Ready, Teacher One

by

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The above committee determined that the thesis is acceptable in form and content and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate during an oral examination. A signed copy of the Certificate of Approval is available from the School of Graduate and Postdoctoral Studies.

ABSTRACT

This study examines how French First-language teachers responded to virtual reality (VR) professional development in 2021 in the province of Ontario. The teachers used higher-end VR Oculus Quest 2 systems in a digital, polysynchronous, collaborative, virtual learning environment during eight fully-immersive teacher professional development sessions. The overall research by design model allowed the researcher and the teacher participants to address one of many gaps in the research on VR by investigating how three areas intersect: (1) teacher professional development, (2) immersive technologies, and (3) pedagogical design. The findings of this study suggest that teachers can interact in VR and collaboratively design immersive learning spaces to increase student engagement but that teachers require time and support to identify the pedagogical applications of VR spaces. Teachers working in VR can reduce physical distance and increase both collaboration and presence; this transforms the professional development experience beyond what was traditionally thought possible.

Keywords: virtual reality (VR); head-mounted display (HMD); degrees of freedom (DoF); immersion; presence

AUTHOR’S DECLARATION

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JOANNIE GIRARD

STATEMENT OF CONTRIBUTIONS

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication. I have used standard referencing practices to acknowledge ideas, research techniques, or other materials that belong to others. Furthermore, I hereby certify that I am the sole source of the creative works and/or inventive knowledge described in this thesis.

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1 Introduction

1.1 Context

In the recent decade, there have been major developments in the field of educational science and education is in a state of change from traditional teaching practices to new learning ecologies supported by technology (Kalantzis & Cope, 2012). These developments have greatly influenced the roles of teachers in meeting the emotional and academic needs of their students (Darling-Hammond & Hyler, 2020). With the current global pandemic COVID-19, even the most well-prepared teachers struggled to keep up with a combination of distance, blended, and in-class learning (Darling-Hammond & Hyler, 2020). In the past year, teachers all over the world, including in Ontario, were required to teach online with little or no preparation due to the pandemic. Meeting the emotional and academic need of students has proven to be a complex endeavor and teachers have relied on traditional means of online teaching by using online meeting platforms such as Zoom, Microsoft Teams and Google Meet. Newer technology such as virtual reality (VR) could be used to create virtual classrooms where students could interact and collaborate as if they were physically present. However, a lack of research in this field, the need for a clear integration framework and the absence of teacher professional development (PD) in VR make this difficult (Stavroulia et al., 2019).

1.2 Understanding Virtual Reality

People have represented their lives through art, sculpture and other media for centuries but VR allows people to represent themselves and exist in the same online space. The online space of VR is also an ideal training ground, as people such as pilots, doctors and military personnel can train without harming their potential passengers or subjects.

VR can be best understood as a spectrum of reality (Milgram & Kishino, 1994). Southgate (2020) explains that VR can be experienced on a 2D computer monitor or mobile screen (e.g., Minecraft) in a room using image and sound projections (e.g., Cave Automatic Virtual Environment (CAVE) where the walls, floor and ceiling may be used as projection screens to create a highly immersive virtual environment) or through a VR headset (head-mounted display or HMD).

Until recently, VR headsets were too complex, expensive and cumbersome to be used in K-12 classrooms. Recent advances in VR technology now make these devices more portable, accessible and affordable. VR is developing faster than expected, caused by a growing demand due to the global pandemic (Facebook, 2021; Radio-Canada, 2021). Software development now permits users to create realistic avatars of themselves to join other people or groups in different virtual rooms as if they were physically present in what is now called social VR or the metaverse. This rapid digital revolution will impact the way people live, learn and work, allowing them to work more seamlessly from digital to physical realties (Hackl & Buzzell, 2021).

1.3 Rationale

New technological developments in VR, such as the ability to connect people in fully immersive, creative environments, hold the potential to offer many pedagogical possibilities for teachers and students alike. Yet, since this technology is still in its infancy, there are important gaps in the research, especially in the field of educational VR and PD in VR. The research gaps will be addressed in detail further in this study's literature review.

In this study, the researcher worked alongside the teacher participants to address the gaps in the research by investigating how these new technologies, along with attention to pedagogical design, could help educators enhance teaching, learning and student outcomes using virtual reality. For this study, an eight-session professional training program for teachers was designed in fully immersive VR setting. Using a designed-based research (DBR) approach inspired by the van den Berg model (2019), the researcher and participants were able to assess and reassess the educational design after each training session, and based on data collected through observation, surveys and video responses.

The purpose of using a DBR approach is to investigate problems and solutions in an ongoing way through assessing and reassessing each training session to refine the process of PD (van den Berg, 2019). The constant revision of the training sessions was done in order to build rich and engaging learning experiences through virtual reality that enhance teaching, learning and student outcomes. PD in VR allows teachers to develop their skills, knowledge and attitudes towards VR over time. While most studies about VR are conducted in a lab setting over short twenty-minute sessions (Bailenson, 2021), participants in this study were provided with their own Oculus Quest 2 device for an eight-week period and were encouraged to try and explore with the equipment between sessions as well. In turn, this allowed them to develop their skills, knowledge and attitudes to provide useful insights on the technology and pedagogical design in a polysynchronous (Dalgarno, 2014), fully-immersive VR environment. Therefore, by applying DBR, the researcher was able to adapt the training from session to session instead of waiting until the end of the study to make changes.

During the eight PD sessions, teacher participants learned how to use the VR equipment and the software. Most of the study was conducted using a VR application called Spatial, which is a social VR platform where users can meet, interact and work together in a virtual environment as if they were physically present. Using this application, participants created realistic avatars (see Figure 1) of themselves and embodied (moved inside the body) of avatars to immerse themselves in a fully-immersive, digital social environment. Through discussion and exploration, participants used the tools to experiment and interact with objects, people and the different environments: mountain lounge, boardroom lounge, boardroom with a table, auditorium and abstract (see Table 1).

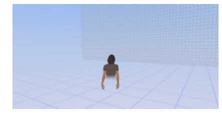
Figure 1

Researcher creates a realistic avatar using Spatial version 3.0

Note. Avatars only have upper bodies as the hardware does not have feet tracking capabilities currently.

Table 1

Five different environments explored in Spatial version 3.0

Mountain lounge	**Boardroom lounge**	**Boardroom with a table**	**Auditorium**	**Abstract**
				

After each session, participants reflected and shared about their experience by completing a survey about how to use this type of technology in their own practice. Participants were encouraged also to explore one or many of the individual simulations (e.g., Notes on Blindness, The Ann Frank House VR, Ecosphere, Gravity Lab) directly from the Oculus library. As a culminating task, participants were then divided into two groups and tasked with preparing a K-12 lesson in VR for the other group using the tools within the Spatial software. Each of the two groups then presented their lesson to the other group.

This study examines the teachers' reports of their learning and applications of their learning in the PD sessions in VR. Chapter 2 offers a review of the literature related to VR in education, innovative pedagogies and PD. It defines the key terms and definitions pertaining to VR: HMD, degrees of freedom (DoF), immersion, haptics, presence, simulation and cybersickness. The theoretical frameworks presented in this study were used to synthesize and understand the data. Gaps in the literature are also identified in this section. The Methodology (Chapter 3) provides an explanation of the *research by design* method (van den Berg, 2019) used to conduct this research and outlines the different ways this study gathers and analyzes data. Chapter 4 provides the findings from the observations, surveys, participant videos and the analysis of the teachers' culminating tasks. Chapter 5 offers a discussion of the findings from the study and their contribution over and above the current literature.

This study finds that teachers can interact in VR and focus on how to design of immersive learning spaces to increase student engagement. Teachers working in VR can reduce physical distance and increase collaboration and social presence which transforms the PD experience beyond what was traditionally thought possible.

2 Literature review

This literature review examines how virtual reality is defined and how it has evolved, as well as the new innovative techno-pedagogical possibilities it offers. It also examines how VR has been used in educational contexts to design innovative learning experiences. The importance of understanding pedagogical design, the technological possibilities and the role of teachers in creating truly transformative learning experiences are also explored. Further, this literature review looks at the evolving role of teachers and the need for PD as technology affordances continue to emerge. Ultimately, the gaps in this field of research become apparent, in part due to the lack of research in this field, the recent rapid technological advances, and the lack of teacher training and PD in VR. Since research in this field is still in its infancy, older, less-immersive screen-based VR (or point and click) was also considered in this review.

2. 1 Definitions

The key terms defined here include: virtual reality (VR), head-mounted display (HMD), degrees of freedom (DoF), immersion, haptics, presence, simulation and cybersickness.

Virtual Reality (VR)

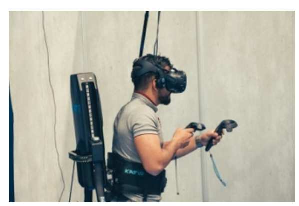
Jaron Lanier, considered the father of VR, first coined the term VR in 1978 (Bailenson, 2018). In his book Dawn of the New Everything (Lanier, 2017), he describes over fifty iterations of his original definition and specifies that:

> VR is one of the scientific, philosophical, and technological frontiers of our era. It is a means for creating comprehensive illusions that you're in a different place, perhaps a fantastical, alien environment, perhaps with a body that is far from human. And yet it's also the farthest-reaching apparatus for researching what a human being is in terms of cognition and perception. (p.1)

He argues that VR, more than any other media, can be immensely beautiful, while simultaneously creepy, and it will amplify your human character (Lanier, 2017). A simpler definition of VR is that it is a technology in which users are immersed in a digital world or physical world simulation created by a computer using a headset (Dalton, 2021). In education, VR allows students to experience various imaginative environments and provides them with the ability to demonstrate their learning by interacting with or creating these environments (Southgate, 2020). Southgate (2020) categorizes the different types of VR technology as screen-based VR, cave automatic virtual environment (CAVE), or head-mounted display (HMD) commonly called a VR headset. Each one is described in detail in Table 2.

Table 2

Types of Virtual Reality

Screen-based VR or point and click	Cave Automatic Virtual Environment (CAVE)	HMD - Tethered or physically connected	HMD - stand-alone or all-in-one
Users are moving and interacting in a virtual world from a computer or mobile screen. e.g., Minecraft, SecondLife, etc. Augmented reality (AR) can also be experienced from a computer or mobile screen. e.g., Pokemon Go.	A CAVE is a physical space (room or structure) used to display images and sounds to create an immersive virtual environment (Southgate et al., 2016). Users are immersed in a virtual world by looking or interacting with wall projection. e.g., Immersive Van Gogh Exhibit Toronto, Klimt immersive experience, etc.	Users wear a VR headset that is physically connected to a computer with a high-end graphic card (sometimes referred to as tethered VR) (Southgate, 2020). Users are fully immersed in a virtual world e.g., HTC Vive, Oculus Rift, etc.	These headsets can be used as stand-alone or all-in-one devices. They are considered wireless since they do not have to be connected to a computer or other tracking devices (Southgate, 2020). Users are fully immersed in a virtual world. e.g., Oculus Quest, Lenovo Mirage, Neo 3, etc.
			

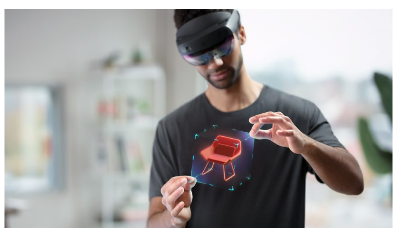
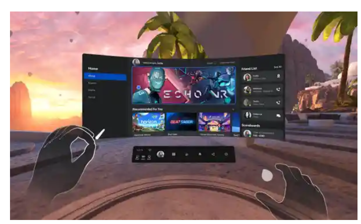
Each of these VR types can be useful in different contexts. Currently, much of the VR software that is available in HMD is also available screen-based to allow for broader accessibility as users merge to more advanced HMD. While CAVE VR is fascinating, it will not be covered further in this study.

Head-Mounted Display (HMD)

According to Southgate et al. (2016), a HMD, commonly called a VR headset, is a device (e.g., goggles or a headset) worn over the eyes that displays a virtual or augmented reality environment. She describes the range of HMDs from see-through holographic lenses to allow digital information to be displayed over the environment (e.g., augmented reality), to opaque visuals that block a user's sight of the real world and replace it with a virtual environment (e.g., virtual reality). Putting on a headset is not like being at the movies; it is more like being inside the movie and, in some cases, influencing the storyline (Southgate, 2020). The Microsoft Hololens is an example of an augmented reality HMD which allows users to see their surroundings. Contrarily, a VR HMD, such as the Oculus Quest, allows the user to be completely immersed in a virtual reality environment (see Table 3) (Milgram & Kishino, 1994).

Table 3

Different types of HMD and their point of view

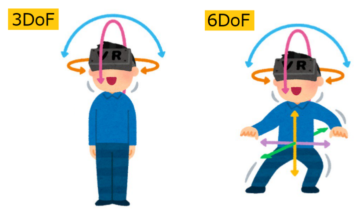
Microsoft HoloLens 2 **Augmented reality**	**Oculus Quest 2** **Virtual reality**
 View of a person using AR HMD	 View of a person using VR HMD
 View inside AR HMD	 View inside VR HMD

Degrees of Freedom (DoF)

Degrees of freedom (DoF) refers to the number of basic ways a physical object can move through 3D space (Google, 2018). There are six total degrees of freedom, and they are rotational movements (x, y and z axes) and translational movements (forward/backward; left/right; up/down) (see Table 4) (Google, 2018). Different types of equipment allow for different degrees of freedom (DoF) and affect the level of interaction and navigation possible in VR (Southgate, 2020).

Table 4

Degrees of Freedom (DoF)

 	
3DoF	6DoF
The user can look 360 degrees as if they are standing or sitting in place in a virtual environment. The user can rotate their head (rotational movements) on the x, y and z axes (e.g., Oculus Go, Google Cardboard). Also, users can interact with the environment by looking at hotspots to activate menus and functionalities (Southgate et al., 2016).	The user can look 360 degrees and move around (translational movement) to explore the environment. The user can move forward/backward, up/down and left or right (e.g., Oculus Quest, HTC Vive). Currently, these are used in high-end VR and are generally more expensive. Controllers can be used to interact with objects; some applications use hand tracking to manipulate virtual environments (Southgate et al., 2016).
 Google cardboard	 Oculus Quest 2

Immersion

Southgate et al. (2016) define *immersion* as a feeling of presence provided by the senses in reaction to the technology and they classify the degree of immersion as passive, immersive and sandbox VR (See Table 5). Simply put, *presence* is the perception of being in the virtual environment (Southgate et al., 2016). Milgram and Kishino (1994) first introduced the extent of presence metaphor (EPM) as the depth of immersion, which can be seen on a continuum (see Figure 2).

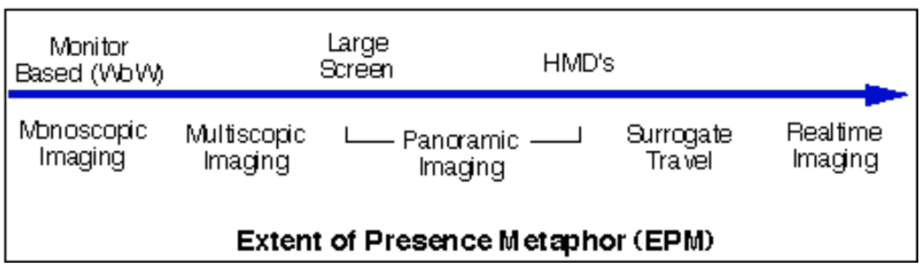
Table 5

Levels of immersive experience in HMD (Southgate, 2020; Southgate et al., 2016)

Passive VR	**Immersive VR**	**Sandbox VR**
Users are limited to viewing the environment and are restricted in their interactions.	Users are granted a high level of autonomy. They can explore virtual environments and interact with objects and in some cases other people.	Users can use tools provided in the app to create things within the app without having to code.

Figure 2

Extent of Presence Metaphor (EPM) dimension (Milgram & Kishino, 1994)



In the extent of presence metaphor, Milgram and Kishino (1994) illustrate that the depth of presence ranges from less presence, an observer looking into the world, to one feeling as if they are present inside the world and experiencing sensations as if they are part of that reality. According to Southgate et al. (2016), there are two different types of perspective or views a user can have in VR. They can experience the world in the first-person, meaning that they view the world from inside the avatar, or in the third-person, meaning that they view the world from outside the avatar. A first-person view is seen as a more immersive experience, as the third person view is perceived as disembodied (Southgate et al., 2016).

Presence

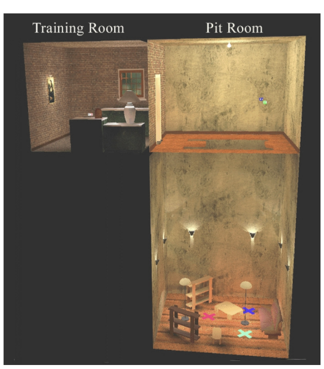
Southgate et al. (2016) define *presence* as the feeling of "being there," where a user experiences a replacement of the physical environment with the virtual one. Bailenson (2018) explains that, since our mind cannot be present in two places at once, presence in VR causes absence in the physical world. Further, *co-presence* is defined as the feeling of "being there with others" as if you were all present in the same space (Southgate et al., 2016). The term *social presence* was defined by Short et al. (1976), as the degree to which a person is perceived as a "real person" and connected to others in the process of communication through a medium.

Simulation

Merchant et al. (2014) define *simulation*s as digital environments that recreate real-life situations and allow users to experiment with different scenarios and outcomes that would otherwise be impossible or too costly. Dede (2009) explains that simulations could facilitate deeper learning by allowing students to learn skills under controlled conditions that may be difficult or impossible to replicate in the real world. Simulations are powerfully realistic tools, as Bailenson (2018) describes, "No matter how prepared you think you are the first time, it still takes you by surprise" (Introduction). For instance, Meehan et al. (2002) asked participants to carry objects in a virtual environment around a 20 feet deep pit (see Figure 3). Although participants knew they were safe, they showed strong physiological reactions such as increased heart rate in the pit room simulation (Meehan et al., 2002).

Figure 3

Side view of the virtual environment (Meehan et al., 2002)



Note. Subjects start in the Training Room and later enter the Pit Room.

Haptic Devices

Haptic devices, such as gloves (e.g., HaptX) or a bodysuit (e.g., Teslasuit), allow a user to touch and manipulate 3D virtual objects and to feel physical resistance (McLaughlin et al., 2001). Haptic-enabled devices allow users to feel the shape, weight, texture and temperature of a virtual object through tactile feedback and allow for a heightened level of perception in a simulated environment (Southgate et al., 2016). Motion can also be captured and enhanced by omnidirectional treadmills (e.g., Vitruix) and motion simulation (giant human-sized hamster balls e.g., Eight365). In addition, other tech companies (e.g., OVR Technology) have introduced the architecture of scents (AOS) to bring the sense of smell to VR. This means that VR can presently appeal to our senses of sight, hearing and smell.

Cybersickness

Not all aspects of VR provide enhancements. Southgate (2020), for example, defines *cybersickness* as a condition that has similar symptoms to motion sickness (headache, nausea and dizziness, and clamminess). Bailenson (2018) cautions that, while there are things that can be done to minimize cybersickness, it is difficult to predict if users will have an adverse reaction in VR.

2. 2 VR History

VR is not a new concept; it can be traced back to the 1960's in the entertainment industry with a single user console called Sensorama, designed to captivate audience attention (Merchant et al., 2014). This led to the emergence of the popular toy View-Master in 1939 (Southgate, 2020). In the 1980's, VR emerged in the field of professional education for flight simulator training and exercises (Merchant et al., 2014). VR adoption has been slow because HMD's were once very expensive, difficult to use and did not include proper instructional design (Merchant et al., 2014). During this era, the popularity of "point-and-click" VR proved to enhance learners' engagement and cognitive skills (Merchant et al., 2014). In the last decade, smartphone technology has paved the way to low-cost VR mobile applications and accessibility (Ralph, 2015). In 2012, the Oculus prototype was massively supported through crowdfunding as the first high-end HMD targeted for home use (Bailenson, 2018). In 2014, Oculus was purchased for over $2 billion by Facebook (Bailenson, 2018). The development of the Oculus Rift, HTC Vive and Hololens have recently generated interest in new digital technologies for leisure, edutainment, and learning (Southgate et al., 2016). It is estimated that by the year 2030, VR and other related industries could boost global domestic product to USD $450.5bn (Dalton, & Gillham, 2019).

2. 3 VR and Learning Affordances

Van Dam et al. (2002) suggest that, while research in this field is in its early stages, the power of immersion alone justifies important investment in VR. Overall, the future of this technology seems very promising as it offers unparalleled possibilities of transforming the way we learn, work and live (Bailenson, 2018). Merchant et al.'s (2014) research demonstrates that VR-based instruction could be significantly effective at improving learning outcomes. These findings are consistent with Ketelhut et al.'s (2010) field experiment which demonstrates that VR could be beneficial to all and is particularly effective for at-risk students, helping to build self-efficacy and being used to spark interest in pursuing a different career path such as science. Their findings suggest that VR environments can also work at improving student engagement and class attendance (Ketelhut's et al., 2010).

2. 3. 1 Spatial Visualization

Important research by Dalgarno and Lee (2010) illustrates the learning affordances of 3-D virtual environments, such as helping students develop enhanced spatial knowledge representation. Lee and Wong (2014) also find that VR programs statistically improved learning gains and were especially effective at helping students with low spatial visualization ability. Civelek et al. (2014) found that students who learned abstract physics in a VR environment had greater learning gains than those who learned the same concepts in a regular class. These gains may happen because immersive VR allows people to see things beyond what they can see with a computer (van Dam et al., 2002).

2. 3. 2 Experiential learning

A second learning affordance of 3-D virtual environments is that they allow for experiential learning tasks that would be impractical or impossible to undertake in the real world (Dalgarno & Lee, 2010). For instance, VR allows participants to travel through time and space and to be inside a cell or to hold a planet (Bailenson, 2018). Further, VR provides students with the possibility to put their learning into practice (Merchant, 2014).

Seymour (2008) demonstrates that VR simulation training is effective in acquiring and transferring new skills. VR allows users to transition from theory to practice (Kapralos et al., 2017) by engaging learners into deliberate practice (Guadagnoli et al., 2012). For example, medical students can practice surgeries without endangering their patient's lives (Merchant, 2014). As Bailenson (2018) explains, VR allows pilots, surgeons and soldiers, etc. to make mistakes and be better prepared for facing life-and-death situations. For instance, in Ketelhut's et al. (2010) study, students were asked to respond to an outbreak to learn about epidemiology and prevention and many claimed to have felt like actual scientists while conducting the experiment. Some students also found that, while the experiment was harder, they liked having to explore and test things out for themselves (Ketelhut et al., 2010). In summary, as van Dam et al. (2002) explain, "Looking at a picture of the Grand Canyon, however large, differs fundamentally from being there" (p. 541) and immersive VR is the closest a person can be when being there it is not possible.

2. 3. 3 Motivation and Engagement

A third learning affordance of a 3-D virtual environment is that it increases motivation and engagement. Research by Merchant et al. (2014) demonstrates that while the "point-and-click" 3-D virtual environment is not as immersive, it has proven to be enough to enhance students' engagement. Moreno and Mayers (2002) demonstrated that student engagement was further increased when students were placed in the more immersive headset in comparison to viewing on desktop-based computers. Ketelhut's et al. (2010) research demonstrates that VR can improve student attendance and increase interest in pursuing a career. Maas and Hughes (2020) in a review of the literature on VR, define engagement as the level of attention given to a task. They summarized studies that showed that the engagement level is increased when students can link what they are learning to the world around them. Likewise, Furió et al.'s (2015) research demonstrates that motivation has a positive effect on achievement. These findings point to the potential of VR to impact engagement and achievement positively.

2. 3. 4 Transfer of Knowledge and Skills

A fourth learning affordance of 3-D virtual environments according to Dalgarno and Lee (2010) is that they can improve the ability to transfer knowledge and skills to real situations by contextualizing the learning objectives. Other researchers (e.g., Merchant, 2014; Sitzmann, 2011; Vogel et al., 2006) found that students performed better when they were in control of their learning environments. For example, students who were in a guided constructivist version of the River City simulation demonstrated a greater understanding of the scientific inquiry method than those who did not have that experience (Ketelhut's et al., 2010).

2. 3. 5 Collaborative Learning

A fifth learning affordance of virtual environments according to Darlgarno and Lee (2010) is that 3-D visuals allow for more effective collaborative learning when compared to a 2-D alternative. Research by Hew and Cheung (2010) finds that VR can help support peer collaboration even when learners are physically distant.

2. 3. 6 Empathy

If VR allows someone to walk in the shoes of another, it can be used to change their perspectives and their world view, and it can be a tool to teach empathy (Bailenson, 2018). Notably, after people were immersed in VR 360-degree documentary about Syrian refugees, Clouds over Sidra, the number of donations made to the United Nations doubled (Bailenson, 2018). As the film producer Milk (2015) explains, VR "connects humans to other humans in a profound way" (9:20). Similarly, Bailenson (2018) suggests that VR serves as a virtual mirror, reflecting our own biases and revealing hidden attitudes such as ageism, racism, and others. For example, research by Ahn et al. (2013) demonstrates that people are more likely to volunteer their time and help people affected by colour blindness after they experience it for themselves in VR.

2. 3. 7 Cautions

Bailenson (2018) warns users that VR is a powerful tool that has both constructive and destructive potential. If not used correctly, this tool could be utilized adversely to induce false memories in children (Segovia & Bailenson, 2009), to inflict lasting pain and even cause durable psychological damage (Bailenson, 2018).

2. 4 The Integration of VR in Education

VR was used to train pilots and military personnel in the 1960's (Blascovich & Bailenson, 2011). In a recent review, Maas and Hughes (2020) reported that this technology was extremely costly and challenging. However, the emergence of smartphone technology has led to the widespread use of low-cost access to 3 DoF VR

(Ralph, 2015). Teachers began experimenting with Google Expedition in 2014 (Southgate, 2020). While some literature suggests that some schools have had trouble integrating even the more common computer technology (Maas & Hughes, 2020), others did not wait for research or applied models to invent and imagine the unique pedagogical potential of VR (Southgate, 2020).

2. 5 The Learning Design Experience in VR

While some educators have made considerable efforts to integrate VR in the classroom, others think that the true potential of this tool is often wasted (Southgate, 2020; Winn, 1993). As such, research development of new technologies such as VR and pedagogical designs are too often seen as two separate paths that never converge (Bailenson, 2018), resulting in educational professionals asking the question, "What am I supposed to do with this?" (Bailenson, 2018, Ch. 10). Further, most virtual learning environments do not have sufficient instructional design built into them (Merchant, 2014). This is largely due to the fact that these technologies are often seen as simple simulations which do not contribute to an improved learning experience (Winn, 1993). Yet, according to Bailenson (2018), if one wants to fully unlock the potential of VR, the learning design should be done in such a way that the lessons emerge from the experience and from the process of active discovery. This is no easy task. Creating VR is a costly and complex endeavor (Bailenson, 2018) and, according to a review of the literature (Maas & Hughes, 2020), few studies include pedagogical design in the development of the learning experience or measure the specific pedagogical outcomes.

2. 6 The Evolving Role of Teachers and Teacher PD

While VR in education seems promising, its goal should not be to replace the classroom teacher (Bailenson, 2018). According to Merchant (2014), teachers have a crucial role to play, as research demonstrates that, even with the best tools, students perform better with guidance. Thus, important investments need to be made to implement VR in schools - notably, investments must be made in terms of time and money to train and support teachers in making informed, critical learning design decisions (Merchant, 2014). According to Koehler et al. (2007), researchers agree that teacher training is not long enough to generate a deep understanding of how to use technology for pedagogy, nor does it provide the experience required to help them understand what the technology can do for them as teachers. Educators need to develop a mindset that allows them to simultaneously think about the multidimensional dynamic that includes the discipline, the pedagogy and the technology (Koehler et al., 2007).

2.7 Theoretical Frameworks

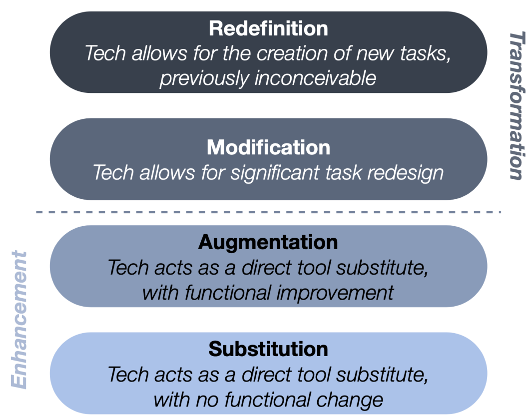
New technological tools provide innovative ways to transform educational experiences by offering learning opportunities that were once inconceivable (Puentedura, 2008). Yet, tools alone are not sufficient to redefine the schooling experience (Hamilton et al., 2016). Learning theory and technology theories can help to make sense of innovations and their potential. The role of teachers has evolved much beyond knowing about the subject they teach and the methodology to teach it; they must understand how to design a learning experience that leverages technological tools (Koehler et al., 2005). Many teachers have not been successfully trained to think about how to integrate technology (Koehler et al., 2005). For instance, many might not understand that two key elements to technological adoption are the perceived usefulness of the technology and the ease of use (Venkatesh & Davis, 2000) but knowing this theory can help to build understanding of tech adoption. According to Dalgarno (2014), teachers must be able to explain not only how, but why to use a technology. Further, they must reduce cognitive load, all while managing multiple channels of in-class and online communication. Educators may use a technology to increase engagement and improve collaborative learning (Dalgarno, 2014). It is no easy task in an ever-changing digital world (van den Berg, 2019), to discern what students need to know (Kereluik et al., 2013). Current training programs may not be sufficient (Koeheler et al., 2005; Zhang et al., 2020) and should be reassessed (Guskey, 2016) to give way to more positive learning experiences and outcomes (Garrison et al., 2010). In sum, greater attempts should be made to support teachers in the deployment of immersive VR in their classrooms (Southgate, 2020). In the next section, applicable theories of technology and learning are outlined.

2.7.1 The SAMR Model

Puentedura's (2006) SAMR model was developed to assess how technologies have a greater or lesser effect on transforming student learning (see Figure 4). The letters SAMR indicate the four different levels of the model: substitution, augmentation, modification and redefinition. Puentedura (2008) explains that while all the levels can play a role in student learning, if a course is well designed and delivered and all other variables remain the same, students could see a greater improvement at the redefinition level. Despite its popularity, the SAMR model is not supported by a theory nor is it the object of a peer-reviewed literature (Hamilton et al., 2016). In their critical review, Hamilton et al. (2016) mention that the model is based on other studies that demonstrate the positive impact of metacognitive guidance, rather than on the technological tool itself. Despite its widespread use, the SAMR model may not be enough to evaluate the complex dynamics of integrating a new technology in the classroom, but it could be combined with other frameworks to guide teachers in a metacognitive process.

Figure 4

SAMR Model (Puentedura, 2006)

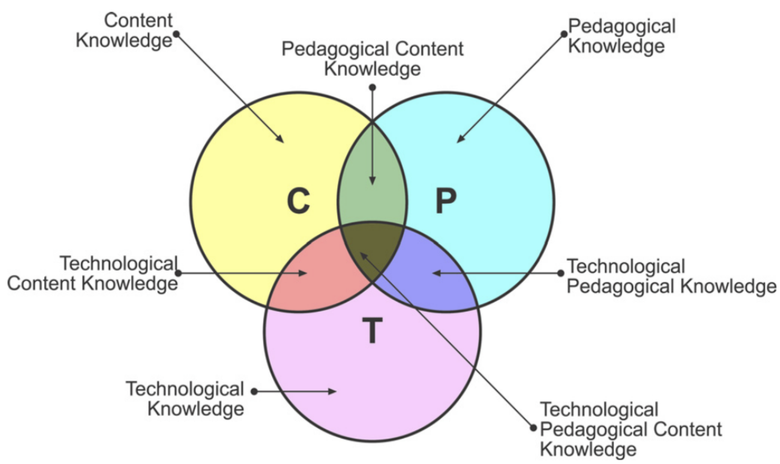


2.7.2 The TPCK Framework

The TPCK framework was developed in 2005 by Koehler and Mishra (see Figure 5). It was designed to understand the complex dynamic relationship among the three pillars of knowledge required by teachers when designing a course that generates deeper understanding: technology, pedagogy and content knowledge. Koehler and Mishra (2005) were also interested in seeing how these areas intersect. Puentedura (2008) characterizes this intersection point, TPCK, as the area where pedagogy, content and technology work in synergy to create a specific approach to a certain topic with a specific type of technological tools. By using this framework, professionals now have seven areas of focus (See Figure 5) to guide their thinking by identifying what they need, in terms of knowledge and tools, to achieve the best results when designing a course (Puentedura, 2008). Koehler and Mishra (2005) argue that the epistemology of integrating technology is a complex multi-dimensional challenge that requires more than disciplinary, technology or pedagogical expertise but a synergy of these considerations. Rodgers (2018) explains that the TPCK framework should be used as way to comprehend how to use technological tools in order to pass down knowledge in a way that improves the learning experience.

Figure 5

TPCK framework: pedagogical, technological content knowledge (Koehler & Mishra, 2005)

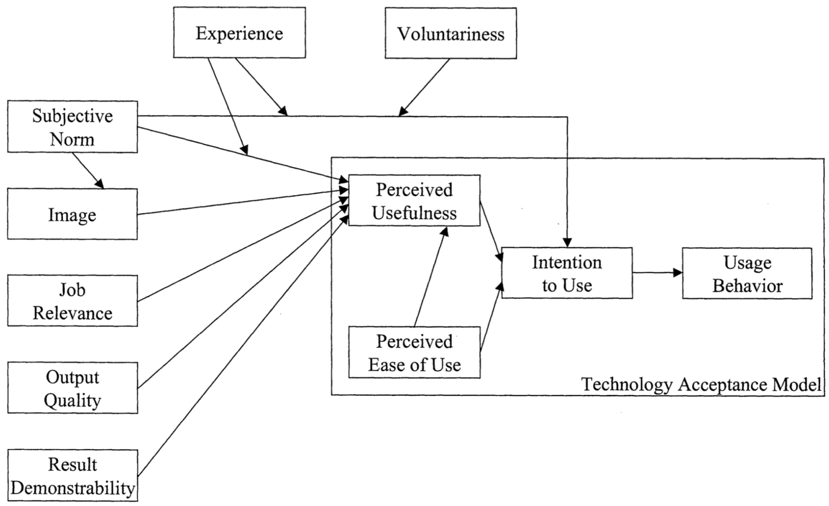


2.7.3 TAM - Technology Acceptance Model

Venkatesh and Davis's (2000) Technology Acceptance Model (TAM) (See Figure 6) was designed to help predict the adoption level of a new technological tool. TAM indicates that *perceived usefulness* and *perceived ease of use* are important indicators in which intentions result in higher or lower usage behavior. Perceived usefulness can be explained by the level to which it is believed that a system can improve one's job performance, while perceived ease of use can be understood as the level of effort required to understand the new technology. Further, if a technology is easy to understand, it will also work at increasing the perceived usefulness (Venkatesh & Davis, 2000).

Figure 6

TAM2 - Extension of the Technology Acceptance Model (Venkatesh & Davis, 2000)

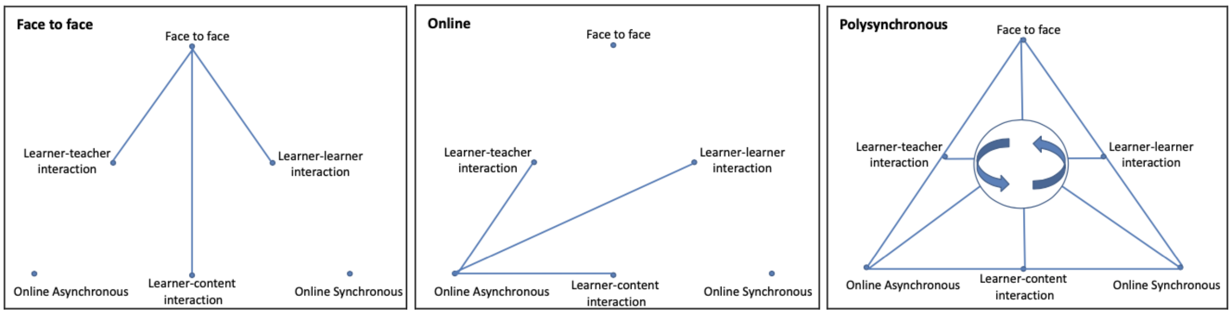


2. 7. 4 Polysynchronous Learning

Dalgarno's (2014) polysynchronous learning model (See Figure 7) aspires to discern the different patterns applied to generate student interaction and engagement. He defines polysynchronous learning as "the integration of learner-learner, learner-content and learner-teacher interaction through a blending of multiple channels of face to face, asynchronous online and synchronous online communication" (2014, p. 676). While in the past, online real-time collaboration was difficult or non-existent, it is now a reality that will likely continue. Although a well-designed, polysynchronous class can have a positive impact on student learning outcomes, effective polysynchronous learning environments are arduous to design and can easily result in cognitive overload. Educators are now facing the challenge to design learning experiences in which students can interact on multiple levels and remain engaged in the experience (Dalgarno, 2014).

Figure 7

Interaction patterns in Face-to-face, traditional online and Polysynchronous learning (Dalgarno, 2014)

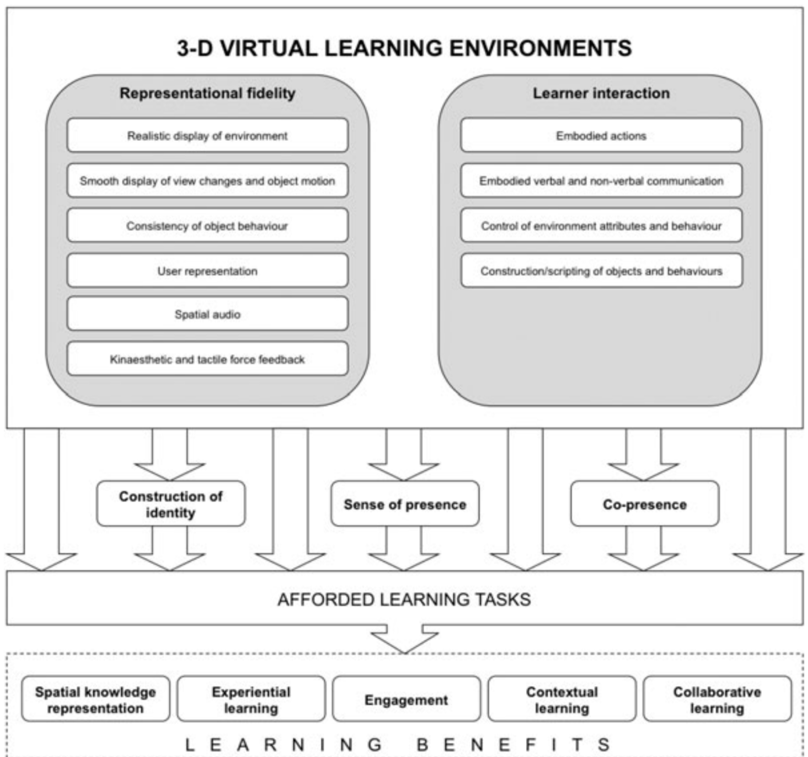


2.7.5 3-D Virtual Learning Environments

In 2010, Dalgarno established the elaborated model of learning in 3-D virtual learning environments (VLEs) (See Figure 8). The goal of this model was to guide further research and design of 3-D VLEs (Dalgarno & Lee, 2010). Dalgarno's (2010) model first presents the three different characteristics of 3-D VLE: construction of identity, sense of presence and co-presence. Dalgarno's (2010) model also presents five learning benefits of 3-D VLEs: spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning (2010). He assumes that advancements in technology will lead to better audio-visual and sensory experience that could lead to a better sense of presence and even co-presence that could have a greater impact on learning outcomes (Dalgarno, 2010). Technology has rapidly evolved in the last decade, leading to enhanced levels of representational fidelity. It may continue to evolve to levels that could make it difficult to distinguish between what is real and what is virtual. For this reason, it is crucial that researchers understand the effects, as well as the potential learning benefits and risks, of this powerful technology on young minds.

Figure 8

Elaborated model of learning in 3-D VLEs, incorporating unique characteristics and learning affordances (Dalgarno & Lee, 2010)



2. 7. 6 The Community of Inquiry (Col) Framework

The Community of Inquiry (Col) framework (see Figure 9) was first established by Garrison, Anderson and Archer in 2000 (Garrison et al., 2010). After much research and critical analysis, they identified key elements in designing meaningful online collaborative educational experiences. They have focused this framework around the different types of "presences" which are: social presence, cognitive presence and teaching presence. Further, their model also looks at how these different areas intersect to create a positive education experience.

Zhang et al. (2020) have used this model to investigate the sense of presence generated by VR in a real classroom situation. They have found that VR intensified the sense of presence, had a positive impact on engagement and interactions and, if properly designed, can be a more effective medium of instruction. They argue that teachers play a key role in fostering student engagement and fostering social presence. Teachers with high social presence are perceived as more active and effective. In turn, social presence leads to higher student and teacher satisfaction which leads to better learning outcomes. Zhang et al. (2020) demonstrate the need for:

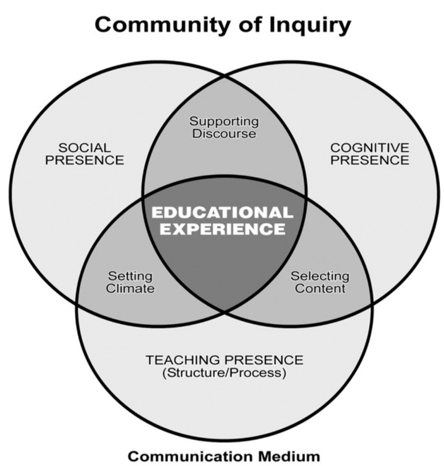
a) teacher training and experimentation in VR;

b) the development of course design in VR; and

c) the urgent need for further research in the field of educational VR.

Figure 9

Community of inquiry framework (Garrison et al., 2010)



2. 7. 7 The Actioned Pedagogy for Immersive Learning (APIL) Framework

Southgate (2020) developed the actioned pedagogy for an immersive learning (APIL) framework by incorporating pedagogy, practice and other literature about immersive learning. The goal of the APIL framework is to support educators in making informed decisions regarding the use of immersive VR applications to meet different educational goals. Southgate (2020) views her theory in three realms: the teacher realm, the learner realm and the technical realm. Educators should use the framework to plan student experiences in VR. In the teacher realm, she encourages teachers to identify the learning affordances of VR relative to the learning outcomes. In the learner realm, for example, she encourages teachers to plan so that students can collaborate, problem-solve and create on their own in VR. In the technical realm, she encourages teachers to consider the developmental stage of the learner relative to the selection of hardware and software. She argues that VR must be understood as an informed choice and more than a device that instantly generates learning (Southgate, 2020).

2.8 Gaps in the Literature

This review has identified several gaps in the literature on VR in education, such as, 1) how to use the technology properly; 2) how to design pedagogical activities with VR; and 3) the role of teachers and students while using VR technology. In particular more studies are needed to document what can happen at the convergence point between the technology, the pedagogy and the teacher's role. Much of the early research on VR was exploratory attempts to map the field. Research indicates the urgent need for further research in this field (Southgate, 2020; Zhang et al., 2020).

Research gaps can also be identified in terms of participants using the technology in a synchronous, collaborative and virtual world experience. This could be explained by the recent developments in the technology both in hardware and software making the equipment more affordable and accessible, and allowing for more realistic presence and social interactions.

Perhaps for similar reasons, much of the evidence in the field of educational VR was gained by using VR software created in-house by the research teams. While this technique allows better control over the learning situation, building VR software is time-consuming, expensive and it makes it difficult to create multiplayer interactions. In other words, it is difficult for a research team to create experiences that compared to the level of immersion and fidelity that can be experienced by using multimillion dollar commercial software.

Most of the research pertaining to VR in 3D VLEs was done using a computer-based "point-and-click" technology, leaving an important research gap in terms of fully-immersive technology (Dalgarno & Lee, 2010). While these studies are important, they do not measure the intensity of presence created by higher-end VR devices which could have a stronger impact on attaining learning outcomes.

Another significant research gap identified by this review of the literature is that little research has been conducted with participants over the course of multiple sessions. Bailenson (2021) also identified this research gap, stating that much of the research to date is limited to short 20-minute experiences and that this is not enough to provide data about behaviour or learning. Further, no one has studied the impact of repeated exposure in VR (Bailenson, 2021). For instance, putting the same people in VR eight to ten times over a short time period allows the researcher to measure the effect of repeated exposure (Bailenson, 2021). This repeated exposure allows users to become more familiar with the technology, perhaps leading to different results.

Finally, at this point there is no overall conceptual framework for teacher development in VR. There is not a lot of research conducted with teachers in VR. While this review found that some more passive simulations were created for teacher training, none included a social environment where teachers could engage with other educators in a collaborative, innovative, inquiry process to imagine how to use current higher-end VR technology to transform their practice.

2. 9 Summary of the Literature Review

In sum, rapid technological developments make it difficult for researchers to understand the educational outcomes possible with VR, while VR is making its way into the homes, schools and the workplace without a clear framework (Bailenson, 2021). Although VR in education seems promising (Dalgarno & Lee, 2010), others such as van Dam et al. (2002) suggest that the power of immersion alone justifies important investment in this field of research. Further, this literature review strongly suggests research is needed in the field that combines VR, educational VR and teacher training in VR.

2. 10 Research Questions

Since the literature review found that there are gaps in research surrounding teacher PD in immersive VR settings, four research questions were designed to guide this research:

1. What elements of virtual reality based PD are more engaging and effective using VR in a polysynchronous, collaborative paradigm?
2. How might VR yield higher levels of meta-learning in the design of engaging, contextualized and authentic learning experiences?
3. How do teacher participants new to VR plan to apply what they have learned from this experience?
4. How will this experience impact participants' pedagogical choices and future learning designs?

To seek answers to these questions, a research study was designed. This study is outlined in the Methodology chapter that follows.

3 Research Methodology

3. 1 Overview and Design

Reviews of the literature on VR in education reveal that there are important gaps in understanding VR and a need for further research in the field of education and VR, as well as teacher PD in fully immersive collaborative VR environments (Bailenson, 2021; Maas & Hughes, 2020). The review of literature in the present study shows that there are areas of VR teacher use that need to be explored, such as the how three key areas intersect: teacher PD, immersive technologies, and pedagogical design. This review informed the design of the present research study. Important research questions arose from the lack of current research in the field of virtual reality and teacher PD. These research questions are listed below in Table 6.

The research in the present study is exploratory. As Jacobsen (2014) puts it, when there is no clear vision of what is, then design-based research (DBR) is best suited to uncover a vision of what can be (Jacobsen, 2014, para.19). DBR, founded by Brown (1992), allows the research to use feedback from the participants to adapt and react by modifying the research as the study unfolds, rather than waiting until the end of the study. The present study consisted of eight sessions of teacher development in VR. The researcher reflected weekly after each session and used participants' feedback, video logs and observations to adjust the PD as necessary. As Brown (1992) argues, educational research "should encourage a reflective practice among students, teachers, and researchers" (p. 174) and should be conducted in an authentic learning environment. Following these criteria (Brown, 1992; Jacobsen, 2014) the research design of this study closely follows DBR. With DBR in mind, the researcher developed an 8-week PD training program for teachers in a fully immersive VR setting, knowing that changes would need to be made on the sessions and the design of the research, based on the participants' experiences.

The participants in this study were teachers in French First-language schools in one Canadian province. First, participants signed up for VR sessions on the Centre Franco's (CFO) website. The researcher shipped a new Oculus Rift headset to each participant. This allowed the participants the opportunity to try VR at home. The eight sessions provided them with the training to become more familiar with the technology in order to envision the pedagogical potential provided by this technology. Every week, participants met in Spatial (an Oculus app) to participate in training sessions where they were encouraged to share their ideas in small and large group discussions.

After each of the eight sessions, participants were asked to reflect on their own experiences and share their reflections and meta-learning by completing a questionnaire and creating a video log of their experience. The researcher also asked each participant to send in a weekly reflection through email or video to guide the design and redesign of each training session. McKenney and Reeves (2020) explain that this type of participant feedback is designed "to enhance understanding about the nature of learning and what facilitates it" (p. 85).

The data collected in this research included: weekly reflections, in class observations – surveys and video logs. These were analyzed once weekly and once following the project. The weekly analysis was used to guide the researcher's reflection in improving the training design by addressing theory-practice gaps (Jacobsen, 2014). Second, the researcher hoped that the teachers would be able to apply new teaching methods offered in the PD sessions based on their own experiences, reflections and meta-learning as defined by Holmes et al. (2019) and van den Berg (2019). Third, after each of the eight sessions, participants were asked to reply to a survey based on Kirkpatrick's (1998) levels to measure PD learning. Fourth, they also shared their reflections through a video log which was analyzed using the theoretical frameworks cited earlier in the literature review for this study (e.g., Puentedura 2008; Holmes et al. 2019). This formative assessment allowed the researcher to adjust the experiential learning design during the research rather than waiting until the end (e.g., Jacobsen, 2014; van den Berg, 2019). The sources of data for this study and their relationship to the research questions are explained in Table 6.

Table 6

Relationship between the research questions and the DBR

Research Questions	**Data collection**
What elements of virtual reality based PD are more engaging and effective using virtual reality in a polysynchronous collaborative paradigm?	Weekly reflections, in class observations – surveys and video logs.
How might VR yield higher levels of meta-learning in the design of engaging, contextualized and authentic learning experiences?	Weekly reflections, in class observations – surveys and video logs.
How do teacher participants new to VR plan to apply what they have learned from this experience?	Weekly reflections, in class observations – surveys and video logs.
How will this experience impact participants' pedagogical choices and future learning designs?	Weekly reflections, in class observations – surveys and video logs.

After each of the sessions, participants were asked to answer a short Google survey (See Table 7). They were asked to provide a short video or audio response after each of the sessions by answering the question, “Did the session today prompt you to think of any applications of Virtual Reality that could be used in your school or your classroom?”

Table 7

Survey Questions

1. Did you enjoy today’s session?
2. Why or why not?
3. What could have improved this session?
4. What was new learning for you in this session?
5. How might you apply what you have experienced in this session in your own classroom?
6. Other comments:

The data collected were then analyzed to evaluate the impact of the teacher PD (PD) based on Guskey's (2016) five levels of the impact of PD. At the first level, the researcher evaluates the perceptions and impressions of the PD by asking if the participants liked the experience, if it seemed to be worthwhile, if it was well planned and meaningful, etc. Then at the second level, the researcher assesses the questionnaires and interviews to see if there was an improvement in acquiring new knowledge, skills, attitudes and dispositions from one session to the next. Participants were asked to share how they plan to apply the concepts of the PD in their own classroom and how it will impact their own teaching design. This matched the analysis of Level 3 of PD which is the application level (Guskey, 2002). The other two levels *level 4: participants' use of new knowledge and skills and level 5: student learning outcomes* were not included in this research.

3. 2 Limitations

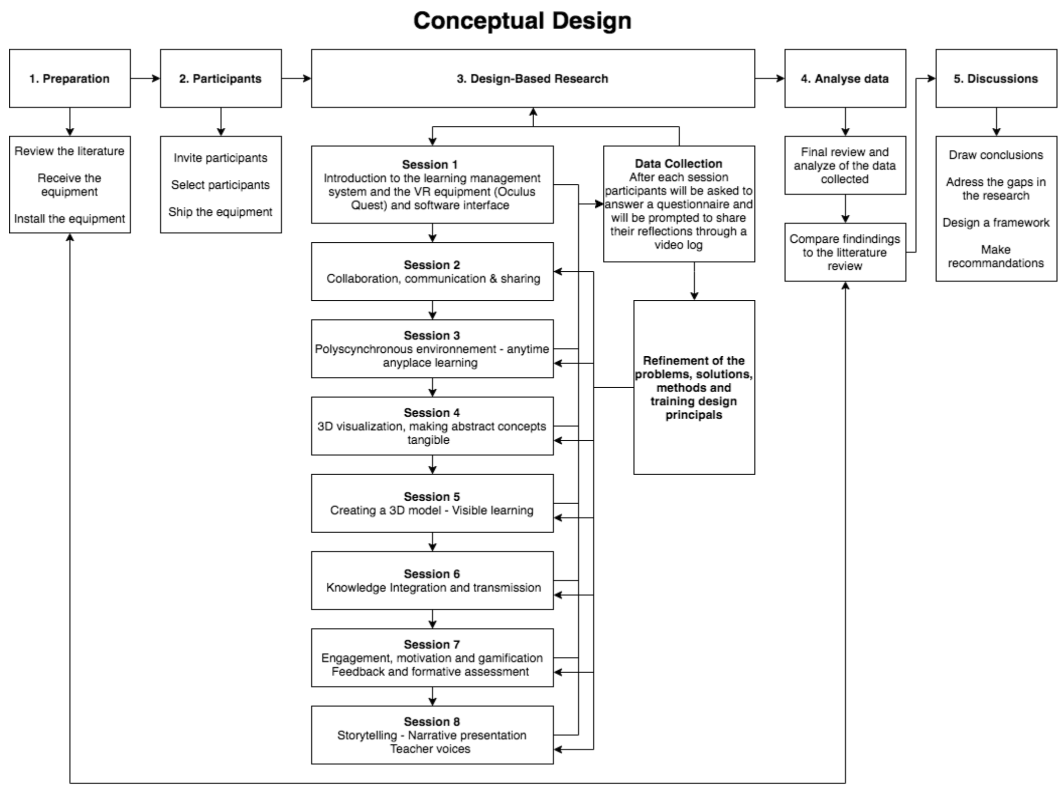
This research was limited in terms of time and cost. It took place over the 2020-2021 school year. Due to financial constraints, the researcher chose to focus the research on one type of hardware, the Oculus Quest, which is the entry level of the higher end virtual reality systems. It allows for a higher level of immersion with 6 degrees of freedom (DoF) with the possibility to interact with the environment as well as other participants (Oculus Quest, Oculus VR LLC, Facebook Inc.). This study used only the software that is available to buy and download from the Oculus store (Oculus Quest, Oculus VR LLC, Facebook Inc.). Unpredictable factors related to COVID-19 did impact this research. Due to the limited sample of participants and limited timeframe for the study, findings could be replicable but not generalizable. This research will, however, pave the way for future research as it is one of the first in this field to engage teacher participants in multiple sessions in VR over a defined period of time.

3.1.1 Conceptual Research Framework Diagram

The following figure (Figure 10) illustrates the different steps needed to complete this research.

Figure 10

Conceptual research design (Girard, 2021)



3.3 Preparation

In preparation for this research an extensive review of the literature and a preliminary field research was conducted. This review found that:

- ✓ There is no clear roadmap on how to use or implement VR in schools;
- ✓ When it comes to using VR, the role of teachers and students is unclear;
- ✓ Few schools currently have access to high-definition VR systems; and
- ✓ Even fewer teachers have the skills or training on how to design learning experiences using VR; and
- ✓ There is no clear framework for teacher PD using VR.

With this in mind, this research was intended to provide teachers with the opportunity to try and experiment with VR; to build skills and competencies for using VR; to connect with other educators in a fully immersive virtual world; to engage in a collective inquiry process; and to imagine what the future of education could look like using VR.

3. 3. 1 VR System

Many VR systems were considered for this research; among these were the HTC Vive, the Oculus Rift S, Oculus Quest and the Oculus Go (see Table 8). The higher-end consumer devices such as the HTC Vive Pro and the Oculus Rift S were not selected because their systems require expensive gaming computers, making their entry price points much above $2 500 per unit. Meanwhile, some software such as Google Earth VR is currently only able to run on such a high-end machine; the cost and the necessity to ship the equipment meant that these were not viable options. While the Oculus Go could have been interesting, it quickly became obsolete and did not offer the possibility of a fully immersive collaborative 6 DoF experience. Further, many schools may already have the Google cardboard type of VR devices, where the users add their smartphone to the apparatus. This offers a passive experience that can easily create cybersickness.

For its high level of immersion, price point, easy mobility and shipment possibility, the Oculus Quest system was originally chosen for this study. While the online store for the Oculus Quest is currently more limited in terms of software choices, it does offer the possibility to experience fully immersive collaborative experiences. Yet, right before these systems were purchased, Facebook released the Oculus Quest 2 on October 13th, 2020. As an attempt to dominate this market, the cost of the Oculus Quest 2 was lowest (CAN $459), the device was lighter and offered a higher resolution and a better overall experience. For these reasons, the researcher opted to conduct this research with the Oculus Quest 2 as the lower cost meant that more participants would be able to take part in the study. This new technology also has a significant impact on consumer and business purchases. This was made evident at first by the high level of demand that made it difficult to acquire the research equipment. This was later confirmed by record sales that surpassed the company projections (Facebook, 2021). This illustrates the urgent need for research, making this study more relevant and significant.

Table 8

VR system comparison

Equipment	Approx. price	Immersion	Software	Portability	Other Comments
HTC Vive Pro	$ 2000 +	High	Large selection	Not portable	Needs a gaming PC add more than $ 2000
Oculus Rift S	$ 500 +	High	Large selection	Not portable	Needs a gaming PC add more than $ 2000
Oculus Quest	$ 600 +	High	Limited selection	Easy to ship	The Quest was originally selected for this study before the Quest 2 came out (October 13th, 2020)
Oculus Quest 2	$ 500 +	High	Limited selection	Easy to ship	It was selected for its price, portability, immersion, definition, and interesting available software (although limited). High demand is more difficult to acquire.
Oculus Go	$ 250 +	Medium	Limited selection	Easy to ship	This system could have been interesting but became obsolete. Does not allow for fully collaborative immersive experiences.
Google Cardboard	$ 10 +	Low	Limited selection	Easy to ship	This system could have been interesting. Does not allow for fully collaborative immersive experiences. Easily creates cybersickness.

3. 3. 2 VR Software

The VR software used in this study was carefully selected. First, the software needed to be available on the Oculus store platform. While most studies create their own in-house software to have more control over the simulations, this requires a larger investment in terms of time and money. Further, this could not be easily done by participants who wished to integrate VR into their own practices. Second, the software needs to allow for interaction between participants. In order to have participants engage in a collective inquiry practice, the software has to allow the possibility for a synchronous multi-user experience. Third, the level of realism, fidelity and overall experience was also considered. Fourth, to provide a positive user experience, the software needed to minimize the risk of cybersickness. As users transition into VR, an interesting feature is the accessibility of the app from other devices such as phones, tablets and computers. Other aspects that were taken into consideration were: the ease of use, the price, the privacy settings and the availability for French language settings.

The researcher classified the selected software into four main categories: the tutorials that can be used to learn how to utilize the equipment and build an understanding of how to interact in the software (e.g., First Contact, First Steps, etc.); the simulations that allow an experience with minimal interaction (e. g., Notes on Blindness, Anne Frank House, Gravity Lab, Ecosphere, etc.); the creative apps that provide the tools to create in VR (e.g., Tilt Brush, King Spray, Gravity Sketch); and the social apps that allow a multi-user creative experience (e.g., Spatial, Altspace, Alcove, Engage, etc.).

3. 4 Research Ethics Board (REB)

Once the professional training sessions were designed, the study was submitted for review to the Research Ethics Board (REB) at Ontario Tech University. Permission to conduct the research was granted by the REB (Ref No: 16082). Research was scheduled to take place between September 9, 2020, and May 3, 2021.

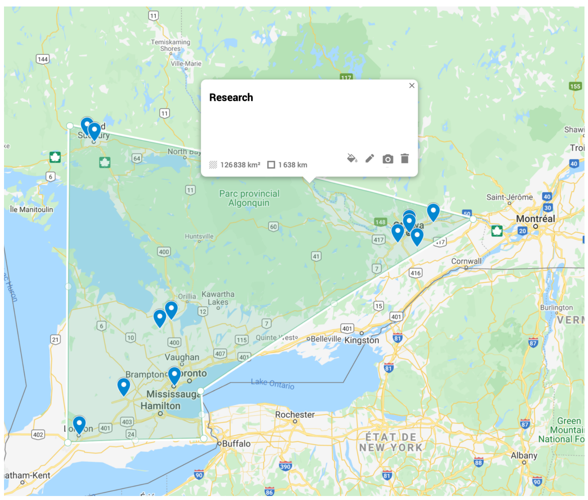
3. 5 Participants

The recruitment of research participants was conducted by email (See Appendix B). The Centre Franco Ontarien (CFO) listed this immersive PD in a publication for French School Districts. Participants who registered for the PD sessions were invited to take part in the study by email. Participation in the study and the sessions was voluntary and was considered to be enrichment (not part of a program or certificate). The number of participants was limited by the availability of the equipment needed by each participant in order to take part in the study. Thus, the participants were selected on a first come, first served basis. The CFO was chosen to provide this training as it already offers professional training opportunities to more than eight thousand members (Association des enseignantes et des enseignants franco-ontariens, AEFO, 2021) covering each of twelve French first language speaking school boards in Ontario.

The eleven research participants that consented to take part in this study are First French language Francophone teachers from the province of Ontario, Canada (See Appendix C.). This diverse group includes a variety of elementary teachers, high school teachers and teachers occupying consultant roles. All have different experiences and skill sets both in terms of technology and pedagogy. Since this training was done on a voluntary basis, it is believed that participants who enrolled in the study had an interest in virtual reality. With the aid of the device and an Internet connection, participants could take part in the study from their own homes which are located on a vast territory measuring more than a hundred thousand square kilometers (see Figure 11).

Figure 11

Geographical location of research participants (Girard, 2021)



Note. For privacy reasons, locations were generalized to city centers

3.6 Funding

The researcher would like to acknowledge that this study was funded by Cadre21 (**https://www.cadre21.org/**). The research study was conducted as a pilot project for a larger partnership project between Le Centre Franco-Ontarien de ressources pédagogiques (**https://www.lecentrefranco.ca/**) and OntarioTech University funded by a Social Sciences and Humanities Research Council (SSHRC) Partnership Engage Grant.

3.7 Immersive PD Sessions

For this study, eight fully immersive training sessions were designed to create engaging, contextualized authentic educational experiences in VR (See Appendix A for full session descriptions.). Using DBR methods, the researcher engaged in continuous reflection following each session and adapted the direction and content of the PD sessions in light of observations, discussions, participant survey and video log entry. The original plan was too ambitious to respect the timeline and needed to be modified to meet the skill level of participants to provide them with a positive PD learning experience. Table 9 provides a side-by-side comparison of the original plan, and the modifications as well as the rationale for the changes.

Table 9

Side-by-side comparison of the PD session changes and rationale

Original session plan posted to participants	**Actual session**	**Rationale**
Session 1 – Introduction to VR Oculus Software and Hardware During this first session participants will be introduced to VR technology. They will learn how to safely set up and use the VR equipment by setting up the guardian. They will experiment with the Oculus software and learn how to navigate through the different menus and options. They will practice interacting within the virtual environment using the remotes, their hands, their bodies and their microphones. Collaborators will discover the different levels of VR immersion. Teachers will share their first thoughts about the equipment, software and experience and how it could be used to transform their current and future educational practices.	This session was conducted in Microsoft Teams. The researcher took some time to meet the participants, their roles, goals and interest in VR. In the second part of the session, participants were asked to set up the equipment and the guardian. Participants were asked to complete two tutorials in VR (First steps and first contact).	Teams was used to set up the backchannel for technical help. The researcher wanted to get to know the participants to establish their learning goals and their initial skill level. Skill levels varied (some had already tried the equipment while others had not yet opened the box). Before the next session an email was sent with a video and pdf guide on how to set up the equipment to provide support.
Session 2 – Collaborating, Communicating and Sharing in VR In this session participants will create their own realistic avatar and they will embody their newly created avatars to enter virtual rooms and meet other participants in a virtual environment. In this space, participants will exchange ideas on what education means to them. They will experiment with different virtual tools such as post-its, 3d models, collaboration boards, pens, etc. to illustrate and share their ideas. Collaborators will be introduced to the SAMR model. Then they will be asked to share their definition of teaching and share thoughts on how	This session started in Microsoft Teams. Half the session was used to guide participants in creating their own realistic avatars. Then participants connected their head sets to embody their avatars by meeting in the collaborative immersive room in Spatial.	Some participants were unable to connect to the room due to their schoolboard email being blocked. Technical support was offered online in the backchannel – Microsoft Teams prior to session 3.

they think this technology could change the way they currently do things.		
Session 3 – Polysynchronous Environments – Anytime Anyplace Learning In this session participants will reflect on how their practices have evolved over the past years and particularly in the last year due to the recent global pandemic. By using different software, collaborators will be introduced to what a polychromous environment is. They will discuss current teaching models and be asked to share their thoughts about how his technology could support teachers and student learning given the current conditions.	This session was done in Spatial. Participants meet all the other participants virtually. They explored the basic tools within the app (adding post-its). The researcher used a presentation in Spatial to present the SAMR model. Participants discussed and exchanged ideas on VR and the future of education.	For the next session, the researcher did not want to place participants alone in a simulation. Building on this session, the researcher wanted to demonstrate how the app can be used to facilitate group work.
Session 4 – 3D Visualization, Making Abstract Concepts Tangible In this session participants will be asked to envision something that is difficult to imagine. What would it be like to be blind? They will share their thoughts with other participants before being transported in a simulation, Notes on Blindness. This VR simulation will let participants experience what it would be like to be blind. Once the simulation is completed, participants will be asked back into the common virtual environment to share their thoughts by adding to their original reflections. Teachers will be asked to share if this experience has helped them make this abstract concept more tangible. They will be asked to reflect on if simulations like this one could be created to help students and teachers learn abstract concepts.	This session was done in Spatial. In this sessions participant were divided into 4 groups. They were asked to go into a room that presented one of 4 VR applications – Notes on Blindness, Anne Frank's House, Gravity Lab or Ecosphere. They were asked to share ideas with fellow participants about how they could use an app like Spatial or the one illustrated in the room to transform their pedagogy. They were asked to explore the simulations on their own to present their impressions to the group.	It was difficult for some to move from room to room. Since this was difficult, it appeared that session 5 as originally planned would be too far outside of zone of proximal development of participants. Participants wanted to explore more applications, tools and options and build their skills and understanding. They wanted to know how to use Spatial in Blended and in Virtual contexts. Session 5 was adapted to this need.
Session 5 – Knowledge Integration and Transmission In this session participants will travel to the city of lights, beautiful Paris. They will be guided on a virtual tour on board a double-decker bus to discover this city's rich history. Once they have completed this visit, participants will be given the opportunity to explore the environment and reflect on their experiences. They will ponder on the impact a simulation like this could	In Microsoft Teams and with the Web Spatial app. Resources presenting different application suggestions, tutorial and training resources were presented. A group discussion about VR, their own personal exploration, impression and pedagogical intentions. Participants were asked to share what they would	Due to the complexity of connecting multiple users in the app Alcove and participants wanting to develop and build their capacity within one app, participants were invited to explore Alcove on their own. Participants asked to have more time to explore and create a lesson. They also

have on knowledge integration and transmission. This lounge setting will be decorated and personalized with travel photos shared in advance by participants. In a show and tell approach, participants will be invited to discuss their images, thoughts and experiences with other participants in smaller or larger groups.	like to start, stop or continue in the training. Using the web version of Spatial participants were taught how to share their webcam, add content from the cloud, share their screen, and create rooms, etc.	wanted to work in small groups. Session 6 was modified to this end.
Session 6 – Engagement, Motivation and Gamification – Feedback and Formative Assessment In this session participants will learn about gamification through first-hand experience. They will be asked to work as a team in a set of friendly team-based competitions. Participants will work together to solve puzzles, play team sports and other interesting activities such as taking flight side by side into virtual planes. As participants discover and play, they will be asked to reflect on their own level of engagement and motivation towards this experience. They will discuss and compare this experience to more traditional and emergency teaching responses to identify the role of experiential learning, play and feedback for teaching content as well as 21st-century competency.	Within Spatial. Participants were divided into two groups (elementary and secondary). Teachers and joined their team's room to begin their brainstorming to create the culminating task, designing an age-appropriate lesson in Spatial.	Teachers wanted to work as a group and explore the tools and functionalities in Spatial. They wanted to have the time which was provided here in sessions 6 and 7.
Session 7 – Creating a 3D Model – Visible Learning In this session participants will learn how to make their learning visible by creating a virtual 3D model. By using different three-dimensional shapes and tools, participants will unleash their imagination to create a 3D representation of their ideal learning environment. Participants will use these tools to illustrate what they have learned thus far. They will be encouraged to take selfies of their avatars and digital photos of their work with the integrated camera option. Participants will exchange ideas on their model and discuss how this could be used in the context of teaching, teacher training and PD.	Within Spatial. Participants planned their lesson by exploring the tools within spatial, importing content from the cloud and other web apps.	Teachers wanted to work as a group and explore the tools and functionalities in Spatial. They wanted to have the time which was provided here in session 6 and 7.

Session 8 – Storytelling – Narrative Presentations – Teacher Voices In this final session participants will be asked to share with the others what they have learned from this experience. Using the virtual tools and models, they will explain how they would like to use this technology to improve their teaching and support student learning. Based on their professional experience and new-gained knowledge of VR they will make recommendations for its use in terms of pedagogical design. Through discussions they will help guide further research by imagining how this technology could transform the world of education, teacher training and PD.	Within Spatial. Group 1 – Elementary presented their lesson to group 2. Group 2 – Secondary presented their lesson to group 1. Participants meet back in Microsoft Teams to prepare the equipment for return.	Participants wanted more sessions.

In the first session, participants were introduced to the VR equipment and the software. The goal of this first session was to get participants to try the equipment for the first time and assess the general skill level of the group. In the second session, participants created their own realistic avatars and embodied them to meet the other participants for the first time in a 3D virtual environment. In the third session, participants engaged in discussion in a fully immersive collaborative VR with other participants. They were encouraged to think about current teaching and how technology could support teachers and student learning. In the fourth session, participants were divided into four groups. They were guided to four different rooms where each presented a different VR simulation available in the Oculus Web store. They were asked to think and discuss how such an app could be integrated in their practice. In the fifth session, participants engaged in a group discussion about the resources they explored and the PD session thus far. They were introduced to the web version of Spatial which allows them to share their webcam, add content from the cloud, share their screen, and create rooms in Spatial VR. In the sixth session, participants were divided into two groups (elementary and secondary) to brainstorm a lesson they could teach in Spatial. In the seventh session, participants planned and developed their session and prepared their presentation to the other group. The final session was used to present their lessons to the other participants. Teachers were invited to share what they have learned from this experience. The goal of this last session was to provide teachers with an opportunity to share their ideas while learning from other participants.

3.8 Data Management Plan (DMP)

All the data for this research was obtained online and was stored in a secure password protected drive regulated by the Ontario Tech University in a cloud-based Google environment that is accessible by the graduate student and shared only with the research supervisor (See Appendix D). Further, the survey did not collect personal information. The audio and video recordings were transcribed. Each participant was assigned a pseudonym in the written transcription and the audio and video files were deleted. Lastly, the data reported from this study could not be connected to any participant. If names were used, the data was anonymized.

3.9 Data analysis - Validity and Reliability

As the survey data is mostly open-ended, it required qualitative data analysis. In addition to looking for emergent themes (Creswell & Poth, 2016), the researcher used Kirpatrick's (1998) levels of PD to analyze the responses. In addition to looking at emergent themes, the researcher used Puentedura's levels of teachers use of technology framework to analyze the responses.

As McKenney and Reeves (2020) explain, DBR should employ the same rigor as qualitative, quantitative or mixed-method studies (e.g., reliability, validity, credibility, transferability, dependability, conformability). For this study, data was gathered through observations, discussions, surveys, video logs and through the analysis of the culminating task. No data was discarded; everything was considered and classified. The researcher organized the data by identifying common themes. There were multiple themes in the first analysis of the data. Next, the researcher looked for common threads among the themes, and started to collapse the themes. Seven common themes emerged from this exercise that were then analyzed using frameworks such as Puentedura's (2006) SAMR model presented in this study's literature review. This led to the synthesized findings which are reported in the next chapter.

4 Findings

This section reports on the Francophone teacher responses to VR PD throughout the eight-week study in 2021. During this time, most of their schools were closed because of the pandemic and the teachers were teaching online. The participants represented six school districts across Ontario. There were five elementary teachers and six secondary teachers. The eight PD sessions were held weekly for 2-hour periods on weekends. In the sections that follow, the findings from the analysis of the individual elements of the data collection are explained.

4.1 Survey responses

At the end of each of the eight sessions, the research participants were asked to reply to a quick six-question survey that was based on Guskey's (2016) five-level model of the impact of PD. The 11 participants chose to answer the survey at least once. Out of the 88 possible replies, 62 responses were collected but some questions were omitted. These responses were used to evaluate the effectiveness of the training program which is explained in section 4.2 below.

4.2 Impression about the experience

Using Guskey's (2016) five-level framework as the basis for analysis, the researcher wanted to obtain a sense of participants' first impressions of the training. At the first level, participants were asked: "Did you enjoy today's session?" Using a Likert scale, where 1 is No and 5 is Very much so, participants rated the training on average as a 4.61 out 5 (N=62) (See Figure 12), meaning that, on average, participants enjoyed the immersive training sessions. A more detailed breakdown (See Figure 13) shows that one participant did not enjoy one of the sessions and that four only somewhat enjoyed the session.

Figure 12

Participants average response to Question 1

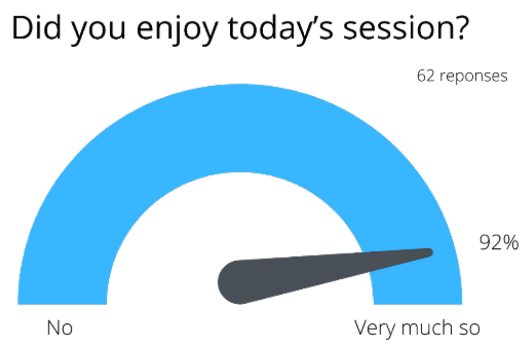
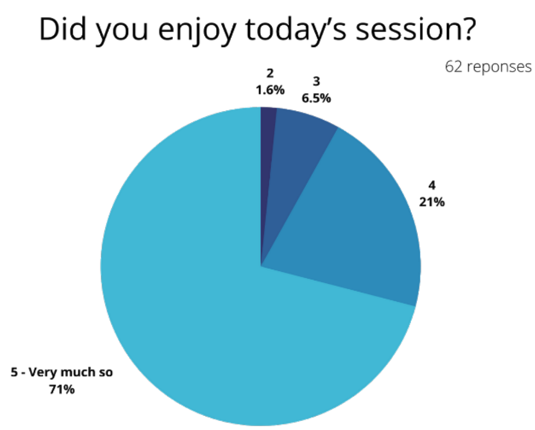


Figure 13

Breakdown of participants responses to Question 1



4. 2. 1 Why or Why Not?

The second survey question sought to delve deeper into understanding why participants enjoyed or did not enjoy the training session by answering the question, "Why or why not?" Participants who had responded positively (see Figure 14) mentioned that they liked being able to share and exchange ideas with other professionals. They said that this gave them ideas and insights on how to integrate the technology into their own practices. Another positive theme among participants was the final project presentation. During the last sessions, participants were divided into two subgroups: elementary and secondary teachers. They worked as a group to design and present a sample lesson in VR to the other group. Some participants mentioned that they liked discovering what the other group had presented in addition to presenting their lesson. Further, some participants attributed their positive experience to being in a 3D meeting room with a nice landscape and being able to feel more present and focused in comparison to more traditional modes of virtual meetings such as Zoom, Google Meet and Microsoft Teams. Figure 14 below demonstrates the frequency of recurring participant descriptors. Words in larger font are representative of the number of times the participants used a word to describe why participants enjoyed the session.

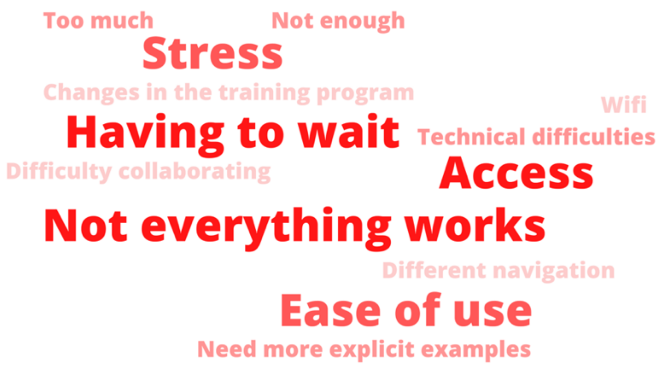
Figure 14

Key themes why participants enjoyed the session

The less positive aspects of the training sessions according to the participants (see Figure 15) was that some participants reported that they felt stressed because they had technical difficulties and it required them to wait until they got connected. Some participants initially used a school board email that disabled their access to the app and had to switch to a personal email account. Another participant could not get connected because the room was too dark and the headset could not calibrate the room, and it took 30 minutes of trouble shooting to find the problem. The degree of difficulty of the training was reported to be too much for one participant and was not enough for another. In the mind frame of an evaluative DBR, some changes were made to the training program, but this change proved to be frustrating for one of the participants who described this frustration in the survey and gave a 2 out of 5 rating for the revised session.

Figure 15

Key themes why participants did not enjoy the session



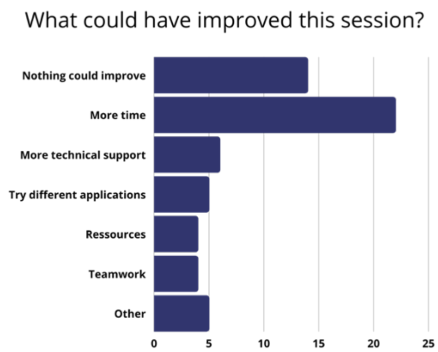
Note. Font size is in proportion to the number of times it was mentioned by participants.

4. 2. 3 Participants' Suggestions for Improvement

When asked what could have improved the session (see Figure 16), 14 responses (N=56) said nothing could have improved the session. Another 22 (N=56) responses mentioned that they wished they had more time in the sessions or that the training lasted over a longer period of time (e.g., ten sessions instead of eight). Meanwhile, six responses indicated that they would like to have more technical support, four would like more resources (videos, course materials, tutorials) and another four would have preferred different groups or types of grouping. Participants' views on the ideal group size were mixed as some said that they would prefer larger while others requested smaller groups. Other suggestions included providing more examples (including modelling a lesson), going over software functionality in more detail, clearer course expectations and more curriculum content-related VR applications.

Figure 16

Participants' summarized suggestions for improving the different sessions



4.3 Participant Learning

To evaluate the learning that took place, participants were asked to identify new learning after each session. To this question, 55 (N=56) responses mentioned that participants (N=11) learned one or more things in the session; these included 93 individual learning occurrences about how to use VR, integrate pedagogy or developed a new attitude such as empathy, engagement and growth mindset. However, 1 (N=56) survey reply indicated that the participant did not acquire any new knowledge during one of the sessions.

The survey responses indicate that participants gained a considerable amount of knowledge in the training sessions, and, for most participants, everything related to the reality that this high-level of VR technology was new to them. They all learned how to use the equipment and how to use the Spatial software. Many participants were surprised by the possibility and level of realism of their avatars and by being able to interact with the other participants (see Figure 15). Further, they were surprised by the different types of environments (see Table 2) and by the ability to move and to teleport. They learned how to interact and access the creative tools within Spatial to add 3D objects, Post-its and take a selfie. Additionally, participants shared that they were impressed by being able to access their own documents from the cloud (Google Drive or Microsoft OneDrive). Many mentioned in their response that this option helped them envision the possibility of teaching using VR. While they all indicated that they acquired new knowledge, skills or attitudes, most participants wanted to further pursue their exploration of VR. They mentioned that they would like to sign up for a follow-up session or were looking to purchase their own headsets.

Figure 17

Participants gather for a group photo with their avatars in the app Spatial 3.0

Note. Photo used with permission of the participants

4. 4 Implementation in the Classroom

While teachers do not yet have access to VR technology in their own classrooms, the researcher wanted to assess potential classroom implementation. Participants were asked: “How might you apply what you have experienced in this session in your own classroom?” In the first couple of weeks of the immersive training, participants indicated that they did not know or see how they could potentially integrate this technology in their classrooms. Yet, their answers were more detailed and informed as the weeks went by. Implementation ideas included seeing the world, visualization, manipulation, modelling, collaboration, breakouts, social-emotional skills, social presence growth, cognitive presence growth, and future applications.

4. 5 Examples of Implementation in the Classroom

Open-ended questions in the weekly surveys and participants’ video and audio logs were analyzed to identify examples of teachers’ thoughts about future classroom implementation. Teachers had interesting comments about social presence, particularly after spending a year on Google Meet, Microsoft Teams or Zoom. One participant said:

> Just having a virtual "3D" meeting, rather than just Google Meet makes a huge difference in my opinion. 2020-2021 has shown us how difficult it can be to keep

> the students' attention during a virtual meeting (ditto for the staff) and the distractions around are numerous. As we find ourselves in a situation where we can find ourselves in virtual teaching from day to day (and who knows how long that will last), I think this is a great way to engage and motivate students.

Another participant saw the potential for VR to help engage students in more active learning and shared a similar opinion by saying:

> For my lessons, I will use the different rooms which is exactly what I am looking for. My class is based on teamwork and collaboration between students. Restrictions due to the pandemic prevent this kind of activity from happening. VR is a solution for me in the future for my classes. Plus, the applications we have explored have all the tools I would need to achieve my course objectives and engage my students in their learning.

One participant thought that VR could help students achieve higher levels of cognitive presence through visualization, creating "a livelier classroom, allowing students to make a better connection between their learning and their experience thanks to a real visualization." Another thought that VR would allow students to achieve a deeper level of understanding through visualization. One participant considered the interactivity affordance of VR and explained:

> I wish I could use this concept of virtual reality as part of my science and social studies, visual art and math classes. I think virtual reality makes the unimaginable accessible. It opens up a really big window to exploration and discovery. Students will be able to see, touch, create, regardless of their level of study. I can easily imagine myself teaching a group of students in virtual reality.

Another teacher also saw that VR could be used for spatial sense (manipulation) and student-directed learning stating, "I love that I could create a space in Spatial where students can walk around and watch and manipulate the resources available to them. As a teacher, I would be the facilitator of a self-guided lesson."

One participant indicated an interest in taking advantage of the social presence possibilities offered by VR for collaboration, saying:

> I could ask the students to create this type of room on a given topic. I could also give one room per team and the class could move from room to room to learn

> from the work of the others. I think such an experiment could serve as the final task for an evaluation. I could also present this room in a real classroom.

Meanwhile, another teacher saw a future use of VR as a mental health break, explaining:

> For now, I feel a great sense of escape and calm. I believe that an environment like this could help students who need to take a break or a sensory break according to their needs. So, for now, I see benefits related to classroom management and the socio-emotional domain.

4.6 Teachers' Voices

In seeking to represent the voices of the teacher participants, the researcher analyzed the themes and subthemes (Creswell & Poth, 2016) in the qualitative data from the open-ended survey questions, the video and audio logs. These are presented next.

One participant explained the wow factor of VR. They said, "Wow you have to live it to believe it. Because everything we went through was incredible. If someone explains it to you, you can't really grasp exactly the possibilities of virtual reality." Another shares how this study brought them a new pedagogical perspective stating:

> I was moved by this training, because it allowed me to see the teaching from a new perspective. In addition, with all the challenges that the pandemic has brought, virtual reality is undoubtedly a way out and a hope to do better.

One participant explained how VR could be used to provide long-lasting experiential learning. This participant "visited" Ann Frank's room in VR in the virtual Ann Frank house VR and noted "I was in her room. I was also there where she hid before going to the concentration camps. I have an image. It's a visual I will never forget."

A participant shared that due to its immersive nature, VR could help students concentrate, explaining, "What strikes me the most is that you can't be doing other things at the same time." Meanwhile, another participant describes the pedagogical innovative possibilities for engagement this way: "The possibilities are endless. To change our environment, change our way of teaching to be able to hook young people, it's really cool!" Further, another shares what they foresee saying, "When the novelty effect will diminish, it is still an incredible tool."

In this time of physical isolation due to the global pandemic, participants see VR as an opportunity for collaboration and wellbeing. One participant stated that, "Virtual reality makes it possible to vary learning environments. Being able to discuss or collaborate in a large group or in small groups increases the motivation and commitment of everyone (students, teachers, etc.).” Another saw that potential for breaking the social isolation saying, “Like my mother who is experiencing loneliness now. Well, I think it would be amazing if she could be at the beach… I think it would help a lot especially at the moment.”

Participants indicated that they cannot wait to integrate these tools into their practice. One of the participants took the HMD into their virtual class on a snow day to show their students and shared:

> A few of my students were able to try out the HMD. Three of them already had an HMD at home. The others were very impressed with the functionality of the HMD. By talking to them, many see a place for the HMD in schools and even predict that it will be glasses rather than an HMD.

Another teacher made a plea to the Ministry of Education stating, “I hope that the ministry will follow ... a good start would be to immerse them in virtual reality so that they see the potential.” Later, this participant indicated the importance for teachers to work with app creators stating, “I would really like to participate in the collaboration with the creators of the applications, especially if we want virtual reality to be at the service of learning.”

One of the participants found the equipment very uncomfortable and said, “It's unfortunate that the Oculus HMD is so uncomfortable on my head. I have to support it with my hands, otherwise I cannot tolerate it for more than 10 minutes at a time. This hinders my experience.” One other wanted more time to explore other apps, but the time frame did not allow it.

In summary, survey data showed that teachers generally saw potential benefits in pedagogical designs in VR such as creating interactive learning activities by using the virtual tools to enhance content visualization. Though participants witnessed these potential benefits, most participants wanted to explore VR further to create more pedagogical content in VR. Similarly, they were interested in keeping up with how VR will transform education. The negative aspects identified included HMD discomfort and technical difficulties.

4.7 Researcher as Participant and Observer

After each of the sessions, the researcher reflected on the session with a partner (her thesis supervisor, Dr. Robertson) and made notes. Once the sessions were completed, the written reflections were analyzed using Creswell & Poth (2016) to identify the themes and subthemes. The following themes emerged: time, technological skills, technological support, backchannel, polysynchronous learning spaces, patience, emergent leaders and social VR.

4.7.1 Time

A considerable amount of time was spent evaluating hardware and software to design this immersive training program. Training was conducted over the course of one hour for an eight-week period. After each session, the researcher took the time to reflect on the session and review the feedback from the participants to adjust and plan the training before the next session. At the beginning of the training sessions, not all participants were ready to start on time; some participants took 5 to 15 minutes to enter the session in Spatial. After a group discussion on the importance of maximizing the time together, participants began to connect earlier by giving themselves more time to access the session. Meanwhile, most participants found that the training or the sessions were too short; participants were always surprised to see the sessions come to an end, indicating possibly that the virtual time of day (always day or night time) within the environment could impact the ways in which one perceives time.

4.7.2 Technological Skills

While all participants were able to use the equipment and the Spatial software, among participants there was a wide spectrum of technological skills demonstrated. On one hand, participants felt overwhelmed by the level of skill required to operate the equipment and on the other, participants wanted to explore more applications and functionalities. Indeed, many participants explored other applications and those who did, said that they really enjoyed the experience. Some participants were impatient and felt frustrated when confronted with technical difficulties or when they were limited by what the app could do. These feelings of frustration and impatience might also have been related to other factors unrelated to the training such as the COVID-19 global pandemic.

4.7.3 Technical issues

During the training sessions, technical support was provided to participants. One of the major technical issues was due to the fact that some participants used their school board email to create their Spatial accounts and were blocked by their board's firewall. Participants had to create a second account with a personal email. A second technical problem was that one of the participants was using their headset in a room that became too dark as the sun set and the headset could not define a guardian (safety zone) and could not work. Issues like this one are more difficult to diagnose when using VR since the person providing the technical support cannot see (at this point in time) what the participant sees in VR. Therefore, the participant must describe to the technical support person what they can see to the best of their ability to troubleshoot the issue.

4.7.4 Back Channel

A back channel in Microsoft Teams was created to facilitate this training while participants took the training virtually from their own homes. The Microsoft Teams platform was used also to provide the initial training and was used to provide technical support as needed by participants. Further, participants received a guide with resources on VR as well as a guide to use the equipment along with weekly email broadcasts.

4.7.5 Polysynchronous Learning Space

The polysynchronous nature of the training requires participants to be able to multitask. Participants had to manage face to face, online synchronous and asynchronous learning as well as learner-teacher interaction, learner-learner interaction and learner-content interaction (Dalgarno, 2014). The multiple channels of communication seemed to cause cognitive overload among some participants.

4.7.6 Emergent Leaders

Leaders among the participants emerged naturally through this training process. Some took the initiative to try the equipment in between sessions or looked into purchasing their own. Many willingly shared their experiences with their families, students and with their peers. One of the participants even went as far as to organize a meeting with two educational officers from the Ministry of Education of Ontario to advocate professional training in VR as well as its integration in the classroom.

4.7.7 Social VR

Participants indicated in the survey and the video logs that they enjoyed working together in the social VR application Spatial. They said that they benefited from peer learning in large and small groups. This data indicates that social VR facilitates different types of grouping such as small, medium or large groups and provides the possibility to curate the environment with different group sizes.

4.8 Summary of the Findings

In sum, this study's findings indicate that:

1. The design-based research model allowed the researcher to reflect and constantly modify the training based on weekly participant feedback.
2. There were elements of VR training to which teachers responded positively:
    - The idea of sharing ideas and perspectives,
    - Meeting other professionals in their field,
    - Creating a lesson in VR and seeing what others have created, and
    - Seeing the different digital environments (Mountain Lounge, Boardroom Lounge, Boardroom with a table, Auditorium, Abstract).
3. There were elements of VR training which teachers found difficult:
    - They encountered technical challenges; and
    - They could not accomplish everything they hoped for as some options are not yet available (digital locks, teleportation portal, reactive 3D objects, etc.)
4. Overall, teachers found the training in VR to be a positive, engaging experience.
5. Teacher training in VR requires significant up-front preparation at this time in order to maximize teacher collaborative time in the PD session.

5 Discussion

In this section, the findings based on the data from the study are considered in light of the theoretical frameworks that emerged through the review of the literature.

5.1 The Culminating Task and SAMR

Bailenson (2018) suggests that active discovery should be used to design learning activities in VR. As such, participants were asked to apply their new knowledge to create a lesson of their choice in the VR environment as a culminating task with very limited restrictive guidelines. For the culminating task, participants were divided into two groups. This strategy seems to improve classroom lesson development in a virtual reality setting. Group 1 was composed of 5 elementary teachers while Group 2 was composed of 6 secondary school teachers. The lessons of each group were very different in their approach and will be compared and further analyzed here using Puentedura's (2006) SAMR model (see Table 10).

Table 10

The culminating Task and SAMR

Level	Examples from the study
S – Technology as Substitution	Group 2 (Secondary) the teachers posted information in Spatial for the students to read.
A – Technology as Augmentation	Both groups set up a virtual classroom in Spatial where they could interact with other participants.
M – Technology as Modification	Both groups changed the pedagogy to engage students into seeking their own answers instead of providing them.
R – Technology as Redefinition	Group 1 (Elementary) The teachers changed the learning space significantly so that students could move within the space around the objects. Visitors could immerse themselves in the environment and compare their avatar sizes to the 3D virtual objects to get a sense of perspective. This group of teachers set up a campfire for an increased sense of social presence. The way they set up the room encouraged students to move around and explore the different learning themes on their own.

5.1.2 Group 1 - 3D museum

Group 1 created an impressive 3D virtual museum (see Figure 18 and Figure 19). A participant described their planning phase as, "a happy accident." When they were exploring the different possible options in Spatial, participants saw that they could add 3D objects. They then decided to add objects to build and customize the room to transform it into a 3D museum about Canada's pioneers. They organized the items by themes and played with the square of 3D objects to provide a realistic visualization of the size of items (see Figure 20 and Figure 21).

Figure 18

3D museum with participants

Figure 19

3D museum - South view

Figure 20

3D museum - East view

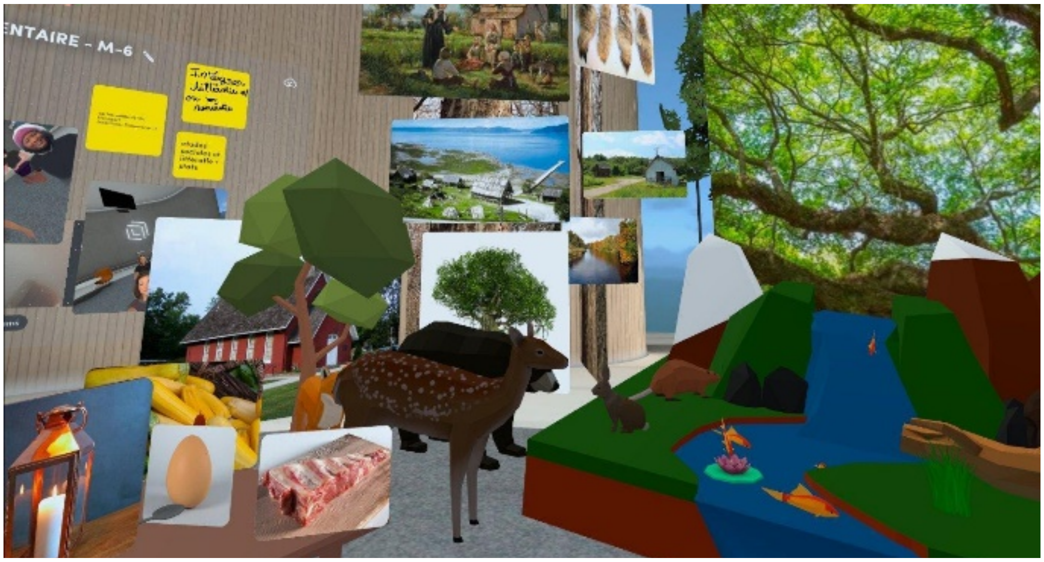


Figure 21

3D museum - West view

This lesson could be used as an example of transformative VR use. Indeed, when participants use the 3D objects to create a visual representation of their understandings, they are using VR at the highest level of Puentedura's (2006) SAMR model. At this redefinition level, technology allows for the creation of new tasks, previously inconceivable. Here, participants were able to use the tools to create a multidimensional representation of their understanding of the subject at hand for the other participants.

5. 1. 2 Visitors in the 3D Museum

The data from the surveys, video logs and observations showed that participants who visited the 3D museum were very impressed by the room and by the possibilities of adding and creating their own more personalized rooms. However, it is important to note that the visitors into the 3D museum did not experience the same redefinition level as creators but only as participants. As participants, they were able to be transported in a 3D museum to listen to the other team's presentation. They observed multiple 3D objects such as the size of animals, the small cabin, etc. Indeed, the activity of visiting this museum would be classified as Puentedura's (2006) modification level as the VR technology allows for a significant task redesign of the learning task. Alternatively, if participants were required after their visit to create their own model after visiting the other group's model, it would then be classified as a redefinition.

5. 1. 2 Group 2 - 2D in 3D

Group 2 participants (secondary school teachers) decided to create a virtual breakout room with multidisciplinary challenges (history, business, math, etc.). They wanted to add 3D virtual locks that would provide portals to different rooms with different themes and challenges. Unfortunately, this was not an available option in VR at the time as it has not yet been developed. Therefore, participants resorted to adding 2D web application elements (see Figure 22 and Figure 23) into the virtual space. For instance, they used images, Google Slides and Google Forms to provide challenges and clues, and to unlock virtual doors (Web pages in Google Form). A few 3D items were added such as scattered Post-its, a group selfie, and a Rubik's cube with a hidden challenge inside (see Figure 24 and Figure 25).

Figure 22

Group 2 Breakout - North view

Figure 23

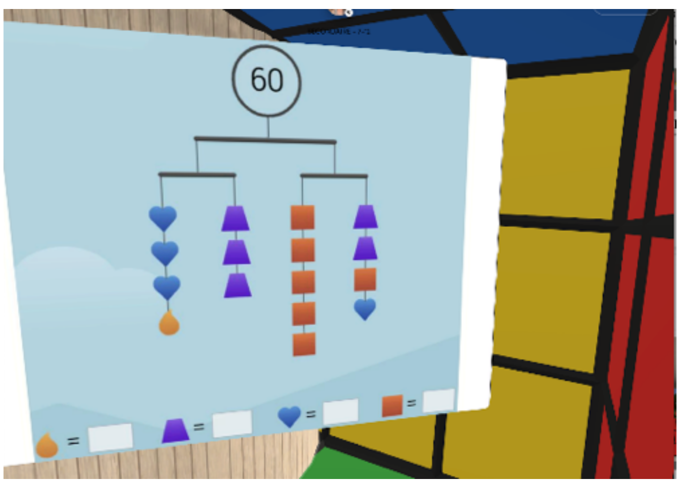
Group 2 Breakout - South view

Figure 24

Group 2 Breakout - East view

Figure 25

Group 2 Breakout - Inside the Cube



Thus, this lesson is an example of using VR at the augmentation level in the SAMR model (Puentedura, 2006). In this example, the virtual room acts as a direct substitution to a classroom setting with functional improvement, such as the unlimited display screens and the hidden room created by the 3D Rubik's cube.

5.2 TPCK Framework

The TPCK (Koehler & Mishra, 2007) framework offers different areas of focus from which to analyze the data identified in this study. The TPCK framework purposefully combines technology, content and pedagogy in teacher PD to help teachers build digital pedagogies (Rodgers, 2018). The skills of the teachers in preparing their VR classrooms were analyzed using the TPCK framework. In the technological knowledge area, the data demonstrated that participants developed considerable technological skills for using VR. Data also suggest that most participants have gained some pedagogical knowledge on how to teach or build activities in VR. Further, observations demonstrate that the intersection area between the technology and pedagogy knowledge remains unclear for participants. Since Spatial did not have specific teaching subject content, data illustrates that some teachers struggled in the technological content and technological pedagogical content areas (see Figure 5). In sum, there was some evidence of the skills in the TPCK model but not full evidence of the combined technology, pedagogy and content that this model articulates.

5.3 TAM Model

TAM (Venkatesh & Davis, 2000) provides another helpful theoretical lens to view the data from this research. Technology acceptance is related to ease of use and perceived usefulness of the technology. All participants, with support, were able to use the technology and the software. Some teachers wanted plug-and-play lessons that they could use with their students. Teachers demonstrated varying levels of ease of technology use, and some struggled more than others.

5.4 Polysynchronous Learning Spaces and Learning Affordances

The polysynchronous model (Dalgarno, 2014) was useful to discern the different types of student interaction and engagement identified in this study. The data analysis demonstrated that participants found that social VR allowed for a realistic level of social presence and was perceived as more realistic when compared to more traditional video-based platforms (e.g., Zoom, Microsoft Teams, Google Meet). One participant said that they felt less timid when they embodied their avatars in a face to face context. They indicated that this could also be the case for some of their students. While all participants engaged in synchronous learning, many participants engaged in self-guided asynchronous learning and explored the other suggested VR applications. The data revealed that the multiple channels of communication seemed to be overwhelming for some and not enough for others. VR could be used as a means to generate a polysynchronous learning environment as defined by Dalgarno (2014) and in some cases may lead to a deeper level of interaction between learners, teacher and content.

The 3D virtual learning (VLEs) model (see Figure 8) designed by Dalgarno (2010) is useful to identify learning affordances uncovered in this study. Indeed, the data revealed that the realism of the environment, avatars and spatial audio were influential factors for participants to envision the potential use of VR. Another important aspect highlighted in the data was the learner interactions, the embodiment, communication, and control over the environment. In line with Dalgarno (2010), the findings demonstrate that representation fidelity and learner interactions lead to a stronger sense of self-identity, presence and co-presence.

Indeed, participants identified many learning benefits in this study that were previously identified by Dalgarno in (2010) which are: spatial knowledge representation, experiential learning, engagement, contextual learning, and collaborative learning.

5. 5 Community of Inquiry (Col)

There were elements in the data that connected solidly with the Col model (Garrison et al., 2010). For example, there were multiple examples of how teachers were engaged cognitively and how they thought their students would engage cognitively with VR (models, simulations, etc.). Participants indicated an enhanced sense of social presence despite having met only virtually. This presence in VR was seen as deeper, more immersive due to the ability to touch, see and manipulate and interact with objects, people and the environment. Indeed, participants said that the level of presence was greater and unprecedented. This higher level of presence was connected to their level of engagement.

5. 6 Actioned Pedagogy for Immersive Learning (APIL) Framework

The findings from the data analysis correspond to Southgate' (2020) findings that more work needs to be done to understand VR as more than a device that generates instant learning. Further, while some teachers (teacher realm) are ready to bring these devices in their classrooms, it is no easy task. During the PD sessions, some participants wanted to purchase some of these devices for their classroom. They began to understand the complexity of what Southgate (2020) describes as the technical realm. Indeed, before implementing VR in their classrooms, teachers must consider (Southgate, 2020):

- Health and safety – with respect to hardware and software

- Developmental stages – Currently there is no known long-term impact on the developmental stages – Therefore manufacturers recommend that users be thirteen years of age or older.
- Each users requires a certain amount of space
- Network requirements
- How to keep track of what students do or see

While there are still many challenges in guiding a group of students in using VR technology, data reveals that participants see VR as a useful technology. With the right training, technological and administrative support it is this researcher's hope that the integration of VR in the classroom would be successful.

5.7 Time and collaboration

There were two clear gaps identified in the literature: the limited time spent by participants in exploring VR and the limited possibilities of collaborating with others in a VR environment. First, the data suggested that an increase in the length and number of sessions is beneficial to VR teacher training. Therefore, time is a factor in developing teacher skills for VR applications in the classroom. If it was not for the number of sessions and time spent in the virtual environment, participants would not have been able to familiarize themselves with the equipment to fully explore the potential of VR applications in education. It would be difficult for potential users to understand the extent of the learning possibilities of VR without spending time exploring the tool beforehand.

Second, the recent advancements in VR technology provide a space to collaborate over great physical distances. Therefore, little research has been done in terms of collaboration in a VR setting, especially in an educational context. Data from this study suggest that VR lends itself to a strong sense of collaboration which created a deeper collaborative online learning community. For example, participants felt more at ease in collaborating with others in this virtual environment in comparison to face to face PD training. Also, participants' body language and social cues were easier to identify in VR when compared to other online training environments. The VR environment seemed to increase the quality of collaboration by improving focus on the task: there were little to no distractions for participants. This deeper collaboration could lead to new partnerships between classrooms, schools, school districts and create unseen levels of communities.

5. 8 Summary of Discussion

In summary, this study's discussions indicate that:

1. The current research reinforces Bailenson's (2018) argument that learning design should be done through active discovery. VR gives teachers the opportunity to redefine learning experiences as defined by Puentedura's (2006) SAMR model. The two groups selected different approaches:

- Group 1 elementary teachers - created a 3D museum
- Group 2 secondary teachers - created a virtual escape room

2. In reference to the TPCK (Mishra & Koehler, 2007), participants were able to explore the technology and discuss general pedagogical strategies but the research was limited in terms of subject area content knowledge.

3. Through the lens of the TAM model (Venkatesh & Davis, 2000), participants saw the potential usefulness of VR in the classroom. However, some teachers struggled more than other in term of its ease of use and continuous PD sessions are important.

4. The current study reinforces Dalgarno' (2010) findings that VR has the following learning benefits:

- Spatial knowledge representation
- Experiential learning
- Engagement
- Contextual learning
- Collaborative learning

5. Teachers reported high levels of cognitive and social presence as described by Garrison et al. (2010) which increased engagement and lead to deeper levels of interaction between learners, teachers and content.

6. To implement VR in the classroom, an emphasis should be placed on teacher training, to reduce technical barriers before involving students in the process. This corresponds with Southgate's (2020) findings.

7. Time and collaboration are key elements in developing teacher training in VR.

This discussion of the findings of the present study compared to findings from earlier studies indicates that the research with the Francophone teachers generated findings that have been unreported to date in other literature.

These findings have prompted the researcher to make some recommendations for further study of teacher PD in VR. These are outlined in the next chapter.

6 Recommendations and Conclusions

Reflecting back on the research questions guiding this study, the researcher found that the research answered all the questions.

The first question asked which elements of virtual reality-based PD are more engaging and effective using virtual reality in a polysynchronous paradigm. The researcher concludes that although all elements were engaging and effective, collaboration was the most important based on the participant feedback. Data shows that participants were engaged in the “rencontre”, French for coming together, with other participants in VR. They felt a deeper connection to the researcher, other learners and learning content which is also in line with the polysynchronous paradigm.

The second question asked how VR could enhance levels of meta-learning in the design of engaging contextualized and authentic learning experience. This researcher observed that VR contributes to higher levels of meta-learning as teacher participants were able to apply their new acquired knowledge and skills and could visualize the effect in 3D. Further, participants were asked to engage in a weekly reflection which also helped participants in creating a deeper understanding of their own learning. Teachers adopted a learner role and transitioned to a presenter and creator role over the eight sessions. Data showed that when participants experienced the other groups’ culminating presentation, they were inspired by new possibilities for VR integration such as creating their own museum and escape rooms. Most were engaged in an active reflection about how they could use this tool in their own practice.

The third research question asked, “How do teacher participants new to VR plan to apply what they have learned from this experience?” This researcher concludes that participants showed their application of their learning by creating the two rooms in Spatial for the culminating task. The data suggests that teachers would like to use VR with their students to create engaging activities such as seeing the world, a virtual escape room or using the different tools and rooms to present, collaborate, brainstorm, and create with their students. Data also shows that most participants want to pursue this PD training to develop and acquire more knowledge and skills pertaining to VR. Further, many would like to use this tool to pursue other PD training as well as meetings and mentorship opportunities in VR.

On a more personal level, this researcher also concludes that most participants have seen other benefits for personal uses such as fitness, meditations and connecting with family members.

How will this experience impact participant's pedagogical choices and future learning designs? This researcher concluded that this experience will have a lasting impact on the participants' pedagogical choices and future learning design. Survey responses describe how this experience allowed participants to gain new positive perspectives about VR and pedagogical design (e.g. the SAMR model). One participant went as far as to advocate the technology to an educational officer pleading them to try the technology.

6.1 Conclusion

This researcher concludes that immersive social VR is here to stay. Its educational uses are, as yet, undetermined. It is a powerful tool that potentially can be used to engage students, reduce physical distancing, generate empathy and help students gain deeper understanding. All students should have access to the best tools and educational experiences possible and VR is a such a tool that it can make this possible.

While we do not know what the next decade hold, new learning tools such as VR could become the traditional new norm. Educators must continue to develop their skills, knowledge, and competencies by searching for innovative ways to meet the emotional and academic needs of their students. Teachers must be prepared to face new challenges and remain current with the evolving technological ecosystem. While teachers must continue to pursue training opportunities, administrators and policy-makers must provide PD opportunities if they want to remain current, competitive, and relevant.

Further, VR offers a promising solution to bridging the learning gaps created or enhanced by the global pandemic COVID-19. Indeed, VR allows learning to transcend the schools, as it can take place anywhere, anytime and with anyone. VR has the power of adding another dimension to learning, that of social presence and human connection. As people feel more connected, they are more present in the moment and engaged in learning. Also, people can be a part of a virtual social community and take part in discussions, presentations and events related to a topic of interest (content knowledge). Moreover, by being part of the metaverse, teachers will understand what is required from students to become digital citizens that live in a world where digital and physical realities coexist.

When attending a meeting, a presentation, a workshop, an event, etc. in VR, people can read the room as well as social cues. They can move and interact with the learning materials, presenters, and the environment. Further, new features, in certain applications such as Spatial, allow for live translation and transcriptions. Also, most VR software allows teachers to import or create visual aids, to build structures, paintings, to import pictures, videos, etc. Learners can also get hands on practice by discovering and interacting with the learning content, or by creating their own virtual representations. These immersive lessons can be created to generate memorable learning experiences. This makes the learning content more universally accessible.

6. 2 Future research areas

While VR in education is developing, there is an urgent need for further research to understand the potential and the risks associated with this powerful tool. As these tools rapidly emerge in the homes and in schools, researchers, content creators, administrators, teachers, parents, and students all need to be involved in questioning and understanding how this technology will shape future generations.

Further research is needed to develop educational content in VR. This process should include content creators (e.g., software engineers, hardware developers, graphic artists, etc.), pedagogical experts (e.g., educational officers, curriculum experts, teachers, etc.) as well as content experts (e.g., marine biologist, historians, mathematicians, etc.). While such an endeavour is time consuming and expensive, the learning content, simulation and exercises could easily be shared globally. Also, further research needs to be conducted in a real classroom setting or in an online class with students. Researchers could work along with teachers and students to develop a teaching framework to design learning experiences in VR.

Finally, more research is needed in the field of teacher PD in VR. It would be interesting to conduct a longitudinal study to see how teachers can incorporate the technology into their classes as well as how the pedagogy can evolve along with the technology.

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Appendix A: Outline of PD Sessions

Ready, Teacher One
A Journey into the Future of Technology and Pedagogy through VR
with Joannie Girard

Session Breakdown

Session 1 – Introduction to VR Oculus Software and Hardware
During this first session participants will be introduced to VR technology. They will learn how to safely set up and use the VR equipment by setting up the guardian. They will experiment with the Oculus software and learn how to navigate through the different menus and options. They will practice interacting within the virtual environment using the remotes, their hands, their bodies and their microphones. Collaborators will discover the different levels of VR immersion. Teachers will share their first thoughts about the equipment, software and experience and how it could be used to transform their current and future educational practices.

Software – Oculus First Steps and First contact

Session 2 – Collaborating, Communicating and Sharing in VR
In this session participants will create their own realistic avatar and they will embody their newly created avatars to enter virtual rooms and meet other participants in a virtual environment. In this space, participants will exchange ideas on what education means to them. They will experiment with different virtual tools such as post-its, 3d models, collaboration boards, pens, etc. to illustrate and share their ideas. Collaborators will be introduced to the *SAMR* model. Then they will be asked to share their definition of teaching and share thoughts on how they think this technology could change the way they currently do things.

Software – Spatial

Session 3 – Polysychronous Environments – Anytime Anyplace Learning
In this session participants will reflect on how their practices have evolved over the past years and particularly in the last year due to the recent global pandemic. By using different software, collaborators will be introduced to what a polychromous environment is. They will discuss current teaching models and be asked to share their thoughts about how his technology could support teachers and student learning given the current conditions.

Software – Spatial

Session 4 – 3D Visualization, Making Abstract Concepts Tangible
In this session participants will be asked to envision something that is difficult to imagine. What would it be like to be blind? They will share their thoughts with other participants

before being transported in a simulation, *Notes on Blindness*. This VR simulation will let participants experience what it would be like to be blind. Once the simulation is completed, participants will be asked back into the common virtual environment to share their thoughts by adding to their original reflections. Teachers will be asked to share if this experience has helped them make this abstract concept more tangible. They will be asked to reflect on if simulations like this one could be created to help students and teachers learn abstract concepts.

Software – Spatial - Notes on Blindness

Session 5 – Knowledge Integration and Transmission
In this session participants will travel to the city of lights, beautiful Paris. They will be guided on a virtual tour on board a double-decker bus to discover this city's rich history. Once they have completed this visit, participants will be given the opportunity to explore the environment and reflect on their experiences. They will ponder on the impact a simulation like this could have on knowledge integration and transmission. This lounge setting will be decorated and personalized with travel photos shared in advance by participants. In a show and tell approach, participants will be invited to discuss their images, thoughts and experiences with other participants in smaller or larger groups.

Software – Alcove

Session 6 – Engagement, Motivation and Gamification – Feedback and Formative Assessment
In this session participants will learn about gamification through first-hand experience. They will be asked to work as a team in a set of friendly team-based competitions. Participants will work together to solve puzzles, play team sports and other interesting activities such as taking flight side by side into virtual planes. As participants discover and play, they will be asked to reflect on their own level of engagement and motivation towards this experience. They will discuss and compare this experience to more traditional and emergency teaching responses to identify the role of experiential learning, play and feedback for teaching content as well as 21st-century competency.

Software - (To be reviewed - coming soon) - Horizon
Other possible software (If Horizon is not out yet) - TBD - Alcove - *Scramble sports - Puppet Fever - Cook out - Gadgeteer – GravityLab - Cubism*

Session 7 – Creating a 3D Model – Visible Learning
In this session participants will learn how to make their learning visible by creating a virtual 3D model. By using different three-dimensional shapes and tools, participants will unleash their imagination to create a 3D representation of their ideal learning environment. Participants will use these tools to illustrate what they have learned thus far. They will be encouraged to take selfies of their avatars and digital photos of their work with the integrated camera option. Participants will exchange ideas on their model and discuss how this could be used in the context of teaching, teacher training and PD.

Software - (To be reviewed - coming soon) - Horizon
Other possible software (If Horizon is not out yet) - TBD - Alcove - *Tilt Brush by google* - *SculptrVR* - *Kingspray Graffiti*

Session 8 – Storytelling – Narrative Presentations – Teacher Voices
In this final session participants will be asked to share with the others what they have learned from this experience. Using the virtual tools and models, they will explain how they would like to use this technology to improve their teaching and support student learning. Based on their professional experience and new-gained knowledge of VR they will make recommendations for its use in terms of pedagogical design. Through discussions they will help guide further research by imagining how this technology could transform the world of education, teacher training and PD.

Software - (To be reviewed - coming soon) - Horizon

Appendix B: Email of approach

Appendix B: Email of approach to Teachers in Ontario's French Secondary Schools (English version for the REB. French version to be sent to the teachers)

January 27, 2021

Subject: Invitation to teachers to participate in a research study examining Teacher PD sessions in VR and the potential of VR use in education

Hello!

You have signed up for some PD sessions on Virtual Reality organized by the Centre Franco-Ontarien. As an attendee at this session, you are invited to participate in a research study conducted by Lorayne Robertson, Associate Professor at Ontario Tech University (Lorayne.robertson@ontariotechu.ca) and Joannie Girard, Master's candidate.

Your PD sessions in Virtual Reality are 8 one-hour workshops where you are immersed in the Virtual Reality experience (online). If you decide to participate in the research part of the workshop, you would be asked to complete a short survey after the workshop and provide some video or audio comments after the session. You are not obliged to participate in the research study. You can take the PD sessions without participating in the study.

For more detailed information, the consent form is attached @ ______ (link). If you would like to participate in the study, you can review, sign and return the consent form to Joannie Girard joannie.girard@ontariotechu.net

If you have any questions, kindly contact Lorayne Robertson Lorayne.robertson@ontariotechu.ca or Joannie Girard by email joannie.girard@ontariotechu.net or by phone 519 496-6396.

This study has been reviewed by the University of Ontario Institute of Technology (Ontario Tech University) Research Ethics Board # 16802 on January 21, 2021.

Best regards,

Joannie Girard MA Candidate, Ontario Tech University
joannie.girard@ontariotechu.net
519 496-6396

Appendix C: Consent form

<u>Consent Form to Participate in a Research Study "Ready, Teacher One"</u>

Dear Participant,

As someone who is attending PD (PD) sessions on Virtual Reality (VR), you are invited to participate in some research. Please read over the information in this form which includes details on study's procedures, risks and benefits that you should know before you decide if you want to participate. Take as much time as you need to decide. You can ask the Principal Investigator (PI) Lorayne Robertson or the Graduate student, Joannie Girard anything you do not understand. Make sure all of your questions have been answered before signing the consent form. You may participate in any or all of the PD sessions without participating in the research study. Participation in this study is voluntary.

The researchers for this study are:
Principal Investigator (PI): Dr. Lorayne Robertson, Assoc. Professor, Faculty of Education
Email: Lorayne.robertson@ontariotechu.ca
Dr. Bill Muirhead, Assoc. Professor, Faculty of Education
bill.muirhead@ontariotechu.ca
Dr. Bill Kapralos, Assoc. Professor, Faculty of Business and IT bill. kapralos@ontariotechu.ca
Graduate student: Joannie Girard, MA Candidate Email: joannie.girard@ontariotechu.net

This study has been reviewed by the University of Ontario Institute of Technology (Ontario Tech University) Research Ethics Board REB # 16082 on January 21, 2022.

<u>Purpose and Procedure:</u>

The PD workshops will be 8 one-hour sessions held in the VR online environment. As someone participating in the PD sessions, you are invited to participate in this study. At the present time, there is little research on teachers' views about using virtual reality. The PD workshops will be held mostly in French with English used as required for technical explanations. After each one-hour session, you will be asked to complete a short online survey (max.10 minutes) and send a brief (5-minute max) video/audio commentary to the Graduate student researcher, Joannie Girard to her email Joannie.Girard@ontariotechu.net. This email is password protected.

The 8 weekly sessions will be held online during 2021. Here is a list of the sessions:

1. Introduction to the VR Oculus Software and Hardware
2. Collaboration, communicating and sharing in VR
3. Polysynchronous environments – anytime anyplace learning
4. 3D visualization, making abstract concepts tangible
5. Knowledge integration and transmission
6. Engagement, motivation and gamification, feedback and formative assessment
7. Creating a 3D model – Visible Learning
8. Storytelling – Narrative presentation – Teacher voices

The data which will be collected from you (your survey answers and the text of your short videos) will help guide the setup of future PD sessions in virtual reality, and it will also help other teachers begin to think about how VR might be used in Secondary Schools.

You may attend the PD sessions without participating in the study. Also, you do not need to fill out the survey every week. Do not worry if you miss a session.

Potential Benefits: If you are someone who is interested in VR and technology, this will provide a collaborative PD experience. The equipment to participate will be loaned to you for the duration of the study.

Potential Risk or Discomforts: There are no known or anticipated risks to you from participating in this study. The level of risk would be the same as any PD session where you offer feedback afterward.

Use and Storage of Data: The data that you provide (weekly survey responses and short videos) will be securely stored in the OnTechU Google Suite which is password protected and accessible only within the OnTechU infrastructure. Only the Graduate Student, Joannie Girard and her supervisor, Dr. Lorayne Robertson will have access to the data. No personal information will be collected. No information will be collected that identifies you or your school. The video data that you send to Joannie Girard will be through the OnTechU Google Meet software which is protected within OnTechU and password protected. The short surveys will be through Google Forms, which is protected within OnTechU and password protected.

The video data will be transcribed by the student researcher, at which time the original video will be deleted from the OnTechU G-suite server. All videos will be deleted at the end of the project, which should be completed by September 2021.

At no time will data be identified with a participant's name. Participants will be assigned a pseudonym for the purpose of the study. When the video data are transcribed, the name associated with the transcription will be the assigned name (or pseudonym). The de-identified data will be kept until the graduate student's research is reported (by December, 2021).

In May, 2021 all of the raw data will be aggregated for analysis (This includes the survey responses and video transcriptions). Following completion of the graduate student's thesis, a report will be generated for the Centre Franco Ontarien, which provides PD coordination for French First Language schools in Ontario. This report will be based on the de-identified, aggregated data only, not the raw data.

After three years, all of the study data will be deleted from the G-suite at OnTechU.

All information collected during this study, including your comments about the PD will be kept confidential and will not be shared with anyone outside the study unless required by law. You will not be named in any reports, publications, or presentations that may come from this study.

Confidentiality: Your name as a participant in the study will not be known to the other participants in the study because participation in the study is a choice. Confidentiality will be provided to the fullest extent possible by law, professional practice, and ethical codes of conduct. Please note that confidentiality cannot be guaranteed while data are in transit over the Internet.

Voluntary Participation: Your participation in this study is voluntary and you may partake in the PD sessions and not in the study. You may choose to participate only in those aspects of the study in which you feel comfortable. You may also decide not to be in this study, or to be in the study now, and then change your mind later. You may leave the study at any time without affecting your employment status. You may refuse to answer any question you do not want to answer, or not answer an video prompt by saying, 'pass'.

Right to Withdraw: If you withdraw from the research project at any time, any data you have contributed will be removed from the study and you do not need to offer any reason for making this request. You will have until the end of the sessions or until March 31, 2021 to withdraw from the research. Once the study is completed, and the data have been aggregated, you will no longer be able to withdraw from the study. Also, it may be impracticable to withdraw results once they have been published or otherwise disseminated.

Conflict of Interest: The Researchers are interested in completing this study. Their interests should not influence your decision to participate in this study.

Compensation, Reimbursement, Incentives: Participants will not be paid for participation in this study.

Debriefing and Dissemination of Results: Participants will be provided with a copy of the report sent to the Centre Franco Ontarien regarding the Summary of Findings from the study. Also, Joannie Girard's MA research will be published by OntarioTechU and participants will be able to access her study by December, 2021 as it will be available online through the OnTechU library.

Participant Rights and Concerns:

We ask you to please read this consent form carefully and feel free to ask the researcher any questions that you might have about the study. If you have any questions about your rights as a participant in this study, complaints, or adverse events, please contact the Research Ethics Office at (905) 721-8668 ext. 3693 or at researchethics@uoit.ca.

If you have any questions concerning the research study or experience any discomfort related to the study, please contact Dr. Lorayne Robertson (Lorayne.robertson@Ontariotechu.ca) or by phone 905 721 8668 x 2881 OR the graduate student researcher Joannie Girard @ joannie.girard@ontariotechu.net

- By giving your consent, you do not give up any of your legal rights against the investigators, sponsor or involved institutions for compensation, nor does this form relieve the investigators, sponsor or involved institutions of their legal and professional responsibilities.

Written Consent

____

__________________________ ________________

Print Study Participant's Name
Signature Date

My signature means that I have explained the study to the participant named above. I have answered all questions.

____

____

Print Name of Person Obtaining Signature
Date

OR Online Consent (given verbally to the student researcher Joannie Girard),

Include the following statements:

1. I have read the consent form and understand the study being described.
2. [If applicable] I have had an opportunity to ask questions and my questions have been answered. I am free to ask questions about the study in the future.
3. I freely consent to participate in the research study, understanding that I may discontinue participation at any time without penalty. A copy of this Consent Form has been made available to me.

☐ I agree

I have communicated my consent to the Graduate Student Researcher Joannie Girard on
_____________ date.

Appendix D: Data Management Plan

1. Participation in the research study is not required to participate in the PD sessions in virtual reality.
2. Participants in the 8 one-hour PD (PD) workshops who agree to participate in the study will be asked to complete a Google survey (Appendix D) after each PD session.
3. The survey is anonymous. Data from this survey will be downloaded instantly to the OnTechU Google drive and it is password protected.
4. After each PD session, participants will be prompted to send an audio or video comment to the researcher about the applicability of the virtual reality discussed in that week's session for teaching in secondary school (See Appendix E for the text of this prompt).
5. Although the survey and a video comment will be requested of each participant each week. If they do not provide a survey or video comment any particular, they may continue in the study.
6. When participants send a video or audio file, it will be downloaded within 24 hours by the researcher and stored in a password protected UOIT Google drive.
7. In March, 2021, the video comments will be transcribed by the graduate student researcher. At that time, the original audio file will be deleted.
8. Transcribing will be completed by the graduate student researcher. The transcriptions will be anonymized upon transcription in March, 2021.
9. After transcription, the anonymized data will be stored in the secure, password protected OnTechU Google drive folder.
10. The data stored in the secure Google drive will be accessible only to the student researcher and the thesis supervisor.
11. In the event of a data breach of the OnTechU Google suite data, the PI will review next steps with the REB and notify all participants of the nature of the breach, and the precise nature of the data that were breached. Since there is no intent to use participants' names in the storage of the data, a breach could only be their audio files for the short period between posting their message and transcription of the data.
12. After three years, all data from this study will be deleted by deleting the files in the UOIT Google drive.