the traffic lights (4) (Sam)
		Cognitive complexity[a]	0	0	1	4	1	
		Collaboration (teacher-learner, learner-learner)[a]	1	0	1	3	1	Students worked together on shared document (4) (Ruth)
		Learning processes (e.g., supporting how to collaborate)[a]	0	1	1	3	1	
		Building relationships[a]	0	0	3	2	1	Support encouraged for one another's ideas and feelings, building on each other's ideas (4) (Henry)
		Skilling/functional[a]	1	1	0	3	1	

The learner dimension focused on observable learning actions. It is notable that in all lessons, learners had some control of their activity. In Gabrielle's lesson, learners had control often. However, the control of pacing or the choice of tasks, was limited; only one teacher gave learners these possibilities. The agency of interaction with others shows mixed results. The teachers handled this very differently (from never to very often). Overall, playtime actions could be observed in every lesson, although the extent of these also differed from lesson to lesson.

With feedback, we have been able to observe teacher-to-learner feedback (n = 6) and learner-to-learner feedback (n = 4) in particular. Unlike Heitink et al. (2016), we could only observe formative feedback once and no summative feedback at all. We assume that this is related to the design of the study, where pre-service teachers had to prepare a short lesson for their fellow students. Finally, the qualities of collaboration and skilling/functional could be observed from never to very often. While the three sub-categories learner support/differentiation, cognitive complexity and learning processes were observed often.

Findings on Learning Challenges

In the following, the six learning challenges the pre-service teachers implemented are presented.

(1) Gabrielle's gallery excursion

Gabrielle took her class to a mock art exhibition in the dynamic zone. She took on the role of a guide and asked her students to walk around the exhibition interacting with the resources she had put up on the boards. Resources included multimedia materials to display aspects of Realism and Absurdism theatre, such as, short YouTube clips, websites, animations, PowerPoints with information to click through, still images, as well as physical tables that were placed to impeded movement along the wall. Students moved around the exhibition freely interacting with the resources. Gabrielle, as museum guide, moved to individuals and small groups of students engaging in their conversations about the aspects of theatre. She gave instructions on how to do things such as how to raise your hand or move to a place. In the last section of the lesson she asked all students to form a circle and to share what they each learnt. She ended the lesson by leaving as the guide and returning as the class teacher to imaginarily take her students back to their classroom.

This lesson featured several elements that would not have been possible in a traditional classroom. A key element of this lesson was that the design gave opportunity for greater student agency and choice to interact with both a) any digital resource and b) any other student, scoring a 5-high on learner action sub-dimension. It was considered an authentic emersion that incorporated coaching, articulation and reflection. As the students were offered multiple digital resources supported by teacher and student discussion it scored a 4 on learner support/differentiation.

Figure 2. Gabrielle's Art Gallery in iSeeVC.

(2) Henry's World War I immersion

Using the holodeck, Henry uploaded a 3D image of a World War I trench. He asked his students to spend time silently diving into the photo and exploring the finer imagery. Students shared their feelings and ideas. Building on each student's responses he then asked students to watch a video on a hanging board. He provided instructions on how to view the video as students had to play it individually and *jump* to indicate when they finished. Students were asked to roam the image freely exploring, then they shared what new understandings they have gained. At the end of the lesson, the experienced was discussed. Each student shared and built on each other's comments as the teacher facilitated the discussion.

Henry took the students on a journey through time, not possible in a traditional classroom. Like Gabrielle's lesson, the virtual world environment became a replica space. Unlike Gabrielle's lesson where students had high agency, Henry stepped students through reflective tasks, scoring a range 1 to 5 on items in learner action sub-dimension with a focus on articulation and

reflective teaching roles. This lesson scored the highest on cognitive complexity as the immersion and video experience provoked highly emotional cognitive reasoning, and applying and building internal cultural understandings. The teacher-to-learner and the learner-to-learner feedback modality created no boundaries for the expression of personal feelings. This lesson was considered the most authentic to the virtual world space as it advantages learning for students in a classroom regardless of distance.

Figure 3. Henry's Holodeck Video in the Trenches.

(3) Lee's drama improvisation

The aim of the lesson was to develop students' skills in improvisation through a range of role play activities. The teacher used the stage in the social area to open the lesson. Students were instructed to form a circle and they played an introductory task responding to statements with the flow of *fortunately…* then next person *unfortunately…* making one story. For the main role play activity students in pairs created a story (intro, complication, resolution) with the sentence starter of *The field stretched on for miles but I knew I was not alone*. Students were given time to work in pairs anywhere they liked. The teacher visited each pairs advising. All groups presented and then reflected on their learning.

This lesson was not advantaged by the use of a virtual world other than providing an online social area to perform, even though there was a lecture theatre in iSeeVC. Students had greater choices of where to practices, but interestingly, no group left the social space. Technologies were used by the teacher as presentation tools and the teacher's role was more traditional in instructing, modelling and coaching.

Figure 4. Lee's Stage for Role Play.

(4) Sam's science five kingdoms

Drawing on students' prior knowledge of classification systems, the teacher explained the classification strategy and how to make a scientific claim to the whole class. Subsequently, the students are asked to individually classify given species by writing names on boards around the room (boards are labelled by kingdom). After this individual work, students were paired up and asked to practice making a scientific claim justifying if the species should be in the given kingdom. They were encouraged to research (e.g., Google) beyond the content given in the environment. During the groupwork, the teacher provided support to each group. Students presented back to the class, group by group, using the scientific statement to claim the classification of the species listed on their kingdom board. The lesson took place in the lab space.

Like Lee's drama improvisation, this science lesson is traditional in process and again is not advantaged by the virtual world environment. Instead of the five boards in a virtual lab, classic paper placards could have been used. Like Lee's, the teacher was instructional and stepped students through the lesson sequence and the technology was teacher-centric as an instructional PowerPoint. Students had less agency indicated by variable scores on leaner action items. Interestingly, the quality dimensions were rated the highest for this lesson.

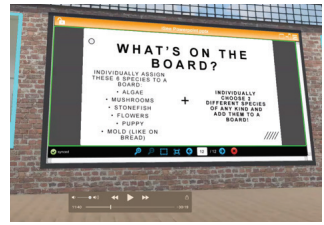

Figure 5. Sam's Classification Instruction.

(5) Patricia's introduction to Mrs Gren

The teacher provided background information on the Mrs Gren classification strategy (acronym for movement, respiration, sensitivity, growth, reproduction, excretion, and nutrition). The students were then asked to work in groups to classify a tree as living or non-living. One group member shared their claim to the whole class. The same activity was repeated to classify fire, bacteria and rock as living or non-living. Whole class sharing at the end was supported by the teacher with lots of encouragement and support by students. The lesson took place in the lab space.

Similar to Sam's and Lee's lesson, this lesson could have taken place in a classroom setting with PowerPoint instruction for example. Student agency was low for pacing and choice and the teachers' role focused on instruction, coaching and articulation. Quality dimensions of cognition, collaboration and learning process scored highly at 4.

Figure 6. Patricia's Application of Mrs Gren.

(6) Ruth's visual art lesson

The lesson started in Microsoft Teams. Instructions were given on how to engage (i.e., raise hands, mute microphone) then the teacher used a PowerPoint to present lesson intentions followed by a Kahoot quiz testing knowledge of art elements. The class was then asked to meet in the dynamic room in iSeeVC. The teacher used both verbal instructions followed up by

points in the chat. Students moved in rotation to analyse a different art work using visual art language. Student work was recorded in a shared word document. At the end of the lesson the teacher asked the students to share main points found as they stood around each artwork.

Ruth was the only pre-service teacher who taught the lesson not solely in iSeeVC and the only one who used the chat function. She scored the highest in the technology use sub-dimension. Ruth explicitly instructed and coached students in how to report/behave in the virtual classroom situation (e.g., raise hand, jump). Her lesson enabled higher student agency than Sam's for example but not as high as Henry's or Gabrielle's. Overall, in the tally of all scores in the observer protocol, her lesson was scored the highest. Additionally, her lesson was underpinned by the use of a number of digital tools and due to the required movement around resources was advantaged by this in the virtual space.

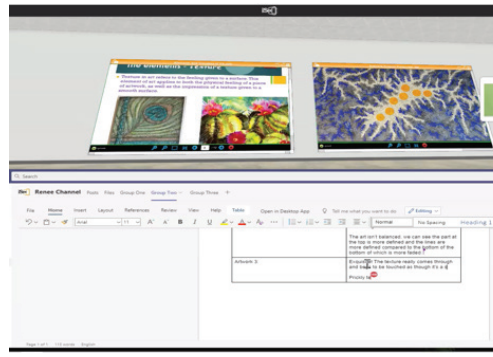

Figure 7. Ruth's Art Analysis.

DISCUSSION AND CONCLUSIONS

This study sought to address the gap in the literature that identifies little to no empirical studies examining how to teach in a virtual world in a schooling context. Drawing on the learning theories in digital technologies the studies in virtual world pedagogies and the experiences of the researchers in iSeeVC, an observation protocol was developed through a number of steps to answer the main research question guiding this study: *What are the pedagogical elements for teaching in a virtual world and their relationship (if at all) to classroom teaching?* To answer this question and based on Heitink et al. (2016) we have identified 9 sub-dimensions with 53 pedagogical

items that can be considered when teaching in a virtual world. However, in fully answering this question there is a need to examine teaching in comparison to classroom practice. We do this by presenting three considerations important for teaching virtually.

Consideration 1: The learner action sub-dimension is an indicator of the authenticity of the lesson design in a virtual world. Lessons by Gabrielle, Henry and Ruth that advantaged student agency through the pedagogical items demonstrated greater appropriation of a virtual world (see Ertmer & Ottenbreit-Leftwich, 2013; Koehler & Mishra, 2009; Prestridge, 2012). These three lessons enabled students' opportunities to make greater choices interacting with the resources, other students and lesson aspects (e.g., pacing). This consideration is based on the fact that a virtual world is built on a gaming platform and as such orientates the user to higher levels of agency and choice (Dickey, 2007). Hew and Cheung (2010) refer to this as the user *acting* on the world that can be considered in regard to objects such a space or board but also another user.

Consideration 2: Pedagogical appropriateness of a lesson, even if a more traditional lesson sequence can be *transferred* from a classroom to a virtual space (see Lee, Sam, Patricia). The validity of this is based on users interacting with each other at a distance (Bronack et al., 2006; Dickey, 2005) and therefore the platform itself becomes the vehicle or a *virtual classroom*. However, as virtual pedagogies are based on what Girvan and Savage (2010) term *communal constructivism* the environment creates a disposition towards collaboratively constructed knowledge and can be examined or framed within the quality dimensions category. The focus then becomes on the level of collaboration. For these three lessons, that did not *per se* advantage the virtual world with regard to high student agency due to a more traditional lesson structure, there was still a high score for student collaboration on each. In other words, as a stepping stone to moving to teach in a virtual world the *lesson* can be successful if there are high levels of collaboration within a stricter lesson structure (less choice). Task based and role play have been found to be the preferred pedagogical approach in other research studies (Girvan & Savage, 2010; Reisoğlu et al., 2017) which was also evident in this study.

Consideration 3: Presence is important. Targeted development of relationships through actions (jumping, hand signals) was evident in all lessons but also through collaborative discussion that supported students to give feedback to each other. Teacher-to-learner feedback was evident in every lesson but there was also learner-to-learner feedback across four of the six lessons. Cheney and Bronack (2011) suggest that a *presence pedagogy*

is needed that foregrounds social engagements of users but also facilitates the meaningful engineering of student-to-student-interactions with a focus again on maximising collaboration in virtual worlds. Whereas Bulu (2012), however, uses the framework of place, social and co-presence. In the observation protocol this was evident as going to a place, such as a World War I trench; social presence was evident in the relationship item and co-presence in learner-to-learner feedback. This highlights the design of a more complete knowledge building community so that these items live and relate together rather than as individual terms.

In summary and to explicate how to teach in a virtual world, the key elements to consider are lesson designs that have high student agency; a design that advantages the space (in other words, cannot be done in the classroom or adds value) as well as collaborative knowledge building activities; and the need to develop presence, a sense of place, social interaction. Notwithstanding the final more complex nuance that to teach virtually these considerations are melded together to create the user experience. This study brings an exploratory look at how to teach virtually. It has shed some light on sub-dimensions and items for further consideration as we advance our teaching to go beyond the physical classroom.

Limitations and Future Research

The present study has some limitations that need to be addressed in future research. First, most of the studies into virtual worlds that underpinned this research were drawn from the tertiary level. Research in schools is more complex but as this sector is advancing in the use of digital technologies and more importantly developing student capabilities for further education, there is a need for further research in this context. Also the use of virtual worlds is often contextualised to students at a distance from one another. However, it is important to consider and research how teachers in a classroom advantage the use of virtual worlds, such as in this study as a virtual excursion.

As this was a qualitative exploratory study, only six pre-service teachers were examined in total. These pre-service teachers were situated in the scenario of a classroom with a teacher-student relationship but also within a schooling context. It would be fruitful for further research to involve school-age participants as the use of virtual worlds is integrated as a distance learning tool and a classroom based tool. This is especially important as we see the advance of fully online schools and also senior high school changes to an alternate timetable that includes home study days.

As a final note, future research pathways for the educational use of virtual worlds is not only necessary but provides what we are interested in examining: that is, the pedagogy in virtual worlds as an antecedent for quality teaching in a classroom. It is an exciting time in education.

References

Albion, P. R., Tondeur, J., Forkosh-Baruch, A., & Peeraer, J. (2015). Teachers' professional development for ICT integration: Towards a reciprocal relationship between research and practice. *Education and Information Technologies, 20*(4), 655–673. https://doi.org/10.1007/s10639-015-9401-9

Allen, J., Singh, P., & Rowan, L. (2019). Professional experience in initial teacher education: Keeping abreast of change in the 21st century. *Asia-Pacific Journal of Teacher Education, 47*(4), 323–326. https://doi.org/10.1080/1359866X.2019.1637599

Angel, R., Tashner, J., Riedl, R., Bronack, S., & Sanders, R. (2005). *An examination of influences of a social constructivist conceptual framework on creating virtual worlds for graduate teaching and learning*. Paper presented at the League of Worlds, University of Melbourne, Australia, November 2005.

Bain, K. (2004). *What the best college teachers do*. Harvard University Press. https://doi.org/10.2307/j.ctvjnrvvb

Bronack, S., Riedl, R., & Tashner, J. (2006). Learning in the zone: A social constructivist framework for distance education in a 3-dimensional virtual world. *Interactive Learning Environments, 14*(3), 219–232. https://doi.org/10.1080/10494820600909157

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Bulu, S. (2011) Place presence, social presence, co-presence and satisfaction in virtual worlds. *Computers & Education, 58*(1), 154–161. https://doi.org/10.1016/j.compedu.2011.08.024

Cheney, A. W., & Bronack, S. C. (2011). Presence pedagogy as framework for research in virtual environments. *International Journal of Gaming and Computer-Mediated Simulations, 3*(1), 79–85. https://doi.org/10.4018/jgcms.2011010106

Clarke, L. (2013) Virtual learning environments in teacher education: A journal, a journey. *Technology, Pedagogy and Education, 22*(1), 121–131. https://doi.org/10.1080/1475939X.2012.731632

Curtis, E., Martin, R., & Broadley, T. (2019). Reviewing the purpose of professional experience: A case study in initial teacher education reform. *Teaching and Teacher Education, 83*, 77–86. https://doi.org/10.1016/j.tate.2019.03.017

D'Agustino, S. (2012). Toward a course conversion model for distance learning: A review of best practices. *Journal of International Education in Business, 5*(2), 145–162. https://doi.org/10.1108/18363261211281753

Dickey, M. D. (2005). Three-dimensional virtual worlds and distance learning: Two case studies of active worlds as a medium for distance education. *British Journal of Educational Technology, 36*(3), 439–451. https://doi.org/10.1111/j.1467-8535.2005.00477.x

Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development, 55*(3), 253–273. https://doi.org/10.1007/s11423-006-9004-7

Ellis, R. A., & Bliuc, A. M. (2019). Exploring new elements of the student approaches to learning framework: The role of online learning technologies in student learning. *Active Learning in Higher Education, 20*(1), 11–24. https://doi.org/10.1177/1469787417721384

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255–284. https://doi.org/10.1080/15391523.2010.10782551

Ertmer, P. A., & Ottenbreit-Leftwich, A. (2013). Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. *Computers & Education, 64*, 175–182. https://doi.org/10.1016/j.compedu.2012.10.008

Ewing, L. A., & Cooper, H. B. (2021). Technology-enabled remote learning during COVID-19: Perspectives of Australian teachers, students and parents. *Technology, Pedagogy and Education*, *30*(1), 41-57. https://doi.org/10.1080/1475939X.2020.1868562

Felnhofer, A., Kafka, J. X., Hlavacs, H., Beutl, L., Kryspin-Exner, I., & Kothgassner, O. D. (2018). Meeting others virtually in a day-to-day setting: Investigating social avoidance and prosocial behavior towards avatars and agents. *Computers in Human Behavior, 80*, 399–406. https://doi.org/10.1016/j.chb.2017.11.031

Formosa, N. J., Morrison, B. W., Hill, G., & Stone, D. (2018). Testing the efficacy of a virtual reality-based simulation in enhancing users' knowledge, attitudes, and empathy relating to psychosis. *Australian Journal of Psychology, 70*(1), 57–65. https://doi.org/10.1111/ajpy.12167

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. In *The international scientific conference elearning and software for education* (Vol. 1, pp. 133–141). Bucharest: "Carol I" National Defence University.

Girvan, C., & Savage, T. (2010). Identifying an appropriate pedagogy for virtual worlds: A communal constructivism case study. *Computers & Education, 55*(1), 342–349. https://doi.org/10.1016/j.compedu.2010.01.020

González-Yebra, Ó., Aguilar, M. A., & Aguilar, F. J. (2019). Co-design of a 3D virtual campus for synchronous distance teaching based on student satisfaction: Experience at the University of Almería (Spain). *Education Sciences, 9*,(1). https://doi.org/10.3390/educsci9010021

Graziano, K. J., & Feher, L. (2017). Online student teaching with undergraduate preservice teachers. Paper presented at the *Society for Information Technology & Teacher Education International Conference*, Austin, Texas.

Gregory, S., & Bannister-Tyrrell, M. (2017). Digital learner presence and online teaching tools: Higher cognitive requirements of online learners for effective learning. *Research and Practice in Technology Enhanced Learning, 12(*1), 1-17. https://doi.org/10.1186/s41039-017-0059-3

Heitink, M., Voogt, J., Verplanken, L., van Braak, J., & Fisser, P. (2016). Teachers' professional reasoning about their pedagogical use of technology. *Computers & Education, 101*, 70–83. https://doi.org/10.1016/j.compedu.2016.05.009

Hew, K. F., & Cheung, W. S.(2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. *British Journal of Educational Technology, 41*(1), 33–55. https://doi.org/10.1111/j.1467-8535.2008.00900.x

Hillman, D., Willis, D., & Gunawardena, C. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *American Journal of Distance Education, 2*(8), 30–42. https://doi.org/10.1080/08923649409526853

Hsu, P. S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends, 60*(1), 30–40. https://doi.org/10.1007/s11528-015-0014-3

Jensen, L., Price, L., & Roxå, T. (2019). Seeing through the eyes of a teacher: Differences in perceptions of HE teaching in face-to-face and digital contexts. *Studies in Higher Education, 45*(6), 1149–1159. https://doi.org/10.1080/03075079.2019.1688280

Kato, H., & Wong, S.Y. (1993). Distance education in Asia and the Pacific: Country papers. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000096635

Kluge, S., & Riley, L. (2008). Teaching in virtual worlds: Opportunities and challenges. *Issues in Informing Science & Information Technology Education, 5*, 127–135. https://doi.org/10.28945/3207

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary issues in technology and teacher education, 9*(1), 60–70. https://www.learntechlib.org/primary/p/29544/

Lai, C. Y., & Yen, Y. C. (2018). Using mobile devices to support cognitive apprenticeship in clinical nursing practice–a case study. *Interactive Technology and Smart Education, 15*(4), 348–362. https://doi.org/10.1108/ITSE-02-2018-0008

Le Cornu, R. (2015). Key components of effective professional experience in initial teacher education in Australia. Retrieved from Melbourne: https://www.aitsl.edu.au

Lee, E. A.-L., & Wong, K. W. (2014). Learning with desktop virtual reality: Low spatial ability learners are more positively affected. *Computers & Education, 79*, 49–58. https://doi.org/10.1016/j.compedu.2014.07.010

Lee, E. A.-L., Wong, K. W., & Fung, C. C. (2010). How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. *Computers & Education, 55*(4), 1424–1442. https://doi.org/10.1016/j.compedu.2010.06.006

Lee, M., Nikolic, S., Vial, P., Ritz, C., Li, W., & Goldfinch, T. (2016). Enhancing project-based learning through student and industry engagement in a video-augmented 3-D virtual trade fair. *IEEE Transactions on Education, 59*(4), 290–298. https://doi.org/10.1109/TE.2016.2546230

Looi, C., Sun, D., Soew, P., & Chia, G. (2014). Enacting a technology-based science curriculum across a grade level: The journey of teachers' appropriation. *Computers & Education, 71*, 222–236. https://doi.org/10.1016/j.compedu.2013.10.006

Loveless, A. (2011). Technology, pedagogy and education: Reflections on the accomplishment of what teachers know, do and believe in a digital age. *Technology, Pedagogy and Education, 20*(3), 301–316. https://doi.org/10.1080/1475939X.2011.610931

Luo, T., Hibbard, L., Franklin, T., & Moore, D. R. (2017). Preparing teacher candidates for virtual field placements via an exposure to K-12 online teaching. *Journal of Information Technology Education: Research, 16*, 1–14. https://doi.org/10.28945/3626

Mabunda, P. L. (2013). Towards a theoretical framework for the use of ICT strategies for teaching practicum supervision. *Africa Education Review, 10*(sup1), S7–S27. https://doi.org/10.1080/18146627.2013.855411

Male, S. A., Hargreaves, D., & Pointing, D. (2017). The emerging suite of virtual work integrated learning modules for engineering students. Paper presented at the 28th *Annual Conference of the Australasian Association for Engineering Education* (AAEE2017), Sydney.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Palloff, R. M., & Pratt, K. (2013). Lessons from the virtual classroom. *International Journal of Information and Communication Technology Education, 10*(2), 93–96.

Peltier, J. W., Schibrowsky, J. A., & Drago, W. (2007). The interdependence of the factors influencing the perceived quality of the online learning experience: A causal model. *Journal of Marketing Education, 29*(2), 140–153. https://doi.org/10.1177/0273475307302016

Philipsen, B., Tondeur, J., Pareja Roblin, N., Vanslambrouck, S., & Zhu, C. (2019). Improving teacher professional development for online and blended learning: A systematic meta-aggregative review. *Educational Technology Research and Development, 67*(5), 1145–1174. https://doi.org/10.1007/s11423-019-09645-8

Praetorius, A. K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: The German framework of three basic dimensions. *ZDM, 50*(3), 407–426.

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education, 58*(1), 449–458. https://doi.org/10.1016/j.compedu.2011.08.028

Prestridge, S. (2017). Examining the shaping of a teacher's pedagogical orientation for the use of technology. *Technology, Pedagogy and Education, 26*(4), 367–381. https://doi.org/10.1080/1475939X.2016.1258369

Quinn, D., Cioffi, E., Hill, S., Kor, M., & Longford, A.-C. (2019). Implementing work-integrated learning in online construction management courses. *Journal of University Teaching & Learning Practice, 16*, 1–14.

Reisoğlu, I., Topu, B., Yılmaz, R., Yılmaz, T. K., & Göktaş, Y. (2017). 3D virtual learning environments in education: A meta-review. *Asia Pacific Education Review, 18*(1), 81–100. https://doi.org/10.1007/s12564-016-9467-0

Rodrigues, H., Almeida, F., Figueiredo, V., & Lopes, S. L. (2019). Tracking e-learning through published papers: A systematic review. *Computers & Education, 136*, 87–98. https://doi.org/10.1016/j.compedu.2019.03.007

Rubio-Tamayo, J. L., Barrio, M. G., & Francisco García, G. (2017). Immersive environments and virtual reality: Systematic review and advances in communication, interaction and simulation. *Multimodal Technologies and Interaction, 1*(4), 1–20. https://doi.org/10.3390/mti1040021

Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready?. *Computers in Human Behavior, 118*, 106675. https://doi.org/10.1016/j.chb.2020.106675

Schmid, M., Brianza, E., & Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior, 115*, 106586. https://doi.org/10.1016/j.chb.2020.106586

Starkey, L., Shonfeld, M., Prestridge, S., & Cervera, M. (2021). Special issue: Covid-19 and the role of technology and pedagogy on school education during a pandemic. *Technology, Pedagogy and Education*, *30*(1), 1–5. https://doi.org/10.1080/1475939X.2021.1866838

Stavroulia, K.-E., Christofi, M., Baka, E., Michael-Grigoriou, D., Magnenat-Thalmann, N., & Lanitis, A. (2019). Assessing the emotional impact of virtual-reality based teacher training. *International Journal of Information and Learning Technology, 36*, 192–217. https://doi.org/10.1108/IJILT-11-2018-0127

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior, 86*, 77–90. https://doi.org/10.1016/j.chb.2018.04.019

Sun, A., & Chen, X. (2016). Online education and its effective practice: A research review. *Journal of Information Technology Education: Research, 15*, 157–190. https://doi.org/10.28945/3502

UNESCO, (2021). *Education: From disruption to discovery*. Accessed 20 March 2021. https://en.unesco.org/covid19/educationresponse

Veletsianos, G., & Navarrete, C. (2012). Online social networks as formal learning environments: Learner experiences and activities. *The International Review of Research in Open and Distributed Learning, 13*(1), 144–166. https://doi.org/10.19173/irrodl.v13i1.1078

Yen, S. C., Lo, Y., Lee, A., & Enriquez, J. (2018). Learning online, offline, and in-between: comparing student academic outcomes and course satisfaction in face-to-face, online, and blended teaching modalities. *Education and Information Technologies, 23*(5), 2141–2153. https://doi.org/10.1007/s10639-018-9707-5