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Using Immersive Virtual Reality for Student Learning: A Qualitative Case Study

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Using Immersive Virtual Reality for Student Learning: A Qualitative Case Study

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We certify that we have read this dissertation and approved it as adequate in scope and quality. We have found that it is complete and satisfactory in all respects, and that any and all revisions required by the final examining committee have been made.

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ABSTRACT

The prominence of virtual reality (VR) in the educational field has grown in recent years due to increased availability and lower costs. I conducted a global study regarding how pioneering K-12 teachers use VR to engage students in learning activities. The purpose of this qualitative case study was to identify how and why teachers used VR for student learning. Fifteen educators from five continents participated in the study. They described their initial VR experiences and how these experiences motivated them to pursue ways to implement VR in their disciplinary fields. I used the video conference tool "Zoom" to conduct interviews. Participants described the "spark" of discovery and recognition of VR for learning. They explained measures to obtain permission, approaches to funding, and the implementation process. Participants developed structures for student learning, transformed physical spaces, and invented pedagogies to ensure positive learning experiences. Participants provided optimal immersive experiences by repurposing content and adopting other applications to achieve learning goals. Three levels of incorporating VR for student learning were identified, including: (1) exploration; (2) acquiring and applying disciplinary knowledge; and (3) content creation and interactive problem solving. The quality of headsets dictated the level(s) of implementation. Dewey's (1923) experiential learning theories as well as the Technology, Pedagogy, and Content Knowledge framework (TPACK; Mishra & Koehler, 2006) helped to interpret data. Successful implementation requires collaboration and pedagogical modifications and administrative support. This study highlights the successful methods and practices for others considering the implementation of VR for K-12 student learning.

Keywords: TPACK, Dewey, Virtual Reality (VR), Innovation, Experiential Learning

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CHAPTER ONE: INTRODUCTION

My study explored virtual reality (VR) and K-12 student learning. Virtual reality, a three-dimensional graphics-based computer system, incorporates head-mounted displays (HMD) coordinated with simulated environments (Pan et al., 2006). In the late 1980s, Jaron Lanier coined the moniker “virtual reality,” a term later adopted by the VR community (Bambury, 2019). The goal of VR involves reactions from the user and a sense of immersion within the computer-operated environment (Minocha, 2015). Maneuvering hand-held controllers that correspond with the headset, users manipulate elements to unleash learning potential in real-time (Huang et al., 2010). When VR users turn their heads, graphics align; viewers look down and controllers are no longer visible; instead, “virtual” hands interact with content by pressing buttons. Users toggle the buttons like video games to move, manipulate, interact, or alter things in VR mode. Built-in headset speakers enhance auditory cues into the immersive elements that change depending on the views of the user. Kluge and Riley (2008) called learning in a virtual world “Pandora’s Box for educators;” meaning endless opportunities for students (p. 132).

Like most technological advances, VR equipment has become more economical and prevalent in society since its inception over 40 years ago (Minocha, 2015). The affordability of VR combined with the increased number of applications in virtual space provide new opportunities for teachers to bring this technology into the classroom for student learning (Lee, Sergueeva et al., 2017). Virtual reality provides experiences the real world cannot and has similarities to “in-depth daydreaming” (Cornell & Bailey, 1996, p. 155). For example, VR systems supply real-time custom feedback cues to help learning based on user interaction (Gavish et al., 2015). Virtual reality systems also provide a safe “learning by doing” instructional approach that can be repeated (Gavish et al., 2015, p. 779).

Virtual reality for student learning may appear complicated and daunting for teachers new to this method of instruction (Regian & Shebilske, 1992). However, in one study, when teachers incorporated immersive environments included with instruction, learners became absorbed with the content, and brought higher levels of engagement (Shin et al., 2013). Bailenson (2018) explained the D.I.C.E. framework regarding possible uses for VR: Dangerous, attempting a task that would otherwise might cause bodily harm; impossible, actions that defy the real world (e.g., time travel, changing genders or race); counterproductive, making a virtual mess and not have to clean it up; and expensive, virtual travel or repetitive practices.

As recent as 2015, VR continued to be in the infancy stage with only two major companies, Sony and Facebook-owned Oculus, creating consumer headsets (Minocha, 2015). One skeptic noted the instability of the VR movement: “Virtual Reality has been the next new thing for five years and counting” (Jenkins, 2019, p. 1). Social media tools like Twitter provide a venue to find resources and real-time communication with VR industry leaders and K-12 trailblazers. This growing movement brings excitement to student learning and allows innovative educators to blend authentic, immersive approaches with traditional instructional practices to the classroom (Fowler, 2015). These simulated learning experiences created sensations perceived as normal, abnormal, dangerous, or unforeseen (Minocha, 2015).

My interest in VR/AR started in 2016 when I experimented with the HTC Vive VR system, purchased by a colleague after she won an innovation grant. She used VR for approximately a year before I considered trying it out. I stumbled upon a reason to try on the headset and that proved to be the pivotal moment that things changed for me. I became overwhelmed. I could see the potential for student learning. I wanted to find activities to use it in my pre-engineering classes but had difficulties finding resources. I turned to social media for assistance.

I scanned Twitter one day and noticed a person offering a few remaining seats to take part in an #ARVRinEDU online seminar starting at 5:00 p.m. local time later in the week. I learned the start time occurred in Gulf Standard Time and realized this webinar would align with my morning planning time during the upcoming school day. In my mind, given the clear exclusivity for the event, I knew this had the possibility to be something special. I discovered this online seminar entailed much more than simply seeing a livestream video from a random VR website.

The organizer of the online seminar emailed me a packet of instructions which required the download of the special VR software, "ENGAGE," through the STEAM software website. I also received instructions with rules of etiquette for participants. After reading the packet, I learned I would be able to "virtually" take part within this online seminar on AR/VR in education.

On the day of the event, I mounted my headset and entered my username and password in the ENGAGE software platform. The screens on my headset went dark and transformed into what appeared to be a museum. I turned my head in every direction to look around and noticed a gallery with nautical pictures hanging on the walls. Further in the gallery, I saw what appeared to be a 20-foot scale model of the RMS Titanic. Examining closer at the deck of the Titanic model, I noticed hundreds of animated human-like figures walking around. In the distance, a man-like "avatar" person appeared to be wrapping up a conversation with another man-like avatar and then he started moving towards me.

After nearly breaching the barrier of my personal space, the avatar reached out to "virtually" shake my hand, calling himself "Steve" and welcomed me to his event. Not knowing what to do or how to react, I awkwardly held out my right hand and observed our "cartoon hands" simulating a handshake even though my hand waved up-and-down in midair to nothing. I verbally responded, not realizing that my headset included a microphone. I detected an accent, but he seemed rushed and informed me this impromptu session would end. Again, my lenses turned black and a few seconds later when they lit up, I found myself in some sort of television talk show studio surrounded entirely by outer space (see Figure 1).

Figure 1

ENGAGE Webinar

Note. The "virtual" stage as it appeared from the audience perspective.

Around the stage area sat an abundance of lifelike virtual effects including a couch for three guests, a chair for the host, a coffee table, shrubbery swaying in the wind, and at the corner of the stage, and a miniature Mars rover model. The audience section included 15 beige couches for the audience members to "virtually" sit on during the presentation. As the start time approached, I noticed that "virtual" participants, named "avatars," appeared out of nowhere.

Soon after I found my seat on a couch, I remembered the etiquette rules when somebody attempted to "virtually" sit on my lap.

The panel of three VR/AR experts sat on the couch. Steve Bambury, the host of this event, led the hour-long discussion for using VR in schools. I later learned people from all over the world participated in this seminar, collectively experiencing this event.

At the completion of the experience, Bambury, our host, invited the group to go on a virtual field trip within the ENGAGE software system. The host warned us to be patient while our screens turned black. A few moments passed before they illuminated. We had been instantly transported to the surface of Mars. Instead of our virtual avatar clothes, all participants donned space suits. In our left hand, a computer tablet allowed us to take pictures around us and take "selfies." Next, I noticed Bambury working on his tablet when a life-sized gorilla appeared before us. This provided participants the opportunity to move next to it and observe the intricate details. Looking up, I noticed a beluga whale floating above our heads. These demonstrations unleashed endless learning possibilities for teachers.

I consider myself fortunate to have been able to take part in other monthly #ARVRinEDU events with Bambury. The events were housed in different virtual environments within the ENGAGE software program. I found these free seminars provided up-to-date and relevant information for educators from around the world. These webinars for VR in virtual reality made a profound impact on me. I wanted to explore future possibilities for student learning. I could not wrap my mind around how these VR experiences transformed my entire instructional philosophy and outlook.

ENGAGE continued to design virtual environments allowing users to explore places and spaces that would otherwise not be imaginable. The business model for ENGAGE focuses on corporate training and educational purposes. ENGAGE allows up to 36 students simultaneously in an environment. ENGAGE offers 1,200+ three dimensional interactive objects, 20+ virtual environments, the ability to incorporate streaming media, create custom content, built-in assessments, and to schedule meetings (ENGAGE, n.d.). The surroundings, when paired with interactive elements, provide safe simulations to be replayed or modified (ENGAGE, n.d.). In my experiences, this software empowers users to unleash creativity and impact learners beyond the scope of imagination with limitless possibilities.

In the days after these events, I reflected on the profound impact this had on me. I wondered how others might also participate in similar learning experiences and where they could take this concept. I felt curious how Bambury, the facilitator, produced the idea to host a VR webinar hosted in a virtual space. This concept led him to seek interested educators, create a session format with protocols, and unknowingly reshape everything I knew to be true about education. I hope to meet and interview innovative educators on the forefront of this movement.

However, at one point of my study, I realized I had been introduced to VR at a much earlier age than I had previously realized. During my adolescence, my family often traveled to my maternal grandparents' home. I reminisced how I played with this contraption which I held to my face and then looked at various black and white photos. I recently remembered that it had been stored in a box in my garage. I came to the realization that this tool proved to be an early iteration of a VR headset, and the inception of this endeavor. My study involved learning how teachers explain their VR journey, pedagogy, approaches, philosophy, and strategies for using immersive experiences with learners.

Research Issue

I see the potential of VR in how it can change how people think and understand difficult concepts. In my own VR experiences, when observing people using VR for the first time, most realized the functions, power, and capabilities of this tool. I witnessed my students (and even my two daughters and son at home) navigate difficult problem-solving simulations with enjoyment not otherwise possible with traditional teaching and learning. Virtual reality provides custom experiences based on interpretations and natural reactions unique to each person (Fowler, 2015). Further, VR offers a sense of empowerment that opens new learning pathways (Psotka, 1995). When teachers incorporated VR with students, they cut the constraints from traditional classroom instruction and inspire students to take control of their learning journey (Psotka, 1995).

Problem Statement, Purpose, and Significance

After reviewing many studies, educators in all academic areas have the ability to incorporate VR with student learning. However, it takes added time and energy to obtain headsets, find age-appropriate applications, and develop activities to connect concepts and standards. Educators must possess a forward-thinking and open mindset with an understanding that pedagogical approaches will change. They need to understand VR should be used similar to a “tool” in their “instructional toolbox” and not the sole contributor for student learning.

Significant instructional changes have transpired over time. From the early beginnings of the teacher in a one-room schoolhouse, using a teacher-centered approach has shifted to a learner-centered approach that accommodates the diverse needs of 21st century learners (Misak, 2018).

The digital revolution supported change and continues to revolutionize classroom instruction and how students learn (Keskitalo, 2011). Remnants of old technologies from the past can still be found in most classrooms: paper, pencils, chalk, and blackboards (Kluge & Riley, 2008). However, most middle and high school students in recent years carry a mobile device to access the world's information and complete coursework.

Purpose

The purpose of this study was to identify pedagogical shifts in teaching and learning using VR. This includes a study of VR pioneers and their experiments using VR. A pedagogical shift occurs when technology empowers the learner to control their academic journey and is not regulated by the information gatekeeper (Keskitalo, 2011). Lawrence (2018) found many factors influencing the likelihood of teachers adopting and integrating technology. Perceptions of technology tools decide whether teachers incorporate them in the classroom (Lawrence, 2018). Teachers who previously found effectiveness and efficiency in technology tools had a higher probability to use them in the future (Lawrence, 2018). Nemeržitski et al. (2013) found characteristics that determined the likelihood to inspire innovative teachers in a school, including teacher self-efficacy and the determination to learn new things. Another teacher innovativeness predictor depended on the school climate and leadership (Nemeržitski et al., 2013). The purpose of this study was to examine how innovative VR teachers contribute to the knowledge of effective teaching and learning.

Van der Heijden et al. (2015) found motivated teachers possessed a passion and enthusiasm to learn. Open-minded teachers created innovative learning activities that moved them away from traditional instructional practices (Van der Heijden et al., 2015) and continued to explore unique and novel delivery methods (Lee et al., 2017). An innovative mindset does not present itself blindly - teachers understand potential risks and the complexities involved with creating new ways of teaching (Van der Heijden et al., 2015). Virtual learning brings new and effective educational opportunities that can be seen and used by others (Kluge & Riley, 2008). The purpose of this study was to identify what educators do and how they integrate VR into the course of their daily instruction.

Collins et al. (2018) acknowledged prior research focused on VR and application-specific learning had not concurred on any general pedagogical theory because of the constant landscape changes. Innovative teachers take risks by implementing new tools (like VR) but often encounter logistical issues. Twining (2009) found pedagogical shortcomings when teachers tried to design immersive learning activities and lacked the of understanding of virtual worlds. Teachers should have strong ability in their content, apply extra effort in planning, and have flexibility to adopt VR (Keskitalo, 2011). However, some students may have found these environments to be overstimulating and to be an obstruction with the learning process (Makransky et al., 2017). Ren et al. (2015) acknowledged the positive impact of VR on student learning but insisted on blending other instructional strategies to produce the best learning outcomes. Answers to the research question expands knowledge of effective pedagogy using a new and promising technology – Virtual Reality.

Significance

The last 20 years brought the integration of computers that supplied teachers the ability to use audio/video projectors to display images and videos to propel instruction. Recent additions of wireless connectivity provide teachers the freedom and flexibility to move throughout the classroom. In addition, many schools now permit students to bring their own device (BYOD) or provide students with a district-owned portable learning device like an Apple iPad or Chromebook.

New tools require a change in instructional approaches, allowing increased student agency with their learning (Makarova, 2018). Over time, the use of technology tools became common, and teachers had no longer been considered innovative (Koehler et al., 2013). New pedagogies need to be defined in between the introduction of new tools and their integration into student learning. Digital technologies provide access to information and provide content interactivity that textbooks cannot (Kluge & Riley, 2008). Learning can no longer be limited to the four walls of a classroom at a specific time. Instead, location and time has become less important to instruction because of the availability of digital tools and access to information (Kluge & Riley, 2008). This study is important because it seeks to identify instructional shifts and the potential uses of VR for student learning –new technologies require changes in teaching and learning to ensure a positive effect on students.

Research Question

I adopted the following research question to conduct my study: How do pioneering K-12 educators use virtual reality for student learning?

Overview of Chapters

This study involved K-12 teachers using virtual reality (VR) for student learning. Chapter One introduced background information on the VR movement, my initial interests and personal connections to this topic, the research issue, and why VR played a role in education. This chapter highlighted how other industries adopted VR for educational purposes and offered a rationale for pursuing this research issues in the problem statement.

Chapter Two provided a review of literature regarding VR and learning. The chapter described early iterations of VR headsets and various applications. The chapter explained how advances in technology increased accessibility in schools. I presented different examples of early adoption practices and explained the challenges in establishing pedagogical approaches. This chapter closes with a description of gaps in research. Because this topic did not have a place in K-12 education until the past decade or so, a limited number of studies existed, presenting an opportunity to learn more.

Chapter Three offered the rationale for why I pursued a qualitative case study methodology for this study. I explained the background information regarding qualitative research and the reasons why I chose it for this study. I described my two pilot studies which established a foundation for pursuing this study. I explained why I selected a case study approach and how I recruited participants from around the world. This chapter also acknowledged the importance of following IRB guidelines to protect all stakeholders. I described how I collected, organized, and approached the data as well as the potential for bias in conducting this study.

Chapter Four presents the data derived from interviewing 15 participants from around the world. After coding and identifying categories, I identified four themes: (1) exposure to VR; (2) acquiring funding; (3) preparing to teach; and (4) three levels of implementing VR. In Chapter Five I analyzed teacher learning with regard to using VR with students as well as VR pedagogy using Dewey's (1923) experiential learning theory. Experiential learning commenced when teachers experienced VR for the first time, which, in turn, caused a "spark" of emotion and desire to have students experience same emotions for their students. Using the Technological, Pedagogical, and Content Knowledge (TPACK; Mishra & Koehler, 2006) framework, I analyzed how the TPACK (Mishra & Koehler, 2006) framework provided a structured interpretation of the skills and knowledge required to implement VR in a classroom.

Lastly, Chapter Six included a summary of the study and a description of the implications for teachers considering implementation of VR. I explained factors that must be considered prior to offering this VR to students and the support needed to help teachers discover and integrate VR. The chapter concluded with a description of the limitations of this study and recommendations for future studies as well as acknowledgement of participant contributions.

Definition of Terms

I adopted the following terms to conduct my study:

3D Printer: An additive manufacturing tool that builds (layer by layer) objects from pliable materials that solidify into desired shapes.

Artificial Intelligence: Adaptive computerization and the capabilities for creating new understanding (Chen & He, 2020).

Augmented Reality: Using an AR application on a handheld device with front facing camera, 3D graphics appear and can be manipulated (Demski, 2013).

Avatar: A visual representation of a person in a virtual space. This includes a picture of a person, thing, or an object that symbolizes their personality.

Discord: A communication tool that offers multiple modalities for interacting with other users.

Escape Room: A challenge-based experience where users solve problems and ultimately [try to] leave the room.

Google Blocks: An interactive 3D design program to create projects in virtual reality.

Lag Time: The wait time for a computer to prepare a function.

Reddit: A forum-based social media platform curated by users.

Second Life: A free, open world game where people interact with each other in a virtual space. No objectives besides interactions with others and various environments required to advance in this game.

Virtual Reality (VR): A headset device that projects 3D images and provides sensations of immersion.

Zoom: A web-based video conferencing tool.

CHAPTER TWO: REVIEW OF THE LITERATURE

Virtual reality simulates real life and provides the brain with the experience of “being there” (Psotka, 1995, p. 407). In that moment, the human mind intercepts, interprets, and encodes information and then stores it into long-term memory (Cornell & Bailey, 1996). If channeled correctly, Makransky et al. (2017) found immersive VR supplied a powerful sense of presence. Bailey et al. (2012) described three types of presence, including physical, social, and self-presence. The type of presence relates to the reaction to the VR experience. Most learning occurs “by doing” or “learning about” a topic and these “lived experiences” within a virtual world provide opportunities to accomplish things that would otherwise be impossible in the physical world (Twining, 2009, p. 508). This study concerns the way teachers use VR for learning in a variety of settings and disciplines.

I conducted a review of the literature to analyze scholarly studies pertaining to the uses of VR for learning. The review offered unique challenges due several factors, including the description of equipment, the various uses of VR, and the studies of VR pedagogy and its effects on student learning. I followed a roughly chronological path in organizing the review findings. I adopted the following themes: (1) Changes in VR Hardware and Software – A Brief History; (2) Commercial Uses of VR for Employee Training; (3) Virtual Reality – Innovative Teachers and Instructional Approaches; (4) Virtual Reality Pedagogy – Changes in Teacher and Student Roles; and (5) Virtual Reality – Costs, Effectiveness, and Limitations

After describing the gaps and tensions is the literature, I selected several analytical theories to explain and interpret the content review findings. Theories included Dewey’s (1923) Experiential Learning Theory as well as the Technological, Pedagogical, and Content

Knowledge (TPACK; Mishra & Koehler, 2006) instructional framework for designing and integrating technology in the disciplines.

The review findings reveal the VR landscape as it changes and expands in commerce and education. I highlight challenges encountered in early VR implementation studies and its impact on pedagogy. Experiments with VR learning were sensitive to the type of equipment available as well as the learning goals.

Changes in VR Hardware and Software – A Brief History

In the mid-1990s, computers lacked the ability to create realistic, changing world images (Psotka, 1995). The computers from that time cost hundreds of thousands of dollars but involved substantial lag time, low-resolution, and cartoon-like shapes (Psotka, 1995). Effects from those experiences caused simulation sickness which destroyed the illusion (Psotka, 1995). Regian and Shebilske (1992) described VR systems from that timeframe as having “impoverished capabilities” to depict the details of the physical world but provided hope for improvements in the future (p. 137).

Predictions in 1996 suggested that by the year 2000, the entertainment industry would be the largest VR market and users would have fewer skills and knowledge to make “sophisticated” judgements and may “get lost” in a VR environment (Connell & Bailey, 1996, p. 155). Other alternatives to VR at that time included expensive dome projection systems with costly projectors, powerful computers, and mechanical systems (Psotka, 1995).

Early immersive experiences lacked realism due to technical limitations. Allison (2008) highlighted the sense of realness became destroyed when users reached to grab a virtual object and their hand disappeared into nothingness. Roussos et al. (1999) also cited the lack of realness in objects when introducing different objects in the virtual world. Students became confused when they met or viewed artifacts in the virtual world as compared to the presentations and their responses in the real world (Roussos et al., 1999).

The VR marketplace continued to grow and became more prevalent in daily life with wearable technology (Misak, 2018). Unfortunately, like most innovations, virtual reality studies conducted recently became outdated due to the continual release of newer technologies. A recent surge in VR devices from technology manufacturers like Google, Apple, Facebook Microsoft, and Samsung created an influx of excitement (Makransky et al., 2017). This push created a shift from software developers and educational institutions to ideate beyond traditional desktop computer systems to VR-based applications (Makransky et al., 2017).

Over the past few years with the improvements in the hardware and software associated with VR, each new device provides a slightly different user experiences with some good and some irrelevant changes. Eager software developers create new applications with hopes of striking gold that coordinate with the onslaught of modern devices, but most programs lack high quality experiences that educators would use. Given that elevated levels of perceptions determined likelihood of using VR, Sun et al. (2015) recommended hardware developers focus not only on headsets and experiences but also creating positive promotional marketing campaigns.

In September 2019, at the “Oculus Connect 6” technology conference, Facebook-owned Oculus surprised consumers and developers with new controller-free features for the Oculus Quest headset released earlier in the year. Starting in 2020, for some applications, controllers were no longer needed in some virtual settings. The Quest uses its four built-in monochrome cameras to track hand gestures and allow users to pinch and swipe to interact with the experience (Han et al., 2019). In an educational setting, instructors might no longer need to maintain a fleet of paired, charged controllers (Han et al., 2019). Oculus suggested that by removing controllers, VR will feel more natural and will allow for new ways to interact within virtual worlds (Han et al., 2019). This update may prove to be a significant attribute that may gather interest within the education community. Schools would no longer need to purchase high-powered computers with the headset; instead, teachers would have the ability to purchase multiple headsets at a much lower cost.

Whatever the device or cost, the uses of VR involve both commercial and educational settings reveal the challenges and opportunities for learning. Studies conducted in the early years reveal the limitations of VR as well as its potential. Commercial users adapted VR for employee training I describe these first to trace the commercial use of VR for learning. Examples of these programs follow.

Virtual Reality in Commerce

In 2014, Google designed a low-cost, entry-level viewer that worked with most smartphones called "Google Cardboard" (Lee et al., 2017). This viewer originated from two Google employees, labeled, "Googlers," David Coz and Damien Henry (Weiss, 2015). Constructed from cardboard, two lenses, Velcro, and magnets, it became available to purchase for less than $10 (Lee et al., 2017). In November 2015, the *New York Times* distributed more than one million free devices to subscribers in partnership with Google to supply deeper content (Weiss, 2015). Users downloaded the smartphone app and assembled the viewer to take part in this ground-breaking experience. The first immersive story called "The Displaced" told the story about three displaced children during the Syrian War (Weiss, 2015).

Google prepared for this launch by having VR-capable smartphone applications, like Google Earth and YouTube, ready for consumer download (Weiss, 2015). An aftermarket wave spawned from this event that supplied pre-made kits or instructions to construct home-made cardboard viewers to replicate the original Google Cardboard viewer (Weiss, 2015). By 2016, 25 million downloads of various cardboard apps from five million users showed the impact of this device (Lee et al., 2017 as cited by Google, 2016). However, according to an update on the Google Store website in March 2021: “We are no longer selling Google Cardboard on the Google Store,” which signaled an end-of-life status for this product.

Tham et al. (2018) studied 20 university students who used Google Cardboard to learn about diverse cultures. They found Google Cardboard to be more helpful compared to traditional texts for learning about cultures and brought different perspectives and deeper cultural understanding (Tham et al., 2018). The increased availability and abundance of newer headsets resulted in other industries seeing value of incorporating VR in workspaces, whether to train, problem-solving simulations, global collaboration, and beyond.

For example, in 2017, Wal-Mart Stores, Inc. incorporated the Oculus Go with new trainees with plans to expand to all 140,000 employees (Morris, 2017). New trainees experienced simulations in a protected environment for situations they would meet (Morris, 2017). For example, the trainee looked at a display case and noticed a price tag missing or saw the crowd rushing through the doors for the upcoming “Black Friday” sales event (Morris, 2017). Using the STRIVR training system, Wal-Mart Stores, Inc. found 70% of employees scored higher on evaluation exams than those who did not take part and 30% found the training to be more satisfying than the standard training method (STRIVR, n.d.).

Similarly, Kentucky Fried Chicken Corporation (KFC) created a supplemental “escape room” training game for store employees with hopes of increasing product quality (Taylor, 2017). This no-cost, 25-minute simulation (available to users with a VR headset) guided participants through the chicken-frying process with narration and consequences when not following the correct instructions (Taylor, 2017). The light-hearted role-playing game stressed the importance of following instructions to achieve quality standards.

In 2017, Lowe's Home Improvement stores developed a VR training station called "Holoroom How To" in stores that placed customers in simulations prior to trying projects on their own (Lowes Innovation Labs, n.d.). This experiential learning simulation allowed customers to complete tasks in a safe, protected environment where mistakes occur and provide a better understanding for the correct approaches (Lowes Innovation Labs n.d.). In this instance, the Lowe's employee played the role of the teacher to ease customer learning and supplied feedback based on reactions throughout the project (Lowes Innovation Labs, n.d.). When the customer later began the project at home, they felt more comfortable with completing the tasks because they had previously practiced the procedure (Lowes Innovation Labs, n.d.).

Verizon Wireless also used the STRIVR platform to provide safety training for store managers to experience different types of robbery simulations: smash and grab and armed robbery at store opening and closing (Jenkins, 2019). Verizon Wireless made it clear that the sole intent of this training involved the protection of store employees and not the devices. Instead, the STRIVR simulation placed the employee in a typical Verizon store when an armed robber stormed through the doors. Throughout the experience, built-in pauses prompted users to choose different options to continue. At the completion of the simulation, the user debriefed with the Verizon training supervisor and provided feedback. This experience built "muscle memory" for the store manager if an actual store robbery occurred (Jenkins, 2019).

Citing an average of around 50 armed robberies per year, Verizon Wireless pursued VR to train managers because traditional training methods lacked effectiveness (Jenkins, 2019). At the completion of this study, 95% of surveyed participants better-understood how to handle these situations if an actual robbery took place (Jenkins, 2019). Concerned that trauma may have resulted from these training experiences, Lou Tedrick, Verizon Wireless Vice President for Global Learning, cited the proximity of professional trainers throughout the simulation and acknowledged that many participants thanked Verizon for creating realistic simulations (Jenkins, 2019).

Lastly, in 2019, the Intel Corporation, known for producing computer microprocessors, partnered with VIVE to design a VR-based electrical safety recertification course for employees. This course had previously been administered in a web-based format, which the employees had taken for years (Rendoni, 2019). Results from this study initially surprised researchers (Rendoni, 2019). They found 75% of the employees struggled with VR-based simulation which caused a disconnect between theoretical and practical knowledge (Rendoni, 2019). Post-test findings proved that 94% of users enjoyed the VR experience and wanted to use the equipment more but the simulation proved that users lacked authentic experience with safety equipment and familiarity of safety procedures (Rendoni, 2019).

Employees that used web-based trainings had never been expected to have deeper levels of understanding (Rendoni, 2019). However, VR-based trainings highlighted gaps with earlier safety practices (Rendoni, 2019). Intel assessed the impact of expected incidents and future incurred costs-per-incident along with benefits from taking part in the VR safety course and estimated a return of investment (ROI) of 300% to expand this training on a global scale (Rendoni, 2019). These name-brand companies blending VR with training suggests credible validation for other organizations to contemplate implementation.

Access to funding to acquire VR technology and professional development needed to support teacher learning prevented many from accessing VR for student learning. Innovative teachers and new instructional approaches led the way for change in education.

Virtual Reality in Education – Innovative Teachers and Instructional Approaches

Most industries go to great lengths to conceal trade secrets. However, educators openly share, collaborate, and find inspiration to bring innovative ideas into their classrooms (Van der Heijden et al., 2015). Teachers understand the vast resources available for learning new ideas and creating and connecting opportunities to grasp concepts (Rose, 2018). Trailblazing teachers tend to trust others' methods and ideas if they helped students learn; however, studies agree educators needed to fully understand and approve their own student learning conditions and environments (Lang et al., 2017; Van der Heijden et al., 2015).

Innovative Teachers

Additionally, when school leaders recognized innovative behaviors from teachers this resulted in increases for using more technology in the future (Nemeržitski et al., 2013). After encountering obstacles and additional time to learn modern technologies, teachers found value incorporating VR when compared to traditional teaching and learning methods (Englund, 2017). Teachers felt comfortable using technology tools and when they found success, they were more likely to incorporate them in the future, while users with negative feelings limited their usage (Lawrence, 2018).

Teachers routinely encounter inadequate experiences when using technology tools (Koehler, 2013.) However, Allison (2008) labeled VR educators "technological optimists" and forecasted pedagogical promise with using virtual reality but proposed the necessity for added studies (p. 343). Similarly, Shin et al. (2013) used the phrase "perceived usefulness" (PU) to determine whether educators found enough justification to integrate VR in classrooms (p. 203). According to Shin et al. (2013), PU determines when a person found value with adopting a system whether it improves job performance and they proved positive correlations between satisfaction and perceived usability.

Psychological factors, like user confirmation and satisfaction, remained critical to determining the acceptance of new experiences with technologies like VR (Shin et al., 2013). Quality experiences along with convenient accessibility in immersive VR environments provided adequate learning opportunities and demonstrated the necessity for adoption of the tool (Shin et al., 2013). Ironically, Ernest et al. (2013) recommended teachers should also experience negative consequences from using VR to have a better understanding of optimal student learning environments.

When teachers combined professional reasoning with content knowledge, they determined how to best-incorporate technology tools into curriculum in coordination with optimal instructional strategies (Heitink et al., 2016). Teachers assessed the value that technology brought to the learning process and the pedagogical approach that made learning more attractive for students. They viewed efficiency and effectiveness to be determining factors to incorporate technology for learning (Heitink et al., 2016). The results from using technology implied the necessity and rationale for instructional changes.

For example, Roman and Racek (2018) studied a university professor who shifted pedagogical approaches when teaching a design lesson using VR. The study involved 25 undergraduate design students; their task involved creating a roadside marker in their city using the HTC Vive headset and Google Blocks application. Students worked independently throughout the eight-week course and focused on small group collaboration to complete various components (Roman & Racek, 2018). Due to a limited number of headsets available at a given moment, student accountability increased during the course. The instructor met with each student and provided real-time feedback while the student wore the headset and immersed in their design. During those sessions, students also provided feedback to the instructor to express issues and concerns while working in VR (Roman & Racek, 2018).

At one point during the course, a student group struggled with the scale of their roadside marker (Roman & Racek, 2018). They unknowingly created six-foot tall letters on the marker itself, but after the instructor noticed this issue, the professor recommended incorporating a person-like figure next to the design, which provided a real-world comparison that resulted in a modification to the design (Roman & Racek, 2018). In this case, VR provided access to visual cues that would not otherwise be available in the physical world. Once students completed the designs, small groups collaborated and critiqued the proposals, they presented final designs to city leaders, and one proposal was selected for construction. Further, at the completion of the course, the instructor solicited additional feedback from a student survey (Roman & Racek, 2018).

VR caused equipment concerns. Students complained that VR controllers had not been charged because previous students had used the power cables for charging personal mobile phones (Roman & Racek, 2018). Students also mentioned smudged lenses from previous users and the proximity in the lab which caused students to bump into tables and chairs during the sessions (Roman & Racek, 2018). However, even with the logistical issues, Roman and Racek envisioned unique learning possibilities with VR and recommended instructors continue to seek out authentic learning experiences with this tool. Innovative teachers experiment with technology to invent new instructional approaches.

Instructional Approaches

Virtual reality provides a variety of instructional methods and approaches for student learning. For example, in 2006, Twining created the Schome Park Programme (SPP) study. The goal of SPP involved the creation of a virtual open learning space using the tools available at that time (Second Life, a popular virtual world game) and invited 200 students and 50 adults to study their different lived experiences (Twining, 2009). Researchers replicated a virtual fictitious island for students to explore and naturally interact with each other (Twining, 2009).

In the SPP, researchers placed buildings and structures that typically supplied protection from the elements, but in a virtual world setting, they served no purpose (Twining, 2009). Students behaved radically different from the real world compared to the virtual world (Twining, 2009). When the teacher and students gathered in the SPP for a demonstration, the teacher began to explain a concept when suddenly, a student wandered off to a different location on the island (Twining, 2009). Participant behaviors changed, given the independence that virtual worlds afforded (Twining, 2009). Freedom from traditional educational systems and conceptions lead Twining (2009) to find philosophies for incorporating educational VR: learning about, learning by doing, and pedagogy.

Ultimately, Twining (2009) noted VR may not be the best tool for experiential learning, with the availability of real archaeological artifacts. For example, one does not need to immerse themselves in different environments when the real world will suffice. However, “process” learning, like playing chess in a virtual world against a computer or another virtual person, could supply enhanced learning experiences (Twining, 2009). Twining (2009) further explained the importance of role-playing in virtual worlds, like experiencing getting married. Younger students would otherwise not experience situations like a wedding ceremony to gain an understanding of this type of event without VR (Twining, 2009). Virtual worlds provided space for students and teachers to be unrestricted and offered autonomy to follow natural tendencies with minimal constraints (Twining, 2009).

Merchant et al. (2014) conducted a meta-analysis of 13 virtual reality technology-based studies and found evidence that VR met learning goals. Merchant et al. (2014) recommended educational institutions should implement VR given the overall cost savings which resulted in increased student achievement. Rolando et al. (2018) found after experiencing VR, students became more engaged in the activity compared to traditional learning activities and students solved complex problems during their simulation.

Rolando et al. (2018) also noted the students, themselves, understood the cost-saving measures from using VR simulations compared to real-life drills. This study yielded high success results with VR simulations and recommended expanding this training system to other organizations (Rolando et al., 2018).

Ren et al. (2015) discovered students showed more interest and retention in VR lab activities compared to traditional methods. Further, when using VR training simulations, laboratory equipment did not incur damage, require maintenance, upkeep, or inflict harm upon student learners. At the completion of this study, participants requested additional activities in virtual settings (Ren et al., 2015). Students gained exposure to equipment prior to using physical equipment and felt more comfortable and better grasped the goals and procedures (Ren et al., 2015).

Because of rapid growth, access to relevant and authentic evidence resulted in gaps of VR's true impact on society (Makransky et al., 2017). Makransky et al. (2017) believed VR caused distraction by sensory overload and it took away from learning goals. Stojšić et al. (2019)

cited Merchant et al. (2014) that VR did not belong in education due to excessive cost, user discomfort, and poor learning environments. However, Huang et al. (2010) recognized that increased levels of authenticity made VR a practical method for education and training. In well-designed VR experiences, authentic learning occurred through interactions that resembled the real world (Calandra & Puvirajah, 2014, cited by Barab et al., 2000). Over time, improvements in VR hardware and software resulted in better user experiences – especially for teachers and students.

Virtual Reality Pedagogy – Changes in Teacher and Student Roles

Roman and Racek's (2018) study provided an example of a shift away from traditional, teacher-led approaches to learning. Instead, the instructor empowered students to take control of learning (Roman & Racek, 2018). When others used VR for instruction, teachers shifted to a facilitator role rather than through direct instruction (Heitink et al., 2016; Keskitalo, 2011). Other pedagogical approaches to instruction using VR included problem-based learning, student-centered learning, applying integrated theoretical and practical knowledge (Fowler, 2015), and collaborative experiential learning (Keskitalo, 2011).

One concern with students interacting with their virtual environment meant the instructor lost control of what happened next (Kluge & Riley, 2008). This philosophical shift from teacher-led instruction to a free format learning experience proved to be difficult for traditional teachers (Kluge & Riley, 2008). Advancements in technology allowed the creation of simulations that fully engaged learners in the environment and the learning environment (Keskitalo, 2011). Virtual reality allowed students to construct different individual experiences while in the virtual world, then the teacher used that data to personalize feedback and critiques (Keskitalo, 2011). In virtual health care settings, VR facilitated teamwork, interactions within the environment, problem solving, and clinical reasoning practice (Keskitalo, 2011). These simulations transferred new knowledge and practice skills that had otherwise not blended theories and procedures (Keskitalo, 2011).

Keskitalo (2011) recommended designing the learning experience around three phases: During phase one, the teacher introduced the topic, concepts, and explained the simulation training process and made real-world connections or scenarios (Keskitalo, 2011). Phase two included learning goals, simulation expectations, participant roles, procedures, rules, and decisions during the time in the VR. After the teacher checked for understanding, phase three included the teacher shifting to the facilitator role and providing feedback throughout the simulation.

During phase three, the teacher evaluated student decisions and their reactions during the final debriefing stage (Keskitalo, 2011). In this final stage, the teacher facilitated a reflective conversation to analyze the entire process (e.g., what went well and not well and possible behavior or decision changes for the next time). More importantly, the instructor made a distinction regarding what happened in the simulation as compared to what may happen in the real world (Keskitalo, 2011). When healthcare workers learned this way, it proved to be essential for student comprehension and patient safety.

Participants from Keskitalo’s (2011) study viewed themselves to be “experts” in the medical field; however, instructors shifted pedagogical approaches to a learner-centered approach focused on the learning process. Instructors understood traditional teacher-led instruction provided only surface-level understanding when compared to higher levels of learning which empowered students to construct individual understanding of skills and knowledge (Keskitalo, 2011). Virtual reality conveyed complex information in interesting and simple ways with higher degrees of immersion and believability (Minocha, 2015). These studies reinforced the impact of VR in education but earlier studies faced considerable hurdles.

Virtual Reality – Costs, Effectiveness, and Limitations

Outcomes from early VR studies produced differing results depending on when they had been published. Two articles written prior to the year 2000 shared similar conclusions that VR lacked hardware and quality software applications (Regian & Shebilske, 1992), exorbitant expenses, and user frustration with low-quality and ineffective experiences (Psotka, 1995). However, within the past decade, researchers found VR became more prevalent in other industries (Jenkins, 2019; Lee et al., 2017; Minocha, 2015; Stojšić et al., 2019).

In the early days of VR, graphics would be pixelated, choppy, and not accurately aligned with user headset motions. In one study, Collins et al. (2018) revisited Arnold's (1971) incomplete constructivism Hypercube study due to insufficient technological tools available at the time. Arnold (1971) claimed learners would gain a better understanding of a Hypercube through simulated interactions rather than through observation. Using Arnold's (1971) original setup with a current HTC Vive VR system, the researchers, Collins et al. (2018), created two learning experiences for comparative purposes. Collins et al. (2018) discovered participants who did not use the VR setup took longer to complete the assessments. This research team successfully replicated Arnold's (1971) proposal but found experienced-based assessments did not generate enough adequate benefits for this type of learning to continue (Collins et al., 2018).

Another study from 20 years ago (when technology proved to be limited), by Roussos et al. (1999), included 52 elementary students in a narrative-based, immersive, constructionist/collaborative, and environment (NICE) virtual garden simulation. The researchers designed a virtual garden and invited students from different schools to collaborate and share the collective chores of gardening. Roussos et al. (1999) saw elevated levels of collaboration, problem solving, narration, and exploration during this study. They stressed the importance of strong lesson planning, setting learning goals, introducing VR theories prior to taking part, and teachers' understanding what VR provides for authentic learning (Roussos et al., 1999).

Misak (2018) studied student writers and improvements showed in their narrative writing styles after exploring virtual environments. Misak (2018) observed significant improvements to stylistic writing after exposing students to virtual worlds through reflective writing activities after they felt a sense of "being there" (p. 42). Misak (2018) noted the more realistic the medium (VR), the more likely the user made connections to the content.

Researchers in another VR study found mixed results from assessments after completing VR simulations and synthesized a cause for varied results (Rupp et al., 2019). Rupp et al. (2019) found participants who used the entry-level headsets verified the effects of motion sickness but found Oculus (high-end HMD) participants more likely to use VR again compared to Google Cardboard users (Rupp et al., 2019). Like many things in life, if a person has an unpleasant experience, they will not want to repeat it.

According to Lövquist et al. (2012 as cited in Salas et al., 1998) computer scientist-generated simulations did not meet user needs until computer scientists began collaborating with content experts and educators to make VR experiences more effective. Calandra and Puvirajah (2014) and Savin-Baden et al. (2010) called the learning curve "steep" for inexperienced users to VR and questioned the pedagogical value of interactive virtual worlds. Shin et al. (2013) warned 3D environments might find a place in education but will be dependent upon the user experience and usability. However, VR technologies and experiences improved over time which resulted in an increased presence in other industries.

Summary, Gaps, and Tensions in Literature

A growing number of industries found value incorporating VR in training and improving customer experience (Jenkins, 2019). These studies focused on industry training and acknowledged the positive impact that VR brings to users. However, when searching for VR educators and best practices, the gap in literature presented an opportunity to look deeper.

In today's educational environment, teachers lack funding to acquire and furnish classrooms with VR headsets. However, with new devices continuing to enter the marketplace, most are intended for entertainment and not education purposes (Jenkins, 2019). Additionally, management and oversight of multiple devices proved to be difficult for teachers to sustain given other instructional responsibilities. Teachers needed to determine whether the extra time and effort investment will be worthwhile. Teachers made the decision to bring VR into the classroom where relevant and existing instructional methodologies do not have a long shelf life. This brought frustration for some (e.g., a teacher acquires funding for a VR headset or multiple headsets and a few months later, a newer, better headset becomes available with different options and features).

The VR landscape can unexpectedly change in a moment's notice. In October 2019, Google launched the new Pixel 4 smartphone and surprised many by the lack of combability with the current Google VR headset, "Daydream View." A Google statement acknowledged previous potential for smartphone VR experiences, but with newer devices (like the standalone Oculus Quest which has a built-in technology), the process of asking users to insert their phone in a headset limits the overall functionality of the smartphone (Price, 2019). Google also acknowledged a decrease of Daydream usage over time, but the app continued to be available for existing users (Price, 2019). Price (2019) acknowledged technology firms have invested "billions of dollars” in VR, but it had not been adopted by the mainstream and still considered a “novelty” (p. 2). From afar, Google, one of the leaders in technology tools and applications, appeared to be abandoning VR.

The gap in the literature concerns the lack of VR studies associated with teacher innovation and student learning. Future studies should explore why and how teachers use VR for student learning. This study may serve as a teacher resource for understanding the uses of VR and the hurdles which must be overcome to implement a new technology. Because the VR industry continues to grow and change, the hurdles teachers must overcome to bring this tool in the classroom should be diminished, thus justifying the necessity for this study.

Analytical Theory

In the next section, I introduce two analytical theories I used to interpret findings and interpret the data collected in my study. I selected Dewey’s (1916) Experiential Learning Theory because VR users have complete control of their actions based on natural behavioral instincts and interests. Virtual reality proved to be an optimal tool for learning because it can simulate various locations at different points in time while offering collaborative opportunities with people on the other side of the world. Virtual reality affords users the ability to experience things in a safe, protected environment that can be repeated when necessary. Next, I introduce the Technological, Pedagogical, and Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). Research by Mishra and Koehler (2006) supports that the most effective teaching practices involve the connections and alignment of content, pedagogy, and technology. Teachers need to determine appropriate technologies, adapt instructional approaches, and understand content when designing and implementing innovative learning activities (Mishra & Koehler, 2006).

Dewey's Experiential Learning Theory

I selected Dewey's (1916) educational philosophy which supports an immersive educational environment combined with experiential learning activities. Dewey (1938) argued that through experiences, curious learners possessed internal desires to seek additional information. Even though Dewey's (1938) philosophies date back to the 1900s, they continue to be accurate today. The teacher took responsibility to understand the learner's landscape and created the optimal learning space; however, under poor conditions, learning did not happen (Dewey, 1938). Perceptions of teachers also needed to be linked throughout the learning process (Dewey, 1938). Dewey (1938) called interactions within an experience a "transaction" based on natural impulses and desires.

After observing students in a condition, teachers identified learner tendencies which assisted in guiding student improvement (Dewey, 1938). From that moment, learners understood the significance and consequences from their actions (Dewey, 1938). Even without computer technology in the early 1900s and understanding the roots of teaching and learning, Dewey's (1938) themes connect when using VR. Blending the themes: VR, pedagogy, and teaching and learning brought a cohesive research approach to this study. I continue to wonder what Dewey would think of this innovative educational tool.

The blending of VR with learning allows users to practice skills and develop techniques in a safe environment. For example, the ENGAGE software platform designed a Sub-Saharan African birthing center experience that trained medical professionals in the moments after a child had been born. This challenge-based experience included a narrator who guided users with tasks and ensured proper care for a newborn. In the event of a mistake, the simulation paused and provided automated corrective actions. The goal of this experience involved training users that when they returned to this type of setting, they felt comfortable with actual childbirth and had a better understanding of what to expect in real life.

ENGAGE also designed a retail store environment for users to understand the skills required to work with inventory and interacting with customers. This type of environment provided first-hand exposure for those who had never worked in this setting. It could also be an experience for developmentally delayed users to better-understand norms and expectations.

Dewey's (1916) experiential learning framework described the effects from reactionary interactions within an environment. When a student practiced a skill, they applied what had been learned through previous training which produced genuine results (Dewey, 1916). Connecting that concept to a simulated VR learning environment, users replicated exercises in a protected environment under the supervision of a teacher who demonstrated understanding of concepts and skills. The popular VR game "Job Simulator" provided challenge-based experiences, like a line cook in a restaurant, auto mechanic, convenience store clerk, and office worker trapped in a cubicle. Although not entirely realistic compared to actual settings, Job Simulator allowed users to solve problems, interact with the environment, play, and feel like an employee in each setting.

Dewey (1916) acknowledged the importance of making mistakes, calling them "incidental requirements" in the learning process. Virtual reality allows users to defy laws of physics, break things, learn cause and effect consequences, and practice until perfect (Gavish et al., 2013). When learners interacted with environments, they made connections to prior experiences and created opportunities for reflection (Dewey, 1938). Dewey (1938) explained that optimal learning actions derived from past experiences. The user received feedback from experiences which deepened understanding from the interactions themselves or the teacher.

The Oculus-based VR application “Toy Box” simulated a carnival game experience. Users operate a virtual sling shot, laser gun, remote control toy tank, ping pong paddle, and boomerang for target practice that they aim towards various breakable items. During this experience, the users do not incur injuries, costs, repairs, or judgement; instead, they enjoy interactions within a virtual playground. The realistic sound effects from targets crashing and shattered glass, created similarities to real life. This un-timed, un-guided gaming application could be used to strengthen dexterity, build hand-eye coordination, stress relief, or just to have fun.

The flexibility VR provides connects with Dewey’s (1916) thoughts, signifying that individual characteristics and actions will vary during learning experiences (see Figure 2). This trial-and-error method resulted in successes or failures and guides learners to make appropriate decisions (Dewey 1916). Dewey (1916) called experiential learning “exercises in application” that produced genuine results. Looking back at my review, Dewey’s support of practice in an immersive environment explained the connection and potential of VR and experiential learning.

Figure 2

Dewey and VR Connections

	Immersion	Collaboration	Experiential	Reflection
Play	X		X	X
Social		X		X
Open-Mind	X	X	X	X
Creativity	X	X	X	X
Flexibility	X	X	X	

Note. Applicable themes connecting Dewey to VR instructional elements.

When I reflected on my review of literature, Dewey's framework related to many aspects to VR and student learning. The technological promise that VR affords in the classroom learning experience contributed to potential widespread adoption. I could only imagine if Dewey lived today to see firsthand the capabilities of VR, he would have much to say about this topic. Not only would VR have reinforced his thoughts on experiential learning, but it could have unleashed entirely new ways of instruction. I selected the TPACK instructional framework to blend with Dewey's (1916) experiential learning theory.

Technological, Pedagogical, Content Knowledge Framework

The TPACK framework represents a resource for different technology approaches in the constructivist classroom. Developed at Michigan State University by Mishra and Koehler (2006), the Technological Pedagogical Content Knowledge (TPACK) framework provided concepts for developing technology in the classroom (Koehler et al., 2013). Highly impactful teachers possess solid understandings of content area, appropriate instructional approaches, and knowledge of technology tools (Mishra & Koehler, 2006). "Master" teachers blend these three areas and demonstrate flexibility and adaptability with instructional practices (Mishra & Koehler, 2006). They gauge student responses from learning activities, which, in turn, drive future instructional decisions. Additionally, this framework helps teachers to better understand the "big picture" when implementing technology (Kolb, 2017). These teachers demonstrate a willingness to reflect and refine instructional practices (Magana, 2017).

TPACK provided flexible approaches for any learning level and focused on the relationships between technological, pedagogical, and content knowledge (Kolb, 2017). Integrating technology into constructivist classrooms might prove to be difficult and look differently for teachers but should be structured towards specific learning goals and learning environments (Koehler et al., 2013). Through balancing the various levels of content knowledge, pedagogical knowledge, and technology knowledge resulted in better learning conditions for students (Koehler et al., 2013). When teachers employed the TPACK framework when designing activities with technology, they did not view it to be an “add-on” for learning but a methodology that better-connected the content with the pedagogy (Koehler et al., 2013).

Summary

In closing, pairing Dewey’s (1923) experiential learning theory with the constructivist paradigm proved to be the natural choice for this study. Adding the TPACK framework to this study reinforced the validity of blending instruction, content, and technology. When students have complete freedom to explore virtual worlds and build upon previous knowledge based on natural tendencies, this empowered students to take control of their learning. Additionally, when they practiced and learned through repetition in a safe, protected environment (under the supervision of a teacher), this simulated space provided optimal conditions for learning.

CHAPTER THREE: METHODOLOGY

I adopted qualitative research methods and the case study approach to investigate how innovative teachers used VR for student learning. Specifically, my study aimed to identify how teachers from different disciplines used adopted unique instructional approaches using VR. In this chapter I describe qualitative research, intrinsic case studies, and the methods I used to conduct my research study.

Qualitative Research

Qualitative research allowed me to use an emergent approach and identify a variety of participant experiences and practices. I selected qualitative inquiry because of the probability of discovering unique methods and changes in practice unique to the adoption of VR for student learning. Qualitative research involves inquiry, the studying of artifacts, and analysis (Patton, 2014). Merriam (1998) described qualitative research as an "umbrella concept" due to vast ranges of possible outcomes (p. 5). Patton (2014) described qualitative research as "personal" (p. 3). The researcher incorporates past experiences, interests, knowledge into their work (Patton, 2014).

Qualitative inquiry also entails the importance of establishing significance (Patton, 2014). Patton (2014) further explained that qualitative research provides flexibility to the researcher to uncover how and why things occur. Bazeley (2013) explained qualitative research involves cases with "a degree of fluidity" (p. 5). Similarly, Yin (2011) described qualitative research as flexible when compared to a fixed research design approach.

Qualitative research involves the understanding of perspectives from participants and not of the researcher (Merriam, 1998). Merriam explained that the data collected is from humans and not inanimate objects. Additionally, qualitative data derives from fieldwork interactions

(Merriam, 1998). Drawing from these experiences, researchers determine theories in the form of categories or themes (Merriam, 1998). Among the major approaches in qualitative research, I adopted the intrinsic case study approach because it allows for the study of innovative practices.

Qualitive research provided a flexible and responsive method to both collect and analyze the data to determine how innovative teachers invented and adapted instructional practices to take advantage of VR. I interviewed educators from around the world and found and identified common practices as well as unique differences in participants' adoption of VR for student learning. Participants offered unique insights, pedagogical approaches, educational philosophies, student exemplars, and more. Creswell and Poth (2018) proposed the intrinsic case study within the qualitative research tradition was an effective approach to present unique or unusual situations, like innovative VR practices in K-12 education.

Intrinsic Case Study Approach

A case study involves an "empirical unit" or the "theoretical construct" of an entity or entities (Patton, 2014, p. 259). Cases involve people or events of a phenomenon for a study (Bazeley, 2013). Patton (2014) explained the focus of the case study involves "the case and not the methods" (p. 259). Yin (2011) highlighted the appeal for qualitative case study approaches to select a preferred topic and then describe details to gain an in-depth understanding of a unique situation.

Merriam (1998) used the term "particularistic," which signified the importance of pursuing a situation or phenomenon. Case studies can be labeled "exploratory," meaning flexibility with gathering data and the potential for unplanned findings (Merriam, 1998). Cases can confirm understanding, bring discovery, or extend the reader's experience (Merriam, 1998). Additionally, case studies focus on the "process," meaning an explanation of the scope of a topic

(Merriam, 1998). Case studies might be chosen for the uniqueness of a topic that may otherwise not be obvious.

Selecting a topic with boundaries, one can graphically present the information to be a “circle” with the “heart” to be the focal point of the study (Merriam, 1998, p. 27). Case studies may provide a better understanding of an interesting or innovative real-world phenomenon (Merriam, 1998). Researchers use qualitative case study approaches because of their interest in discovery and interpretation and then aspire to uncover unifying characteristics or themes (Merriam, 1998). Cases involving similarities develop into the same phenomenon (Bazeley, 2013). Interpretation of data becomes impacted by past experiences and beliefs (Bazeley, 2013).

Participants used different implementations of VR with students. When I identified participants for my study on a global scale, I created a broad list of identifying characteristics that distinguished their contributions to VR. Creswell and Poth (2018) recommended using a matrix to create boundaries for organizing data collected during research, which helped to reign in the potential for unintended widening of the study. I created a methodical, systematic approach for this process beginning with receiving approval from the Institutional Review Board (IRB) to conduct my study (see Appendix A).

The purpose for selecting an intrinsic case study approach is to examine in depth the way innovative teachers used VR for student learning in K-12 education. The rationale for this case study project was to provide a better understanding of how high-end VR educators used this technology, including their habits, pedagogical approaches, and instructional philosophies. In the next section, I provide a description of the methods used to conduct my study, beginning with gaining permission to conduct my study from the Institutional Review Board and following the guidelines for conducting human subjects research.

Institutional Review Board (IRB)

I followed all the guidelines established in human subjects research. All participants completed the University of St. Thomas general consent form which informed them of the following: (1) the scope and sequence of their participation in this study; (2) potential risks from participating; (3) rationale for pursuing this research area; (4) protection of privacy and confidentiality for participating; (5) the right to withdraw; (6) provided additional information to answer questions or concerns; and (7) gaining their signature to acknowledge consent. Prior to starting the interview, I verified and confirmed all particulars with each participant to confirm their understanding and importance of the IRB. I captured their acceptance on video. The IRB approved this study that involved participants answering questions in an online interview using the web conferencing tool, Zoom (see Appendix B). I did not interview any students or participants younger than age 18 and did not conduct any interviews without the completed IRB consent form signed by both parties.

Recruitment and Selection of Participants

I recruited K-12 teachers in the VR educational world by following conversations on social media and participating in multiple VR webinars. These methods allowed me to solicit voluntary participants for my study. For example, one day after I received IRB approval, I participated in an immersive VR webinar for educators hosted in ENGAGE. At the closing of the event, the hosts provided an opportunity for participants to travel up to the stage and share research projects. I took advantage of this opportunity to share my research project in front of a room full of VR educators from around the world (see Figure 3). Additionally, I found success in contacting global VR leaders by sending a tweet or email in hopes of garnering a response and each person (thus far) had reciprocated a reply.

Figure 3

ENGAGE Webinar

Note. The side view from the VR webinar when I first solicited participation for my study.

On Facebook, I followed a public group entitled “Virtual & Augmented Reality for Education” which had 5,500+ members who contributed daily to various conversations regarding education and VR. I also created posts in the group, “VR in Education.” I noticed other researchers solicited feedback or participation in scholarly studies in this forum. I advertised my study multiple times (see Appendix C).

One of the VR presenters in a different webinar recommended I participate in conversations on Discord, another social media website. Once I became accustomed to the navigation of the program, I created posts for potential participants. I also participated in VR meetups using “Alt Space,” a social and immersive meeting platform. These meet ups incorporated a brief presentation regarding VR and education and an opportunity to connect and collaborate with other VR users. I also used this opportunity to advertise my study.

The most successful method for identifying and connecting with potential participants involved the social media platform Twitter. The number of “followers” did not determine whether a person would qualify for this study. Instead, the content quality of their posts and profile details aided in the identification of potential participation during the selection process. I also analyzed potential participant Twitter accounts, including the ones they followed and the reciprocal accounts that followed their account. The VR education online community in all platforms provided a welcoming and collaborative environment to share ideas and work to expand this movement.

Initial contacts involved sending direct messages (DMs) to users who “followed” me back, or otherwise I “tagged” them in public posts. When they indicated their willingness to participate, we continued our conversation through private interactions. I requested their email address and I attached the recruitment flyer which provided additional details. Once they agreed to the terms and conditions which included them returning the signed IRB consent form, I signed the completed form and provided a copy for them along with a Zoom invitation. I also provided them the interview questions relating to all academic areas which included inquiring about general philosophies for VR. We established a time that best fit their schedule. Interviews occurred at all hours of the day, depending on participants’ availability. In a few instances, they took place late at night or early in the morning. I interviewed one participant living in Australia – this mean a local time of 3:00 a.m. for me and 6:00 p.m. for the Australian participant.

I named participants after players on the 1987 Minnesota Twins baseball roster (see Table 1). I converted men baseball player names into women-associated names for women participants. A number of the participants came from the United States of America but there were also participants from Europe, Africa, and Australia. Two participants, David Kaser (2019) and Craig Frehlich (2020), authored books relating to VR and education and granted permission to use their real identities for this study. Many people had roles such as teacher, instructional support, technology specialists, or school leadership positions.

Table 1

Participant Information

Pseudonym or Actual Name	Geographic Location	Role	Content Specialty
Sally	Canada	Technology Integrationist	English as Second Language (ESL)
Alison	Canada	Pedagogical Counselor	English Language Arts
Tomi	California	Teacher	Multiple Subjects
Joe	Texas	Instructional Software Specialist	Multiple Subjects
Randy	Nigeria, Africa	“Kid Facilitator”	Former Lawyer, Educational Entrepreneur
Jeanie	Minnesota	Teacher	STEM
Mike	Australia	Director	STEM
Steve	Australia	Head of Digital Innovation	Technology
Chrissy	Kentucky	Teacher/Researcher	Special Education, Elementary Education
Dani	California	Teacher/Specialist	English Language Learners
George	Australia	Learning Technologies Integrator	STEM
Keith	Minnesota	Teacher	STEM
Les	England	Teacher	English Education
David Kaser	Ohio	Teacher	STEM
Craig Froelich	Singapore	Teacher	Design and Technology

Data Collection

After reviewing the consent form, I began the interview process. During the interview process, I recorded and saved each session to the “cloud.” Data collected from this study are only accessible with a password. Throughout the interview process, participants could stop the interview at any moment without repercussions. During interviews, I wore a headset and ensured no audio could be heard by others in my home. Only my dissertation chair and I had access to the recordings.

During the interviews, I used the same set of questions (see appendix B). Some participants required all eight questions to provide adequate responses, while others only needed a few prompts. I began each interview with similar questions to collect their background information. From there, I adopted a semi-structured interview process and gauged the content of those initial responses to determine the rest of the interview. Patton (2014) called this "creative interviewing." I avoided interruption and waited until the end to determine if adequate data had been provided. This method increased flexibility for participants to further explain thoughts and perspectives rather than adhering to prescribed questions. Adaptive interviewing proved to be necessary when dealing with participants from outside of the United States. Interviews did not last longer than one hour.

In some instances, participants from other continents used some alternative words or phrases than those traditionally used in the United States. For example, private K-12 schools are called independent schools elsewhere. Differences in culture became prevalent when learning about popular sporting events in other countries compared to the United States. I had an understanding and awareness of those differences which aided in adapting questions to participants from around the world. Those distinctions increased the depth and diversity to this study.

Data Analysis

I completed all interviews and subsequent data coding within a three-to-four-month period. I used Zoom-generated text transcriptions from each interview. After each interview, I listened to the recordings and compared them to the transcripts to verify accuracy. Some international participants exhibited regional dialects and there were a few instances where recordings produced subpar audio quality and required further deciphering.

I used NVivo to code and analyze the data. I uploaded each transcript into NVivo and began analyzing the responses. I created 40 codes with an average of 471 references per participant. References ranged from 120 up to 1,291 for one participant. From there, I identified common themes and placed them in categories. Participants with unique data variables had been identified and placed into groupings.

According to Patton (2015), finding commonalities amongst innovative practices and pedagogical approaches started at the entry level. I documented and reflected on each participant's story throughout the interviewing process. I analyzed each transcript and highlighted sections of transcripts which assisted with identifying patterns. I also reviewed video and audio recordings with transcripts to ensure accuracy.

Given the possibility for a wide range of responses, I created an organizational system for the results (see Figure 4). I created a matrix to organize data into various categories based on patterns generated from the interviews. From there, I identified themes and determined the sequential order to explain the various accounts.

Figure 4

Matrix

B	C	D	E	F	G	H	I	J	K
	THEMES								
	Cardboard Experience	Initial Exposure Level	Reaction	Funding	Situation	Brainstorming/Inspiration/Planning	Classification		Activities
Participant									
Sally	x	Tilt Brush		x	Tech $ Request	x	Creative		x
David	x	Expeditions		x	Grants	x	Innovative		x
Alison	x	Oculus GO		x	Tech $ Request + Verification	x	Collaborative		x
Tomi	x	Arcade		x	Donor's Choose	x	Isolated		x
Joe				x	Donor's Choose + Donation	x	Collaborative		x
Craig (+ Collin)	x	HTC Vive		x	Private School	x	Creative		x
Randy	x					x	Innovative		x
Jeanie	x	HTC Vive		x	Grant	x	Collaborative		x
Mike	x	EARLY-pixelated		x	Partnership w/ college	x	Innovative		x
Steve	x	Expeditions				x	Innovative		x
Chrissy	x	Play Station-homemade		x	Grant	x	Creative		x
Dani	x	Cardboard		x	Tech $	x	Creative		x
George	x	Expeditions		x	Private School + Grant	x	Isolated		x
Keith	x	Samsung Galaxy (Student		x	Admin Found	x	Collaborative		x
Les						x	Creative		x

Note. This matrix aided in the organization of data.

For each theme, I grouped similar responses together. I synthesized responses to best fit the criteria to bring cohesiveness from the variety of participants. The background and content expertise of the participants varied, but their connection to VR and learning did not. Once I coded and analyzed the data, I organized the data into a case record that articulated the qualities and characteristics of VR educational leaders. I created an organizational matrix with a spreadsheet. I generated a color code system from the transcripts for each theme and determined how participants aligned, which Patton (2014) called, "convergence." I sorted the similar colors together which assisted in generating a sequence. As I wrote each theme, the groupings assisted in identifying patterns and suggesting coherent, chronological accounts. Providing a detailed description of participant responses meets the criteria for qualitative research.

Reliability and Validity in Qualitative Research

Golafshani (2003) used the word “stability” to refer to reliability in qualitative research. Reliability in qualitative research becomes evident in the data analysis phase. Participant experiences and practices fit within the various themes of this study, showing a general pattern after coding individual responses. For example, the practice of pairing students together due to limited availability of headsets became a prevalent strategy used by VR teachers. The “reliable” results were confirmed because the VR teachers individually designed this activity on their own without insight from others. However, when others used a similar strategy, the instructional strategy was “confirmed” as reliable because other participants reported the same strategy. Similar attributes with pedagogical changes became evident when multiple instances, such as VR teachers shifting to a facilitator role, were revealed as a consistent data theme. A thorough description of the entire process provides some assurance of the quality in a qualitative research study.

Patton (2014) explained that validity is used “for judging a research design” and “assessing its credibility and utility” (p. 693). Similarly, Golafshani (2003) explained that researchers needed an additional measure of accuracy for qualitative research which resulted in the implementation of validity. Although sometimes closely connected with reliability, validity in qualitative research can also have multiple meanings (Golafshani, 2003). For example, qualitative research provides flexible methods for collecting and triangulating data through participant interviews. I used a variety of applications to collect and analyze data.

I found that voice dictation accuracy in word processing programs had significantly improved over the years. During the interview process adopted for the pilot study, I replayed video recordings of the sessions and created transcripts in real-time to transcribe into text. I experimented with transcription using Google Docs and Microsoft Word but found the latter yielded better accuracy. Creswell and Poth (2018) called this “intercoder agreement” to triangulate the data through multiple modalities.

Throughout this entire process, I continued to reflect upon and revise coding practices to ensure uniformity with analysis and revisions. During this time, I routinely met with my doctoral cohort on a weekly basis to discuss general procedural methods and practices, which Merriam (1998) branded, “peer examination” (p. 204).

Creswell and Poth (2018) listed five criteria which should be applied to evaluate the “quality” of qualitative research studies. This included the following questions:

1. "Does the research question drive the data collection and analysis" (Creswell & Poth, 2018, p. 266)? Coursework in this doctoral program provided opportunities for me to conduct two pilot studies to investigate and implement the best methods for this study. Those in-class activities allowed for collaborative discussions and, ultimately, aided in deciding that qualitative case study was the best fit to answer my research question.
2. “To what extent are the data collection and analysis techniques competently applied” (p. 267)? When I interviewed participants, I made certain that questions pertained to relevant topics for this study. Further, when assessing and analyzing transcripts for quality control purposes (prior to coding), I verified that participant contributions provided a comprehensive representation of their descriptions.
3. “Are the researcher’s assumptions made explicit” (p. 267)? Yes. As the primary researcher, I withheld all judgements from participant contributions. I maintained the highest ethical standards to ensure accurate representations and accounts. Personal opinions or philosophies (to the degree possible) did not impact participant contributions.

4. “Does the study have overall warrant” (p. 267)? Given the ever-changing landscape and increased availability of VR in education, the demand for studies like this will increase. In recent years, VR has become more prevalent in society and schools which signifies the importance of this study. The challenges of the Covid-19 pandemic demonstrated the necessity for better ways to remotely connect, which makes VR a contender for large-scale expansion.
5. “Does the study have value both in informing and improving practice and protecting the confidentiality, privacy, and truth telling of participants conducting in an ethical manner” (p. 267)? This study permitted participants to maintain privacy or, in two instances, reveal their names as agreed. Safety and security of data were held in the highest regard out of respect to the participants but also for doctoral education practices. All records and documentation from this study will be destroyed in three years.

In the next section I describe how I maintained the highest levels of ethical conduct and paid respect to the process, participants, and the standards of the field and the University of St. Thomas.

Ethical Considerations

I waited for IRB approval from the University of St. Thomas and the consent of my dissertation chair, Dr. Sarah Noonan, before beginning my study. Throughout the entirety of my research project, I did not profit from, nor solicit any proprietary computer software platforms. Patton (2014) explains that the role of the researcher does not involve judgement. Further, the researcher should focus on gathering data even when tempted to stray off topic (Patton, 2014).

Merriam (1998) explained that the interview process involves “risks and benefits to the informants” (p. 214). However, I protected the identities of my participants (with the exception of the two participants who granted permission) and ensured their contributions remained in secured, encrypted computer systems. I guaranteed safety and comfort throughout the interview process and remained observant for any signs of discomfort or uneasiness. I did not skew or falsify data that solely favor positive results from this study. All participants elected to receive a copy of this study once published, which they will receive via email when completed. Any and all data will be destroyed three years after publication. I truly appreciate their contributions. When given the opportunity, I will proudly present this study to audiences small or large.

Summary

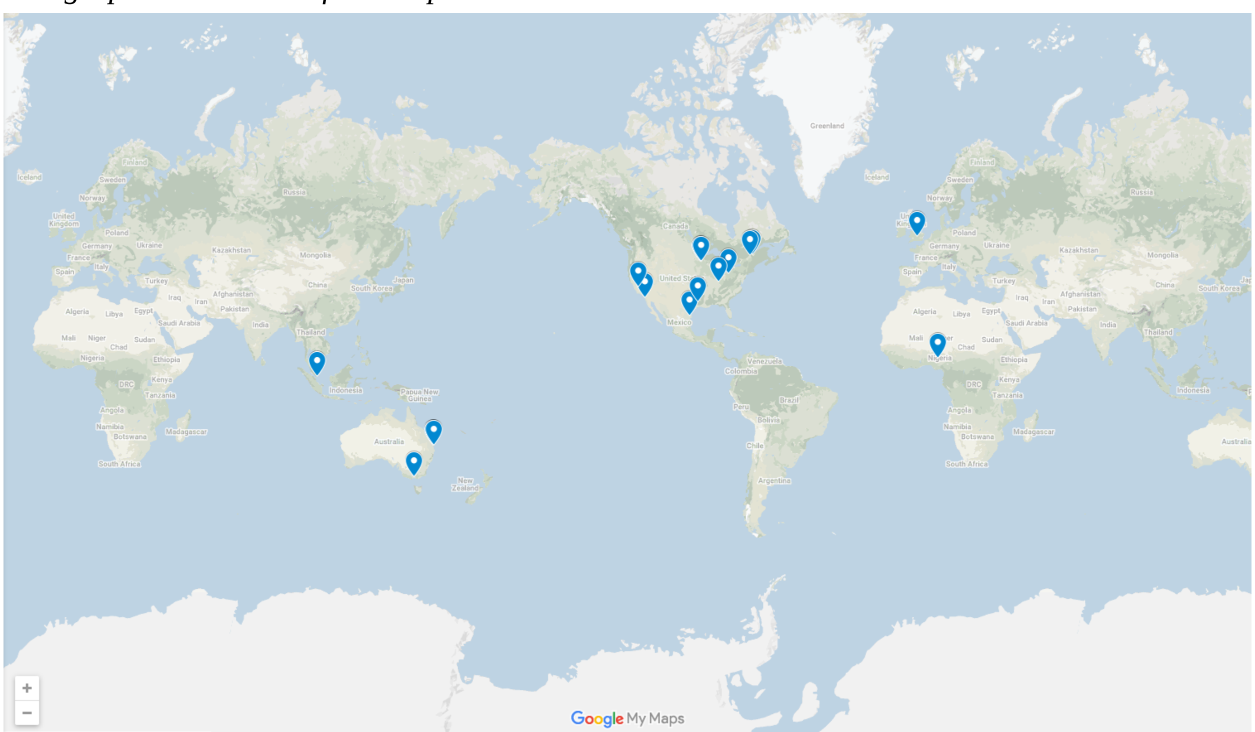
In this chapter I described the methodologies adopted to prepare and conduct. This included an explanation of qualitative research and the case study approach. I acknowledged the strict compliance of IRB guidelines and my research role. I explained how I recruited and selected participants, the interview process followed, and the way I organized the data and identified five major themes. Lastly, I acknowledged my own biases with interpreting the data and strategies adopted to reduce this challenge. I also describe the quality of the study based on reliability, validity, and ethical considerations in qualitative research. In the next chapter I introduce the findings from participant interviews.

CHAPTER FOUR: DISCOVERING AND IMPLEMENTING VIRTUAL REALITY FOR LEARNING

In this chapter, I present information regarding how 15 VR educators from around the world (see Figure 5) adopted unique methods to incorporate VR in learning and teaching. Four themes emerged after I completed the data collection and analysis process, which included: (1) initial exposure to VR, (2) acquiring funds and determining implementation, (3) preparation, and (4) the three levels of incorporating VR for student learning.

Figure 5

Geographic Locations of Participants

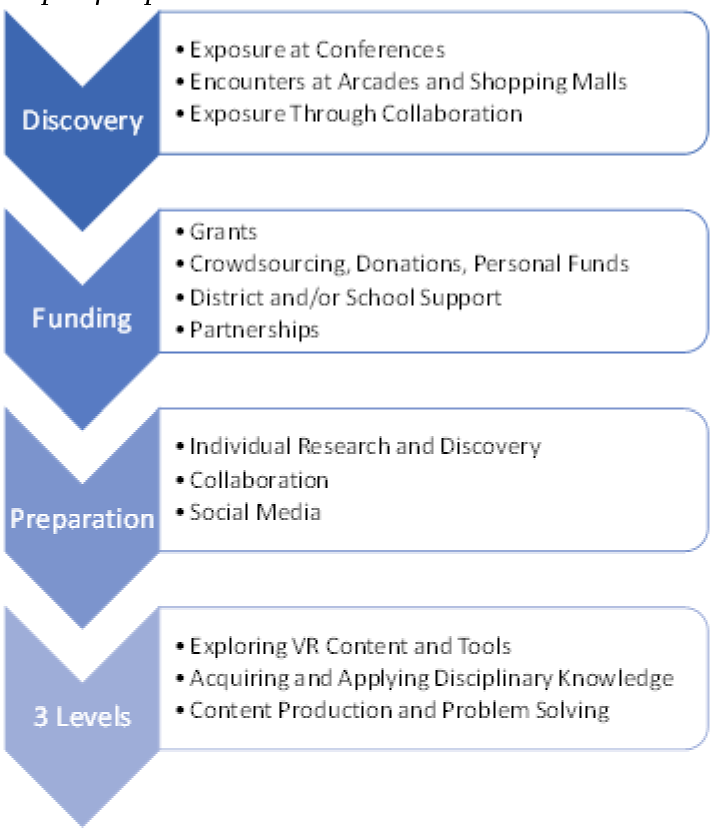


Note. Each pin represents the location of each participant.

First, I shared how teachers first learned about and later decided to use VR in their educational practice (see Figure 6). Next, I explained how participants struggled to find the funds to purpose VR technology and created VR learning activities. While some participants' initial exposure involved low-cost, consumption-only headsets, others became introduced at the highest quality, with Six-Degrees of Freedom (DOF) headsets.

Figure 6

Steps of Implementation



Note. The four themes of this study.

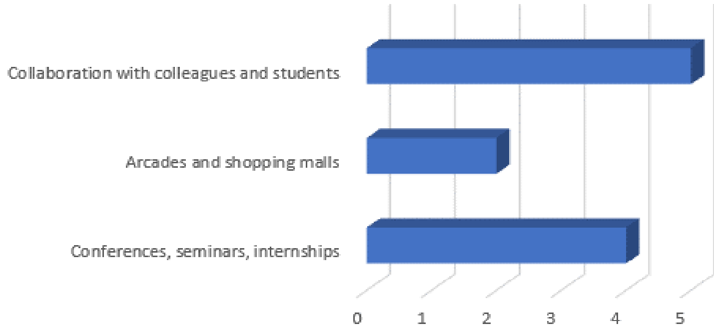
Then, I illustrated how participants implemented VR in class. I provided examples of different types and levels of implementation. Participants found different types of support to implement VR learning. This required teachers to deploy VR in creative ways and repurpose available content to align with disciplinary goals.

Participants taught students ranging from elementary through high school. They represented different academic areas extending from teaching “core” subjects (such as science, social studies, and math) to elective classes. Some participants served in instructional support roles but worked with students and colleagues. Regardless of the headset quality, participants’ initial exposure to VR inspired them to envision their students using VR for learning. Moments after immersing themselves in this virtual world, participants made it their mission to acquire funds, establish pedagogy, and discover the probable impact of VR on learning.

Teacher discovery of VR into three categories: (1) conferences, seminars, and an internship; (2) an arcade and shopping malls; and (3) collaborations with a spouse, colleagues, and students (see Figure 7). No matter how participants became exposed to VR, whether through lesser-quality cardboard devices or high-end headsets, the sequence of VR users followed the same pattern—surprise, excitement, and recognition of the potential of VR for student learning.

Figure 7

Initial Experiences



Note. Initial exposures to VR.

The entry-level headset, Google “Cardboard,” used various free applications downloaded onto most smartphones and secured by magnets. Three participants, Steve, George, and Dani experienced VR for the first-time with Google Expeditions on the Google Cardboard headset, which provided the viewing of 360-degree immersive experiences. Most teachers have been known to have limitations regarding budgets; however, this price point made entry-level VR accessible for many. Priced around $15 per headset, this early VR device provided enriching experiences, allowing teachers to pursue this technology further.

The next level in quality of headsets involved the Oculus Go, Oculus Quest 1, Oculus Quest 2, Oculus Rift CV1, Rift S, and HTC Vive. These devices provided better graphics along with one or two hand-held controllers. They included built-in processors rather than affixing a smartphone onto the headset.

The Oculus Rift CV1, Rift S, and HTC Vive headsets required a tether to a high-powered computer and ancillary sensors to function. These high-end devices also required high-powered computer processors. These systems commanded higher operational costs above and beyond entry level, off-the-shelf models. These more advanced models used webstores to download VR applications which also required stable Internet access and connectivity. Additional knowledge and understanding of VR combined with these challenging logistics required substantial efforts from teachers even before they considered VR implementation.

Initial Exposure to VR

The first theme incorporated participants' initial VR experiences. Each participant had the ability to recollect the headset type, immersive applications, and lasting impressions. They recalled the time and location of events from their first VR experience. Often, these initial experiences energized them and inspired expanded ideas about the possibilities of VR and learning.

Many participants serendipitously encountered VR without seeking it out. In recent years, VR headsets have become more readily available on the marketplace for consumers—no longer limited to specialized industries. In a few instances, participants stumbled upon a VR display while in a public setting and made the decision to learn more. This initial inquisitive event led to the discovery of VR technology and future consideration for learning. Participants became exposed to various models of VR headsets ranging from entry-level Google Cardboard to higher-level consumer models Oculus Rift, and HTC Vive.

No matter how participants became exposed to VR, whether by cardboard devices or high-end headsets, the sequence of VR users followed the same pattern—surprise, excitement, and recognition of the potential of VR for student learning. Methods through which teachers discovered VR ranged from: (1) Conferences, seminars, and internships; (2) arcades and shopping malls; and (3) collaborations with spouses, colleagues, and students.

Knowing how teachers learn about VR technology and its potential uses may prove useful in scaling up the incidental uses of VR to a more consistent and wider use of VR for learning.

For example, Dani recollected her first VR memory, stating, “It’s funny, when I was a kid, I used to mock those silly VR things in the malls that just looked ridiculous with people and goggles.” She vowed, “I’m never going to be one of those people.” However, years later, when representatives from Google visited her classroom with Cardboards for students to try, her perceptions changed. She witnessed student reactions and increased engagement to virtual experiences and decided in that moment that VR belonged in her classroom. Another method for teachers to gain exposure about new technologies involves leaving the confines of their classrooms.

Exposure at Conferences

One method to present new technologies to the marketplace involves tradeshows and professional development sessions at conferences. Various regional events, hosted around the world, allow various companies to set up displays with representatives to facilitate hands-on experiences. In most school districts, teachers gain approval and funding from school administrators to attend conferences to learn more about various topics. This process often involves some sort of application and behind-the-scenes efforts to ensure learning continues while away from school. For example, George attended a conference in Melbourne in 2014 and became exposed to VR with Google Cardboard using Google Expeditions. Similarly, Mike also experienced VR with Google Cardboard while attending a technology conference.

The entry level headset, Google Cardboard, used applications downloaded onto a smartphone and secured onto the headset by magnets. This device provided content consumption through 360-degree video experiences but is considered lower quality. At that time, George learned that access to VR was limited to Android smartphones and realized the use of VR technology would not function without adding students' ability to use iPhones. George waited until 2015 to adopt and use VR technology in learning and teaching.

Likewise, Steve remembered a Google technology conference in Australia "a few years back." He attended a session about VR and after the half-hour presentation, he concluded VR proved to be a "realistic option" for the classroom. Steve said, "This really powerful technology has come of age." Although Steve initially felt skepticism about adopting technology associated with brand-specific technology locking consumers into limited device options, the low cost of ownership made it possible for future implementation.

Mike recalled he first experienced VR in 1989 at a time when VR existed in specialty businesses and industries. He remembered the experience, stating: "This is incredible. It doesn't matter that it's just pixels; like, this is incredible. I always thought, you know, one day, things will change, and we'll get there." Increased availability in recent years allowed Mike to compare differences between early VR and current immersive experiences. For example, after Mike tried Google Cardboard at a conference, he saw his predictions from 1989 held true.

Newer devices no longer required a robust computer system or included a bulky headset. Instead, the folded cardboard with two lenses and a smartphone from one's pocket provided a better experience while costing less than $20. Mike said, "Wow, you know? This has got to be used. It's cheap. It's accessible. And that's what I really liked about it. Then the buzz of VR started to come back into the fold." Fast-forward 30 years after Mike's initial exposure to VR when the first high-end, non-tethered VR headset Oculus Quest became available in May 2019.

After using Oculus Quest, Mike exclaimed, "Holy crap! This is awesome!" He reflected on the changing VR landscape with Quest saying, "We're here. We're finally here. Everything's catching up. This [VR] technology is only going to accelerate quicker." Mike experienced the transformational capabilities between different headsets over three decades.

Mike welcomed VR industry advancements which provided improved graphics and interactive applications to expand to more users. These headsets became available to consumers, serving as a new form of entertainment. Mike noted he occasionally brought the headset home to entertain friends for personal use.

Encounters at Arcades and Shopping Malls

Two participants experienced VR with high-end VR headset brands which included Oculus Quest 1 and 2, Oculus Rift CV1, Rift S, or HTC Vive. The Oculus Quest 1 became the first high-end, 6-DOF headset that did not require a tether to another computer, which increased accessibility for general users—especially educators. However, Oculus Rift CV1, Rift S, and HTC Vive headsets required a tether to a high-powered computer to run the software, along with an increased purchase price. These high-end devices had previously only been available to purchase online; however, they became available to purchase in-person at various retail locations.

Craig and his son saw HTC Vive at a mall in 2014 and became intrigued. Craig assumed this VR setup was "just another marketing ploy" after he signed consent forms to grant access to his son. Craig watched his son navigate various challenges in an immersive laboratory game, but later became persuaded to try out the new technology. Craig explained, "[S]o sure enough, I put on a headset and that's when the magic happened for me. I just could not believe how real it looked in there." The HTC Vive provided a high-quality experience for Craig, changing his view of VR and its uses in learning and teaching.

While immersed, Craig noticed the controllers vibrated while interacting with virtual elements. He felt "a sense of presence and immersion." Inspired, he wanted to learn more about capabilities and potential for student activities with VR. After that initial experience, Craig reflected, "[I] was just excited to understand and learn more about the potential that VR has (in learning) because it was so believable." This serendipitous experience persuaded him pursue VR further.

Similarly, Tomi taught middle school and described herself as a "gamer." She randomly discovered VR while vacationing in Japan at a VR arcade. Tomi already understood the video game landscape (in general), but her perceptions changed after donning a VR headset for the first time. The VR arcade apparatus included physical components that further amplified human senses. For example, this station included a reactive, carpet-lined floor along with a nearby fan which simulated wind during immersion. Tomi exclaimed, "Oh my God. VR is amazing!" and described it as the "next level." Toni had not considered VR to be a learning possibility at that point.

After the vacation, Tomi casually used VR at a local arcade in California. Tomi realized spending $30 an hour to use VR equipment for each session became financially impactful so she decided to invest in her own Oculus VR headset. She continued to explore VR applications, but over time, Tomi contemplated whether VR had a place in education.

Further, Tomi reflected on the magnitude of VR and said, “That's why it's always so magical every time I put it on; I forget how transformative and how to just teleport somewhere else. But as I've been playing in VR, I definitely think there's educational uses for it.” Through the culmination of these experiences, Tomi realized that passions for gaming and this new discovery could bring new learning opportunities for students. Successful implementation often leads to conversations with colleagues and expansion into other classrooms.

Exposure through Collaboration

In general, teachers need the opportunity to connect with others to gain exposure to new ideas and concepts. These discussions often benefit those involved in the discussions through brainstorming and problem-solving practices. For example, teachers regularly share experiences, research best practices, and coordinate logistics for upcoming lessons. These conversations often lead to innovative activities in the classroom.

For example, Chrissy considered herself to be a “non-traditional” teacher. She resisted “worksheet” activities and pursued opportunities that made school “fun.” Chrissy’s instructional philosophy focused around changing how students learn, rather than changing the ways she taught. She described a willingness to experiment with different learning tools, practices, and pedagogy to meet student needs. Chrissy “stumbled upon” VR after observing an Oculus headset and decided to purchase it using personal funds—even without experiencing it firsthand.

Chrissy taught special education and hoped VR could be a possible alternative learning method compared to traditional instructional techniques. She partnered with her “super techie” spouse, who had previously assisted bringing other technology tools into her classroom. She realized that she did not grasp all logistics with implementation but understood she had the capacity to figure things out along the way.

Already a tech enthusiast like Chrissy, Alison also possessed a willingness to try new things. Alison also had never used a VR headset; however, one day while brainstorming with a colleague, a conversation inspired her to investigate. She partnered with a social studies teacher to find ways to incorporate VR technology into her English language learning (ELL) classes.

Alison understood the socioeconomic factors affecting students’ access to technology and wanted to leverage the power of immersion with VR. However, she also understood the rigorous and lengthy funding processes to obtain equipment. Even without having used a VR headset before, Alison remained optimistic for possible outcomes and started the application to acquire funding.

Through similar collaborative discussions, Sally began her VR journey at a high-level by observing the creation of 3D drawings using Google Tilt Brush based on a recommendation from a colleague. Tilt Brush allows users to “paint” drawings on a virtual, 3D canvas. Together, they started to develop a project where students could “draw their feelings” on virtual, 3D facemasks; an activity for social emotional learning (SEL). She exclaimed, “[I]'m freaking out! I can paint all over the room and not make a mess! I think there's potential for this.” She began to understand the potential for VR but prioritized making learning “meaningful” to bring VR into her classroom and not using it just for entertainment purposes.

Likewise, Keith taught STEM classes in the school Makerspace and understood the landscape of technology tools, but not VR. One day, a student brought in a VR headset and encouraged him to try it while he walked through the school cafeteria. His first VR experience involved a simulated rollercoaster ride. Keith described it as, “the craziest thing I’ve ever seen.” This encounter fascinated Keith but he wondered if VR could provide other experiences. Keith wanted to better-understand the difference between consuming content compared to creating content. He wanted to connect VR experiences to new learning activities within the schools’ Makerspace.

Later in the school year, Keith experienced VR on a field trip to the environmental science department at a nearby university. While observing his students participate in VR activities, he asked the college students and staff about bringing VR into his own classroom. They downplayed his questions and explained that VR technology belonged elsewhere and not at the middle school level. They told Keith, “Oh, this [VR] equipment is too expensive. Middle schools can never be able to have this.” Inspired, Keith initiated the process to purchase a headset for school and acknowledged that he went onto procure two additional headsets for the Makerspace.

Summary

Most of the participants did not actively seek out VR. Instead, they experienced VR at random encounters at conferences, in public, or through collaboration. They saw beyond anticipated gimmicks and flare which motivated them to better-understand the power and capabilities that VR might provide for their own students.

These initial experiences provided fascination, stirred emotion, and energized participants to begin determining the next steps of implementation regardless of price or time commitment required. Participants may not have fully understood potential risks or promising rewards involved with incorporating VR in school. They also likely could not predict how to determine accessibility or invent new instructional strategies to facilitate learning. They may not have understood how students might react when immersed or if school administrators or parents would even allow students to use the tool.

However, the common theme shared by participants became evident when they saw beyond the current use and different levels of equipment and discovered the potential of VR to facilitate new ways of learning. Initial VR experiences created a spark of inspiration and compelled participants to begin exploring the purchase of headsets.

Acquiring Funds and Determining Implementation

The second theme describes various methods regarding how participants obtained funds to purchase VR equipment and implementation. The academic setting, creative aptitude, and level of administrative support played a role in how participants acquired funds. For some teachers, this process involved minimal effort and for others, this became a long, arduous undertaking. Either way, this pursuit required additional time, energy, collaboration, and in some cases, ingenuity. These teachers obtained funding the following ways: (1) submitting grants; (2) using crowdsourcing, donations, and personal funds to purchase the equipment; (3) forming partnerships; and (4) gaining district/school support for the next initiative.

Grants

Two teachers obtained funds for VR equipment through grants. Jeanie looked to the school district’s partnering educational foundation to pursue the purchase of VR equipment. Every year in her suburban district, teachers applied for grants up to $5,000 to fund innovative projects. After a recent summer internship the previous summer, Jeanie requested $5,000 to purchase an HTC Vive headset, gaming computer, and VR applications. During the application process, Jeanie explained how funds impacted learning by providing answers to four questions: (1) “How you're going to use it in the classroom?;” (2) “Can you collaborate with other teachers [with this project]?;” (3) “How that's going to work [collaboration]?;” and (4) “How is that [the innovative project] going to look if the grant gets approved?”

After securing the grant funds, Jeanie purchased the HTC Vive and a gaming computer desktop machine along with two camera tripods for the sensors. However, with depleting funds to complete the VR setup, Jeanie acquired an unused laptop cart from the school district along with peripheral accessories like computer monitor, keyboard, and mouse. In order to fulfill all grant obligations, Jeanie documented purchases and submitted paperwork for final authorization. However, she had not anticipated the extra effort needed to complete the setup to make the VR station operational. Her creativity with procuring the final components with little or no funds made the completion for the VR setup possible.

Similarly, David’s funding came through innovation grants provided by a nearby aeronautics manufacturing company. He noted the neighboring facility could almost be seen from peering outside of his classroom windows. David learned about a corporate initiative which funded educational STEM initiatives throughout the local area. Given the geography and low number of surrounding schools that applied for grants, they awarded David funds for VR equipment. David explained the grant opportunity, “What’s kind of fun with them [the manufacturing company] is when you’ve got an innovative idea, they like to jump on it, when you’re doing something that nobody else is doing.” He previously taught math and computer science classes but had recently taught tech-focused courses. This grant allowed for the design of a student-led, standalone VR course. Jeanie and David secured funding through nearby organizations and could access funds; however, not all teachers have access to those types of resources.

Crowdsourcing, Donations, Personal Funds

Next, two teachers used the crowd-sourcing website “Donors Choose” to elicit funding for VR projects. For example, Joe understood hurdles involved with purchasing materials. He acknowledged administrators often viewed new technology tools labeled, “fads” or “gimmicks” because they sometimes yielded little return on investment (ROI). He attributed those premonitions because of administrators “not knowing [technology tools] well enough.” Joe explained that he previously encountered barriers with securing administrative approval for technology purchases. With this knowledge and understanding, Joe used the crowdsourcing website “Donors Choose,” to obtain classroom materials. This type of fundraising succeeded in funding a VR project focused on empathy.

Similarly, Tomi also used Donors Choose for funding. During the school year, Tomi sought funding for multiple projects; sometimes she sponsored individual funding campaigns or ran multiple campaigns concurrently. Rather than soliciting funds strictly from family and friends, Tomi explained the preference to obtain financial resources from the Internet. During one of those campaigns, a local company funded all Donors Choose fundraisers throughout the entire city. Tomi declared this gesture, “The best moment in teaching history!” While it may seem that Tomi had an easy time obtaining funds, it required creativity and interactions when soliciting on the crowdsourcing website. Nevertheless, other teachers also had supportive administrators and parental support to fund innovative projects.

For example, Craig taught at a private school in Canada before relocating to Singapore. He described differences in public versus private funding process in the country. He explained tuition at his private school to be “quite high” but also relied on “some public funding.” Craig clarified that school funds could be used for educational resources and capital expenditures. Further, Craig illustrated that many private schools had access to “philanthropic parents who like to donate to certain causes.” In one instance, he explained how he became the recipient of a generous parent donation:

> I had a particular parent who I had taught her two sons and they were excited about design, technology, and innovation. So, the parent (during parent/teacher interviews) said that we would like to give me $10,000 towards new and exciting innovations. And so right away, it was more than just a week after I come back from the Microsoft store. I said, “I have an idea.” I pitched it to her, and she was elated. She saw that this would be a good addition to our school. I took that $10,000 gift and we purchased three HTC Vive Pro’s with the appropriate computers that had high enough graphic cards to run the HTC Vive headsets and we set them up in a dedicated room and that became our newly minted VR lab.

Craig’s recent VR experience at the nearby mall occurred about one week prior but now he could purchase VR equipment because of this philanthropic contribution. Donations occasionally happen but often, educators relied on school support to fund innovative initiatives.

District and/or School Support

George worked at a private school or independent school located in Australia. Part of George’s instructional responsibilities included the finding and implementation of new technologies. After discovering VR at a technology conference, George presented findings to school leadership which resulted in the eventual purchase of VR equipment. Given financial standings of the institution, the process to acquire funding did not involve much additional efforts beyond the initial proposal. However, not all participants found access to technology in this manner.

Conversely, Sally taught in a public school outside of Montréal, Québec. She explained limitations with some nearby remote schools in the district that had just recently installed Wi-Fi only a few years prior. She noted previous limitations and struggles to access technology infrastructure. In her role, Sally helped decide which technology tools to bring into school through a purchase process which required district administrative approval. In years past, technology funds provided items like Chromebooks, iPads, 3D printers, and robots—but never VR equipment.

To receive funds for VR equipment, Sally completed an application which included 33 different measures to validate the procurement of equipment. Prior to writing the request, she realized many administrators did not know much about VR. She understood this predicament and had to provide VR understanding and functionality through the approval process:

> It's not something that principals know a lot about. I think my best sales pitch is when I put the 'glasses' on them, and they try them out. It's always wild. The effect that I like to show them that it can go beyond the walls. But usually once they try them out, they're so amazed at what they see (since they're also educators), they usually see the potential.

She described one administrator after they tried VR the first time: "Wow! So, we could go to Rome and see the Colosseum? And the students could go and see this?" After demonstrations like this, Sally realized that decisionmakers needed to test the technology (rather than rely on preconceived notions) which resulted in funding approval. Sally purchased eight headsets which led to other schools in the district having similar purchase abilities.

Similarly, Alison also completed a funding application through the district technology office. Not only did Alison teach students, but she also oversaw management of the technology budget, which increased her workload responsibilities. The application process required answering multiple questions relating to the use of VR in the classroom: (1) What would be the project with the intent of the connections with the program?; (2) How are we [the district] going to see things?; (3) How are we [the district] going to spend the money?; (4) How much for equipment?; (5) How much for training?; (6) How much do we [the district] expect to see in terms of recreation and things that stay in the environment?; and (7) Am I able to give something back to the community?

This multi-year process required the submission of annual artifacts to demonstrate acceptable use of funds. The submission determined whether or not to fund the program for the upcoming school year. Like previous years' purchases, Alison had to submit photos and examples of VR learning activities. These extra efforts enabled Alison to fulfill the requirements after receiving the funds from the district or school as well as demonstrate high levels of professional obligations.

Similarly, after many years working at the school, Keith demonstrated work ethic and professional accountability which carried influence in the pursuit of new equipment at school. Keith explained that building administration permitted him to "run with whatever crazy ideas that I might have to set up our STEM spaces." Keith managed the schools' STEM Makerspace and leveraged the personal interests and content background of the building principal which helped the procurement of funds for VR equipment.

Keith regarded the capabilities of VR to be "another avenue for students to gain information and be engaged." He knew the building principal previously taught science, so Keith demonstrated a virtual anatomy experience which simulated travel through blood vessels. He recognized this administrator could connect with these concepts and provide an optimal user experience for this person. This distinction highlights the importance of teachers selecting suitable VR applications that garner emotional responses and connect previous experiences. After a successful VR experience demonstration, the principal approved and even assisted in the pursuit of additional funding for VR equipment for the Makerspace. However, Keith needed more money and explored other funding channels.

To obtain additional funding, Keith and his colleagues transformed discarded "butcher block" tabletops from a recent school remodel and cut them into silhouettes of the state for coffee tables. The sale of $500 tables allowed the purchase of an HTC Vive headset. They also solicited funds from a local company to purchase a laptop. Keith employed these multiple funding sources to obtain VR equipment for the school Makerspace. His ability to influence school administration provided the impetus and along with creativity and solicitation proved to be a successful acquisition method.

Conversely, it took Dani multiple phases to influence district "decision makers" to purchase VR headsets for her students. She attended various district level technology trainings where she discussed implementing VR. At the same time, she expressed the necessity to purchase "more than just Google Cardboard headsets" to provide better immersive experiences. Dani described the process, "talking to everybody under the sun." At one point, she considered purchasing equipment with personal funds to prove the point of buying better VR headsets. With the better headset, Dani proposed, "We could play with it and then you'll get to see what I'm talking about." She understood that by having decisionmakers use the device rather than discussing would provide better understanding. However, the message was not well received at that time.

According to Dani, technology leaders found interest in the pursuit of AR instead of VR. They told Dani, “No, AR is where it’s at. Not VR, AR is where it’s at.” She pleaded with them and explained that her students had “never been to the beach, never been to a forest.” She pointed out, “I teach students that can’t go on vacation.” Dani believed that VR provided experiences beyond her classroom walls that AR could not. After multiple attempts to persuade district leaders, they changed their minds. Perseverance proved to be a successful tactic.

The district purchased 36 Merge VR headsets; however, Dani later learned the headsets required smart phones, which not all students owned. Through additional efforts, Dani acquired 20 discarded smartphones from the district. These devices provided access for students who could not bring their own phone to school to use for immersive learning activities. The partnership with Dani and the district technology team enabled the successful implementation of VR.

Partnerships

In addition to the crowdsourcing website, “Donor’s Choose,” Joe partnered with Merge Labs, Inc., a VR/AR multimedia company that produces AR and VR equipment. On a whim, Joe explained how he used social media to contact Merge Labs to request a classroom set of VR headsets. They responded with an offer for a free classroom set of VR headsets. Surprised by the generosity of Merge, he exclaimed, “… and they sent me a class set!” Joe found by simply reaching out to Merge resulted in a new partnership and the acquirement of headsets.

Chrissy influenced decision makers to provide direction and bring VR to the school. She partnered with a local university, which had previously provided $25,000 annually for her school district to fund professional development opportunities. Chrissy proposed the idea to her "incredibly supportive" principal and suggested they purchase VR equipment in lieu of traditional professional development, compared to past years. Chrissy explained to the principal that this would be "an amazing opportunity to get some fantastic tech." They responded with, "I don't get it, but I trust you." Those funds allowed Chrissy to purchase two Oculus Rift headsets which resulted in the beginning of a successful pilot program.

Summary

Participants used various avenues to purchase VR equipment beyond traditional educator roles and responsibilities. They understood limitations with school resources, so they sought alternative schemes which required additional effort and in many cases, ingenuity. They applied for grants, influenced administrators, or created partnerships to access devices. Now that they possessed equipment, the next phase involved incorporating this technology into classrooms and determining how to make VR learning impactful.

Preparation

When participants began taking steps to incorporate VR into classrooms, they continued to face limited resources which forced additional creativity. In nearly all cases, teachers became the sole users of VR at school which forced them to customize instructional approaches and modify practices. They partnered with district and school technology departments to ensure VR equipment functioned within the schools' infrastructure. Participants also re-arranged classroom space to accommodate the new equipment. They began identifying educational learning applications to incorporate in upcoming lessons. In this section, three different planning approaches have been sorted into the following methods: (1) individual research and discovery, (2) collaboration, and (3) social media.

Individual Research and Discovery

Teachers rely on professional development, collaboration, and individual creativity when designing new learning activities. They reflect on past experiences and modify when needed. These practices tend to be individualized based on the learning preferences of the teacher and how they discover creative concepts. For example, Tomi became inspired to incorporate VR when she thought lessons became “boring” and wanted to find ways to make them more exciting. Tomi spent free time “gaming” and thought of new ways to “tie [gaming] into my content” while playing video games.

Tomi described the “private journey” of exploring VR. She had not collaborated or connected with others using VR at school. Tomi noted a different VR landscape during that time when few teachers used VR and even fewer teachers discussed it on the Internet. Tomi sampled various programs prior to consideration. She explained, the “number one thing” included “playing everything first.” Tomi played “a lot of bad VR” and described the “painful” process of eliminating inadequate applications.

For example, Tomi explained that some applications involved “bad controls or bad graphics” while others lacked quality experiences. Some applications provided “really short” encounters with “not a lot to do” leaving users wanting more. Most often, those applications could be found in the “free” section of Oculus webstore.

Tomi also cited a contributing factor was whether to pursue an application based on user reviews. If users left positive reviews and enlightening comments, Tomi considered the application for future purchase. If they had low scores and poor reviews, she looked elsewhere for better alternatives. Throughout this process, Tomi continued individual research but later discovered other educators had curated lists of VR applications. These practices continued while Tomi ensured optimal learning conditions for students.

Lastly, when considering ideal VR applications for learning, she evaluated time constraints keeping immersive experiences to fewer than 10-minutes per session. She said, “It’s a really tiny [time] investment even if it’s not fully matching my curriculum; it can be a great ‘hook’ for a lesson.” These “short burst” VR activities added excitement to Tomi’s classes whenever she felt things had become stale.

Sally described how she found inspiration for new learning activities at random times. For example, she cited an instance in a bookstore when she stumbled upon a coloring book. She took drawings from the book and created a scavenger hunt activity for English language learners. She explained the discovery process, “I’m always trying to see how this could fit.” When considering potential activities, she asked herself, “Could this be motivating for students?.” Like other teachers, she turned to social media for ideas.

Sally interacted with others on social media for new learning but admitted that it felt “overwhelming” when she tried to “keep up-to-date with everything that’s going on.” She used the tool “Google Keep” to bookmark ideas, tools, concepts, and classroom examples to later “check out one day.” Through this process, she also went on to analyze the profiles of the accounts to determine the credibility of the users. She explained decisions on whether the teacher shared interesting ideas or just an “actual project” to consider in the future.

Another participant, George, worked independently to research VR activities after he acquired funding. He admitted, “There wasn’t really a plan; it sounds ridiculous.” George spent hours researching VR applications to bring into the classrooms at his school. He brainstormed alongside colleagues to create immersive projects. George collaborated with teachers to learn more about their content area and then went onto identify VR applications to implement.

At first, some teachers expressed initial suspicions about using VR and questioned whether it met their curricular needs. To implement VR, George learned that it required a complete redesign of learning units—meaning more work for the teachers. He cited the importance for teachers to "want" to use this technology. Implications from teacher leaders in the building proved to be a contributing factor whether fellow teachers incorporated VR. George found that without the desire to use VR technology for learning, successful implementation would not be possible.

George considered the first year with VR "a test" and did attempt to connect any new curricula. However, he partnered with "specialty" teachers to develop pilot VR activities. George described technology aptitude for these teachers to be "confident." This pilot program with pioneering teachers proved to be a low-stakes approach, which later inspired others to consider implementing VR in the future.

Similarly, Dani became inspired to implement VR because of personal hobbies and decided to bring it to school. She previously participated in historical reenactments "to get inside the head of a character and think like them." Dani "learned so much more about the Civil War" from those events and wanted to blend her personal interest to entice students to get more involved in the study of history. Dani wanted students to pretend they lived during the Civil War. Dani knew she could not bring students to historical reenactments, so VR brought history to them.

Dani examined various 360-degree YouTube historical reenactment videos and explained, "This [VR] started getting into my brain to let me know that I could take them [students] in a different way with me." Virtual reality provided students foundational understandings to discuss experiences prior to analyzing text from particular time periods. Dani learned that VR supplied not only a transformation of time, but a geographic expedition. In this instance, Dani's personal interests played a key role in determining how VR could be implemented.

Alison had a systemic process to determine whether to bring new technology into the classroom. The initial deciding factor involved usability for all stakeholders. To be considered for potential use, Alison explained the end users needed easy access to the tool but without experience the tool firsthand, this became a concern.

Even without first obtaining VR equipment, Alison could not have predicted logistics and issues with logging into devices and starting an immersive experience. She explained, "If I see that it's going to take hours and hours to get people to actually use it, for sure, it's discarded." She described the process further, "If I'm struggling after 20 minutes with the tool (trying to look for things), I know I'm going to lose some students." She focused more on the student experience rather than possible outcomes from immersive learning.

Alison described the process when she attempted the Oculus Go headset the first time and found the log-in process cumbersome. She identified an early obstacle because of the prompt that forced users to log into a pre-existing account. Thinking further, Alison questioned whose account students used to log-into each device during a typical class. Also, if students needed to download apps, she navigated through the student viewpoint. In that moment, the barriers for student usability complicated the start-up process. Frustrated, she acknowledged, "Forget it; too complicated. We're not there yet. We won't be able to use [it]." Alison relied on her past experiences working with students to come to the determination that this method would not yield successful results. She also acknowledged the benefits of working with others.

Alison enjoyed brainstorming with others because “ideas just grew.” She discovered other impressions and explained the transformation that led to “spark another one [idea].” She recognized that social media provided a venue to see what others have created. She realized that she may not have similar equipment but could make variations from original ideas to work for her. Alison adopted a primary learning experience for her students involving the consumption of information through 360-degree documentary videos. The filtering process to determine which videos to show students should elicit some sort of initial emotional response from the teacher to be considered. This identification process became the measure to determine the possibility for future incorporation. Alison informally used the criteria she created in consideration of new technology. Alison explained, “We want these videos to help them question themselves and see could they make connections between them.” She cited a video of a farmer using a tool to collect wheat in a field. She did not elicit any emotional response or connection to the farmer, so according to her selection process, it had been removed from future consideration.

In contrast, Alison discovered a 360-degree documentary video from the local farming implement company, Massy-Ferguson. This resulted in great interest from her students because of their ties to farming and even some students owning that specific brand of farming equipment. She understood how unique geography impacted decisions on the content she brought into her class.

However, on the other side of the world, another participant taught literature in the United Kingdom. Les explained the struggle to inspire students to “create more meaningful characters for [their] story writing.” In the U.K., students took the General Certificate of

Secondary Education (GCSE) exam. Requirements for this exam required Les to teach 15 poems focused on “power” and “conflict.” For example, students had to envision “invading another country and killing people or defending a territory” and write about that experience. Les confessed, “these kids couldn’t be further from a war zone” and had “never been exposed to any form of conflict.” Les explained that the intent of the standardized exam checked for understanding of the content and examined written commentary—which had been the areas that Les wanted to improve.

Les embraced a problem-based approach and sought methods to generate empathy from students. He considered the British English Curriculum to be “very Victorian” and “incredibly old fashioned.” He pondered, “How do we get you, the students, to appreciate this context?” When he thought more about incorporating empathy within writing, he presented this scenario to them: “How would you feel if this was your mate?” He acknowledged that students knew a person had died, but the students felt “no sympathy or empathy” for others they had not known. Les ventured into VR for assistance.

Les considered VR to be a possible solution for this issue: Students needed to be more creative and empathetic. He continually reflected and studied previous attempts to enhance student learning. For example, for a writing activity, students drafted stories and used tech tools that provided the most versatility and met their needs. Les acknowledged past instructional practices and rationalized that he “doesn’t use tech for tech’s sake.” Instead, he pursued tools that provided “meaningful impact.” Through the use of VR, Les concluded that after embracing VR, engagement increased and perspectives changed which led to the improvement of standardized test scores.

Similarly, Craig embraced his schools' outdoor learning philosophy to find new ways to teach science content. He described his teaching style "highly indoctrinated with the idea that learning needed to be highly experiential." For example, Craig taught science concepts which brought students outside and had them toss bean bags into "Hula Hoops" to simulate how consumers and composers interact. He believed VR could assist experiential learning, "because it's so real and could help fulfill a need." He contemplated designing possible alternative VR activities to be safer, less expensive, and not require cleanup in lieu of traditional classroom practices.

Prior to implementing VR activities in class, Craig mentioned the importance of "having a plan ahead of time" called, "VR Lesson Guide." He identified two questions: (1) "What do? we want the kids to do?" and (2) "What is it they want to learn?" Craig cited the importance of having learning goals or targets and explained how VR learning differed from traditional learning models. Now that Craig curated various applications and a framework for instruction, he focused on facilitating learning activities with this tool.

Craig explained that after 26 years in education, he understood impactful learning experiences. He had knowledge about other online game-based 2D science simulations and impact, but with VR, it took those experiences to new levels of understanding. He also worked with the schools' IT department to create a "Steam" user account and also individual student accounts. He described the process to identify potential VR activities on Steam: Craig called it "fishing" through the use of Google searches and browsing the "Steam" website. He noticed that by filtering searches labeled "educational" resulted in "boring experiences" for end users. Craig experimented with a few VR applications and felt "not inspired at all." He said, "It wasn't what I thought a VR headset should be used for." Craig described the "painstaking" sorting process to be "time consuming" which took place during preparation time or after school.

Through this identification process, when an application provided a concept that unlocked new learning, he purchased it. He knew that "Steam" provided refunds from purchases within 30-days if not satisfied. At one point, he mentioned that he wished "Steam" used similar artificial intelligence (AI) controls like Netflix which featured a "recommended" feature based on search history, usage, and prediction. However, Craig also enlisted student assistance to discover new applications for consideration.

Craig collaborated with a particular student who had previous experiences with gaming. The student assisted him with the identification of new VR experiences or other 2D games, which he called, "pancake games." Craig described a strong understanding of connections with gamification and learning, which aided him with identifying worthwhile VR applications. However, if an application presented any form of violence or "gun play," he "steered away" from bringing it into the classroom. He described this filtering system originated "in my head" rather than relying on search functions within the webstore—a skill that had been developed over time working with students.

At the same time, Steve focused on career-readiness skills for students, so they could enter the workforce better-equipped by embedding "Lean Startup Processes" that involved emerging technologies. His high school offered a variety of semester and year-long technology courses. Steve acknowledged that many students already acquired skillsets in other tech courses through coding Arduinos, VR, or 3D printing. Steve had an instructional philosophy focused on solving real world problems that used real world skills. Additionally, Steve preferred activities when students created content rather than consume it. He sampled multiple technology tools relating to AR and VR prior to making a final decision which headsets to purchase. He created a tiered system to provide lower quality headsets for younger learners and higher quality headsets for older learners.

Steve explained the rationale for understanding varying levels of headsets, saying "The solutions [VR headsets] have to be robust and have to be managed effectively." He continued that for students in grades 7-9, "we didn't want moving parts because they like to play and fiddle with things whenever they can." For lower grades, he spent around $25 per headset which required "minimal training" but also an opportunity to learn more about the impact of this technology. His experience working with students at different development stages became a contributing factor in deciding which headsets to pursue.

Collaboration

When thinking about teacher collaboration, one might think this concept only applied on a teacher-to-teacher connection. Often, teachers forget students bring a wealth of information and experiences to class on a daily basis—an overlooked and untapped resource. They may not know they have passionate students who may bring expertise in a variety of interests that could help the teacher and fellow students. For example, David taught high school STEM classes in Ohio. He shared the story about the start of his VR journey. A few years back, David noticed a current events article related to virtual reality. This random discovery led to a discussion with some students sitting nearby. David wrote down five questions for students to ponder, which all began with the words "*What if?*" David mentioned three questions: (1) What if we created a class with Virtual Reality?; (2) What if it was student led instead of teacher led?; and (3) What if it wasn't based on games but based on education? He pondered these questions which began the process of creating a standalone VR course.

David described the trust he built over the years from building administration and school district. He said school administration “knew the work that I put into things and that I refused to accept failure along the way. They trusted me, so I went to them with the idea and they said, ‘That’s great! Go ahead.’” David had previous experience writing curriculum for new courses, usually completed individually during summer months. The newly proposed VR course would be a different concept; it necessitated student input. At that point, he predicted this student-designed course would gain approval from school administration.

From there, conversations with the newfound stakeholders continued. David facilitated discussions and asked student opinions on various topics related to school and learning. Together, they drafted ideas on the whiteboard and discussed concepts: (1) What would be the class structure?; (2) What would be the role of the students?; (3) What would be my [teacher] role?; (4) What would be our purpose?; and (5) What is the purpose for creating this class? He pondered the potential impact from involving students and their learning.

David explained, “The cool part of it was the whole [VR course] idea; it was born with five questions that I had, but a lot of the technical expertise, I drew from bunch of 15 and 16-year-old kids.” They brainstormed devices(s) to purchase along with the pros and cons of available products. However, they soon realized the lack of physical classroom space did not accommodate equipment. This factor forced them to prioritize mobility to be a deciding factor.

While the school year progressed, David decided to include students in the grant writing process which led to the eventual award of $35,000 to establish the standalone VR course. Soon after receiving funds, he mentioned the continued collaboration with a few students throughout summer break. David explained how he sought student input to discuss technical considerations like USB ports, graphics cards, dedicated RAM capacities, and deciding which laptops to purchase. The coordination of logistics demonstrated a mutual ownership in creating this course—even while away from school. The willingness of students to assist during summer break signaled the potential impact for a successful proposal.

This innovative course expanded Virtual Reality access throughout the entire school. David and his students knew from the beginning they did not have the capacity to design VR applications. Instead, students surveyed the VR landscape and identified the best educational applications. Students tested many different VR applications and went onto present findings to the class and collected feedback from fellow classmates who decided which to pursue. After observing presentations, students completed a Google Form and provided feedback which aided in the? decision-making process whether or not to proceed.

David considered public speaking to be a deficit for students and a leadership opportunity to build presentation skills. He reflected on the entirety of the project and replied, “I just don't know that it gets any better as far as involving kids.” Rather than leaving all decisions to David, this approach brought in more student voice and ownership.

Similarly, Keith benefitted from online user reviews to decide whether to pursue VR applications (or not). He acknowledged that Steam had “a lot of just absolute garbage” and understood potential risks of purchasing bad applications. He also knew applications should be appropriate for middle school learners. He explained if applications had positive reviews and cost less than $10, he spent personal funds to test the program prior to exposing [it] to students.

Keith taught in the schools’ STEM Makerspace and partnered with many different content areas and other students in the building. Teachers requested time in the Makerspace and brought classes down to work on various projects. Keith informed teachers about the capability and functionality of VR equipment, so they collaborated and identified goals while they used the

Makerspace. Keith explained available VR programs and how to structure lessons. Together, they brainstormed units and potential takeaways.

For example, Keith explained a partnership with a language arts teacher who wanted to enhance student writing skills. He asked additional questions which led to discovery and connections with the Makerspace equipment and their content area. Keith knew about a “homeless VR activity” that could invoke emotional responses and enhance first-person narrative writing. His problem-solving conversation turned into a collaboration. These types of collaborative, problem solving activities allowed a wide range of users access to innovative tools and new ways of learning in the schools’ Makerspace.

Similarly, Mike also became inspired to solve a problem at school. While working in Australia, Mike noticed that after graduation, “higher-achieving students” chose to venture to faraway, larger universities rather than attend a nearby (smaller) university. He told the story of how he found a solution to this dilemma. Mike contacted the nearby university and offered a possible solution which highlighted the institution’s “amazing resources.” Mike wanted students to learn more about “what the university does.” This idea later transformed into the creation of a two-day STEM chemistry program using VR.

During this design process of the program, Mike realized “no concrete pedagogy [existed] around how we actually use these types of [VR] tools.” He exclaimed, “Holy crap! There’s a massive gap in this field.” He thought in that moment, “No wonder it’s [VR] being poorly used in the classroom.” Mike insinuated that schools invested in VR technology only “to get static use for one particular class, once per year” but never reached maximum potential.

At one point of the interview, Mike prefaced a thought with a brief confession and admitted, “[W]e don’t really get a lot of success from students in VR.” Mike conceded that some studies claimed successful impact, but others identified no difference between VR and standard teaching. He highlighted the increased engagement with VR, which “is always good,” but he maintained the necessity of needing “pedagogy to support the learning.” In addition to the partnership with the nearby university, Mike also developed an immersive chemistry program. Mike took the time to research previous VR studies and impactful learning. He searched social media tools like Twitter and LinkedIn to learn more.

Mike considered himself “a creative person” and came up with new ideas to “leverage off the success” of new activities. He worked with a team to design a new VR chemistry application. Mike described how the team shared “big, hairy, audacious goals with where we want to go with it.” Mike instilled a mindset where the team “effectively provided critical professional feedback to each other” with hopes of improving their product. Mike explained a fundamental aspect of innovation, “[I]t wasn’t always about the tech.” He stressed the importance of “getting students to think about what they’ve learned in a normal, two-dimensional setting and then reformatting their memory when it came to the way things were visualized.” Ultimately, this philosophy provided a better preparation for students upon their eventual entry to the workforce based on anecdotal results over the years.

Likewise, Jeanie used a variety of approaches when considering new applications. Jeanie became aware of possible VR applications after receiving marketing emails from organizations promoting STEAM. From there, an initial identifier, which she called, the “smell test,” involved whether the application had been categorized in the “gaming” section of the web store. When Jeanie sorted through various VR activities to use in classes, she explained the first requirement, “it can’t be just a game.” She also used student teaching assistants throughout the school year and tasked them to go to the Steam webstore and search possible applications. From there, she gathered input and decided whether or not to purchase, increasing the likelihood of providing high quality experiences for students.

Jeanie also observed these student teaching assistants (TA's) while immersed in various applications. They would occasionally peruse the Steam gaming store to consider new titles for class while Jeanie observed from afar. If students demonstrated excitement, she explained the analyzing process whether those responses had been caused by the gaming or by educational aspects. She identified potential learning concepts and catalogued where the application could fit within the engineering curriculum. She asked, "could these concepts be replaced or augmented by the VR activities?" Jeanie confessed, "not that games are bad, but if it's too much game and no learning, then it gets eliminated." She relied on firsthand experiences and knowledge to make these decisions.

Jeanie also explained one instance where she thought she had found a viable VR math application but this inclination later proved to be incorrect. While searching the Steam website, Jeanie perused different categories (e.g., education or engineering). She discovered a VR calculus application in the education category. After experimenting, she anticipated that using this application could be "amazing" for math students. Jeanie shared the application with a math teacher to gauge input. Responses proved to be lackluster. The math teacher described the VR experience having been "too serious" and "they [the students] didn't 'glob' onto it; didn't engage with it." The math teacher did not consider it to be any different than what could have been taught in the classroom. Rather than turning to user reviews or personal knowledge, a colleague provided enough information to be the deciding factor. In this instance, Jeanie learned more about this math application from a trusted colleague while others turned to strangers on social media to learn more.

Social Media

Several participants turned to social media tools, like Twitter and Discord, to gather ideas, collaborate, and share classroom projects. They used searchable keywords and chats moderated by VR leaders to narrow the concentration of topics. In these conversations, relationships had been built, and in some cases, credibility validated. In addition to collaborating with colleagues, Jeanie turned to social media websites to gather ideas and inspiration prior to using VR in the classroom. She spent summer months perusing other teachers' VR activities and learned more about how to implement activities for the upcoming fall semester. She found value with this on-demand learning platform.

Like Jeanie, Joe also turned to Twitter to collaborate and find inspiration. Using this tool, Joe posted photos and discussed VR activities which resulted in companies reaching out to pilot their product and, in return, gather his first-hand feedback. Additionally, Joe collaborated with VR educational leaders like Jaime Donnelly, creator of www.ARVRinEDU.com, to gather ideas and share findings. Joe credited Donnelly to be an inspiring voice and motivation to try new things. Joe described a few instances after sharing innovative activities which prompted the response, "Well, I didn't even know you could do that!" The community discussion provided a platform and increased participation amongst educators.

Chrissy also described early online collaborations with social media, saying, "there wasn't a big [VR] community back then." Further, she continued, "there wasn't Discord and things like that. If there was, I wasn't aware of it." Chrissy taught special education and sought new ways to connect with students. She mentioned the constant struggle to teach students communication skills and never found a viable solution that involved technology tools. Chrissy identified two important facets in teaching: (1) Knowing your craft and (2) knowing your students. Her school had been categorized Title I, where 98% of students received free/reduced lunch with an 80% African American population. She realized students had likely not seen or heard of VR, let alone experienced it. Her initial goal to use VR involved the creation of “those meaningful connections so that students would remember the content.” For example, when it came to teaching volume, Chrissy used 2D photographs to explain the concept but wondered if VR could help. Chrissy viewed herself “like a hippie teacher that always is doing things differently.” When it came to “thinking outside the box” she explained, “You destroy the box; you don’t even need it.” Chrissy understood how teachers became accustomed to routine classroom practices but wanted to break down barriers to expose students to broader concepts and philosophies.

Geographical Limitations

On the other side of the world, Randy understood limitations from teaching in the African nation of Nigeria. He had to consider the constraints of the infrastructure prior to bringing technology into the classroom. He cited the differences in technology infrastructure in Nigeria compared to the United States or Europe and acknowledged the limitations. He said “we're not very advanced yet [technologically], so I had to take into consideration that landscape” when making plans to incorporate VR into classrooms. During our interview, Randy acknowledged the challenges of using technology tools in his country: “Here, the peculiarities of online engagement; take for instance, we've had this Zoom meeting for less than 20 minutes and my network has disconnected us about 15 times.”

Randy explained five possible outcomes for comprehensive engagement with tech tools: (1) Will it be possible for me to download applications?; (2) Will we require parents to purchase the headsets for their students?; (3) Do I purchase them and give them to students for free?; (4)

For maintenance, who will be in charge of the devices?; and (5) Do we let students take them home or do we keep them at school? In this instance, Randy had unique, circumstantial limitations other participants did not have to consider, yet he persevered.

Summary

Participants approached the planning and brainstorming phases using a variety of different methods. Context matters—teachers experienced unique circumstance and developed their own process to incorporate VR into the curriculum. These educators better-understood the risks involved and probability of unknown obstacles. Now, participants could begin the journey of providing immersive experiences to students.

Three Levels of Incorporating VR for Student Learning

I sorted participants into three proficiency levels based on the type of pedagogical implementation with VR. These levels include: (1) exploring VR content and tools, (2) acquiring and applying disciplinary knowledge, and (3) creative production—using problem solving, interdisciplinary approaches, and professional skills. The first level involved consumption activities with lowest-cost headsets and did not require significant training or prior VR knowledge. The second level involved connecting immersive activities with curriculum. The third and highest-level empowered students with the creation of immersive content and problem solving. To obtain the highest-level, educators demonstrated high levels of instructional proficiencies along with mid-to-high quality headsets. They needed to understand the capabilities of hardware along with the available VR content and employ their creativity to design optimal learning experiences.

Participants saw potential in connecting VR applications with any K-12 content area. However, many of the applications often only involved low-level, passive learning activities—

the consumption of information. Some participants had been limited by the quality of their headsets that did not allow for the creation of content. They had been left to connect immersive curricular activities within learning activities. However, at the highest level, student learning and achievement required additional planning and effort.

Teachers needed considerable knowledge of VR tools, access to mid-to-high end headsets, and recognizing strengths and weaknesses of their students. The highest levels of VR learning consisted of students solving problems and creating content in immersive environments that blended multiple content areas. Teachers attained high levels of implementation through arduous work. To achieve the highest level, participants started at level one which involved introductory activities.

Level One: Exploring VR Content and Tools

Similar to their own introductory experiences to VR, teachers used similar tactics to create fascination when exposing students to VR. Level one VR activities provided an entry point for introducing immersive learning concepts for first-time users—a novelty for most students. Participants stated most students had never used VR, so they created orientation activities to introduce this new learning tool. Ten participants used level one, 360-degree video content for introductory activities. Participants wanted VR to be the "hook" to capture attention, reinforce concepts, and generate interest. Teachers used 360-degree videos for brief exploratory experiences, above and beyond what textbooks provided. The most common application in level one involved virtual tours.

The website vr.YouTube.com offers 360-degree videos played on mobile devices with a headset icon located in the video settings. On a desktop computer, YouTube videos with a compass located in the upper left corner allows users to control the directional viewpoints while the video plays. Teachers used YouTube 360 videos or the Google Expeditions mobile application for initial VR experiences. Although no longer supported by Google, “Expeditions” provided virtual tours and experiences facilitated by teachers. From a connected tablet, teachers controlled various 360-degree videos synced onto student headsets. They narrated different features during immersive experiences. Participants identified connections with their content and validated the motivation to use “Expeditions” in class.

Impact to Learning

Dani cited the initial rationale for using Google Expeditions because of limited socio-economic conditions with some students who had never experienced a vacation. Dani also observed changes after VR activities and described the process: “Kids need to experience something first, then we can dive into that later. It actually works.” She explained, “The pedagogical impact is strong because you have kids that remember the content because it was invoked; you know, [an] emotional response.” She examined the significance with “individual experiences” through immersive activities.

Dani shared some general student commentary after they used VR. They said, “I really enjoyed (this one thing) that I never enjoyed before. Maybe I want to learn more about the medical field?” She overheard another student contemplate, “Maybe I want to go into space for real, because this was really neat.” Student commentary during and after immersion provided feedback to Dani that signaled positive impact to the lesson.

Similarly, Alison also introduced VR to students by showing a 360-degree documentary-style videos of various nearby landscapes—different from their own surrounding area. She explained some students had never seen other types of landscapes in this fashion. Alison also observed students’ reactions during immersion. She explained, “It brings them closer; some of them will almost try to go and touch things if they were there." She described the impact of VR further, "It makes sense to them. It's something that is a lot more personal than just the screen at the front of the class or a picture in a book." Through this process, she also noticed students experienced separate occurrences even when they used the same application.

For example, Alison explained after students reflected upon VR experiences, they shared stories of what they saw (or learned what others saw)—an unanticipated opportunity for new learning. Alison summarized immersive learning: "It's like they are really going to places where we want to take them, and it sounds like if they were there; if they lived there." In one instance, a student exclaimed, "I cannot believe I traveled to Italy today!" Alison described the student, "gleaming" after the immersive experience. Another student describing something after being immersed. They said, "Wow! This was amazing and the collision was so big!" She explained that these types of reactions had not been garnered when using non-technology approaches.

When Alison compared VR to past instructional practices with using 2D photographs, she said, "The only thing missing is the smell [to make the immersive experience better]." Alison found students felt "like they've been there, and they are more precise with their answers and their connections." She realized VR had made a positive impact. Alison described instructional changes: "when you're traveling around the classroom, it becomes very visible that they do get [understand] the content" and also found students "don't have the barrier of being shy;" an unanticipated outcome.

When rationalizing how students better-understand content post VR, Alison said, "They are able to use it [new vocabulary] in the right context. We are really allowed to let them live in the experience but for us to be the first witness that the learning has taken place." She saw firsthand the impact to learning on her own students but now wanted to share these resources with others. Alison also reflected about influencing other teachers to attempt implementing VR. She understood that may have limitations when trying to explain the impact of VR but preferred a hands-on approach: “It’s just one of those things where you can talk about it but until you actually put it on and experience it, there’s no comparison, really.” She understood perceptions could change if given the opportunity to expose VR to other teachers.

Similarly, Craig persuaded a colleague to try VR. He tried to alter preconceived notions that VR had become “just another shiny toy out there.” He eased them into VR through the use of an immersive underwater experience where a giant whale “sort of brushes up against you as you’re standing in a boat.” He continued, “[VR] is a magical machine; an awe-inspiring device that makes things come alive.” Craig declared, “Your dreams come true because VR has the potential. These could be learning experiences that kids always wish they could do but never had the opportunity, time, or money to do it.” Further, he said “I just see and convince people that that’s where VR is going, and I get a headset on them and they sort of realize the potential.” Craig learned to persuade others to believe in the tool but they had to experience it for themselves. In those initial moments, he saw perceptions change.

Exploration Potential

Exploratory experiences engaged students through discovery and recreational uses to generate interest. George described working out of the technology hub at his school. Students often visited this space and tried out the school’s VR equipment. He explained the process of learning how to incorporate VR into lessons. He labeled it, “informal,” because they had not designed any curriculum or activities around the tool.

George worked with another teacher using Google Expeditions which could be facilitated by a teacher on a tablet. They discovered a video focused on the Great Wall of China and designed a learning activity. They had the ability to project 360-degree images on student VR headsets. The application provides narrative text along with student prompts.

Also, for Randy, his students became enticed after using VR for the first time. He described an introductory VR experience when students observed an immersive volcanic eruption. He said, “It was amazing. The feedback was amazing. By the next class, you had them asking for the VR ‘boxes.’” He explained, “There’s [student] eagerness to have the ‘box’ on. That’s it. That’s the first measure of willingness.” Further, he said, “ It’s not you having to ‘implant’ them. No, it’s the learners having to tell you. That’s a key reason [for using VR].” He described the rationale for implementing innovative teaching practices.

Randy explained, “We are really careful not to stifle the progress of these kids; really careful not to hinder their creativity.” He continued, “We have a balance of ideas. We measure arrangements against syntax. We measure organization against spelling. That’s why our own grading system is (more or less) to see how well the listener understands what is being done.” Randy described how students interpreted VR experiences, saying, “They are seeing things for themselves so rather than having to tell them, they are the ones who are going to tell you.” He summarized, “With VR, it is an individual experience.” This student-centered approach increased engagement and progress.

Regarding the impact of VR on student evaluations, Randy explained, “Just because you’re not seeing it in the report sheets does not mean that you’re not making progress. [You] see the progress. Your kids are making it right here, right now.” Randy provided access to this new learning tool and observed students embrace the technology and changes to learning.

Tomi explained the intentionality with providing optimal VR experiences. She started “simple” by demonstrating 3D drawings or by observing 360-degree videos that did not require interactivity—only consuming. Tomi acknowledged that some students felt intimidated and displayed signs of hesitance prior to using VR.

Ensuring Wellbeing

To combat those feelings, Tomi encouraged students to try some “kid-friendly” VR experiences. For example, she used the “Disney Movies VR” application found in the Oculus webstore, which included *Beauty and the Beast* and *Coco* immersive experiences. Students who had seen these motion pictures associated familiar characters with colorful surroundings from the videos. This effort into ensuring students felt comfortable during immersion provided an example of meeting the needs of students rather than assuming all students gravitated to the headset.

Another example of a teacher going above and beyond involved a teacher who built an adjoining VR contraption. Rather than have the student experience a video with the VR headset, Chrissy found ways to make immersion better. In one instance during a 360-degree roller coaster video, she attached a chair to a skateboard and secured the student with a belt. She moved the student concurrently with the video to improve the experience. These measures provided additional sensory feelings for students during the simulated amusement park video. She described this student experience, “exciting” and “fun” and continued to discover new ways to use this technology.

Participants introduced VR to students to increase student engagement and bring new perspectives to learning. Level one activities generated different perspectives not accessible through traditional methodologies like lecture and text. They understood that VR connected background knowledge and generated new insights. Even though these exploratory activities only provided surface level conceptual understandings, teachers now had new abilities to blend content area with this learning tool. During level one activities, teachers observed student reactions for formative feedback purposes. Student responses to immersive activities provided evidence to teachers and then determine next steps for instruction. However, like any novelty, interest in level one VR activities declined over time.

Teachers discovered during these activities that VR should not be continued for prolonged segments. Participants became cognizant that student engagement decreased after these exploratory VR experiences. Teachers needed to transition to other learning activities and build upon the newly learned concepts. These low-cost headsets had become another instructional tool in the instructional toolbox—and not a substitution of the teacher. Successful implementation of this tool still required planning and changes to pedagogy. Entry-level VR activities provided a steppingstone for 11 of the 15 participants who later went onto blend curricular activities with VR—the second level of implementation.

Level Two: Acquiring and Applying Disciplinary Knowledge

The second level of incorporating VR involved connecting specific content and curricular activities. Teachers identified VR applications that fit within their content and sometimes with multiple content areas. They found connections with immersive experiences and blended learning activities. Five participants identified empathy to be one motivation for incorporating VR experiences.

Keith reflected on the rationale to use VR in the school Makerspace. He explained, “It’s all about the engagement with the kids.” For example, Keith used the app, “Becoming Homeless: A Human Experience” to simulate housing instability. Developed in 2018 by the Virtual Human Interaction Lab at Stanford University, this seven-minute experience simulates a person, who recently became unemployed, navigating changing conditions. Researchers at Stanford designed this application to generate empathy and expose different living perspectives. Students in the Makerspace experienced the simulation and later, wrote a first-person narrative which connected to the homeless theme in a language arts class.

Keith also cited an example where involved students learned about the Pearl Harbor attack with the application, “Remembering Pearl Harbor.” Rather than employ traditional teaching methods, which included reading facts and information about the attack, students used VR. Keith summarized this new student experience: “to be able to have an immersive VR experience where you’re on a ship during Pearl Harbor; that’s going to open a kid’s eyes in a completely different way than reading about it off a page.” He simplified the rationale to pursue VR instead of traditional teaching methods: “All of these are just different avenues to get kids information, but this one is just fundamentally more engaging to kids.”

Similarly, Chrissy also discovered a new, yet informal way, to implement VR. Rather than use traditional methods to teach mathematical concepts like calculating volume, she designed an activity using the Oculus VR application named, “Block.” In the virtual environment, she observed how students interacted with manipulatives by moving objects. She explained that students became “more focused” during the activity compared to past practices. She described them, “engaged with it in a new and exciting way.” She later tracked those same students and learned they had answered similar questions correctly on math assessments. Chrissy also used the Oculus App, “Virtual Speech,” which simulated a venue for students to practice public speaking. She could still provide feedback, but found students felt more comfortable in the immersive environment and could practice speeches before taking the state-mandated assessment.

Similarly, Sally also planned, but ultimately postponed, an activity (due to the Covid-19 pandemic) that involved students giving virtual speeches. Like Chrissy, her students would practice delivering speeches in front of simulated people (avatars). After each attempt, students would receive feedback in a “safe” environment that could be repeated, when needed. She described the intent of this activity, for “nervous students who are afraid to speak publicly” and would give them the opportunity to practice in a simulated environment. She hoped these practice sessions would “have an impact on helping students develop skills that they might be afraid of in real life, especially special needs students.”

Sally also employed VR to “motivate” special education students to bolster their writing skills. She expressed frustration with the constraints of conducting traditional writing activities: “Nobody’s motivated in doing that. It’s not interactive; there’s no actual fun doing it.” However, she continued, “If you’re doing it in VR, you actually can turn around and you can look around and you’re living it as you’re describing it. I think you develop skills more than content.” Sally explained the process of pairing students with an application called “Nature Treks VR.” She described the original intent for the recreational application allowed users to explore faraway places like underwater, beaches, deserts; however, not for educational purposes.

In this application, students experienced different landscapes and described what they saw to their partner. Sally explained this activity exercised oral vocabulary skill-building for the immersed student and listening and writing skills for the partner who captured feedback. Each student had the opportunity to experience different landscapes and explain what they saw and went onto compose summaries from the experience. She explained students enjoyed this interactive writing activity compared to previous writing activities.

Discovering Alternative Applications

Sally also shared a conversation that had taken place earlier in the day of our interview with a colleague who had recently tried VR. Her peer described how they used a meditation application with a student in crisis. After 15 minutes, the student calmed down enough to reset. She went on to explain that through conversations like this, she identified new uses for VR she had not previously considered. Thinking further about considering other possible VR applications, Sally said, “I don’t see the educational purpose yet … [but people might need to] take a break from the real world in their virtual world; I think there are other issues that [VR] could help [with] in the future.” She went onto explain another impact from using VR. Sally noticed increased empathy from her students after experiencing a prison cell simulation that created a better sense of understanding. Sally used the two-minute application named, “6x9: A Virtual Experience of Solitary Confinement,” so students could briefly experience imprisonment.

Afterwards, students discussed pros and cons of prisoners in isolated environments. From that discussion, they drafted an opinion essay. She summarized their experience, “[The students] actually lived it and just for that minute or 90 seconds, it was enough to make them feel themselves (confined) so they actually thought it had an impact on their writing.” She continued,

> I think once you have empathy, it affects learning across the board; [this changes] your understanding and your critical thinking. It can help anything from science, to history, to math, Spanish, and French. It can help anything once you have critical thinking.

Her positive experience with these immersive activities broadened her outlook with blending multiple content areas.

Similarly, Les also taught writing skills and understood the benefits of designing multi-curricular activities. He explained the rationale for creating five different immersive activities and described changes to pedagogy because of highest weighted portion of the annual standardized assessments. Les understood traditional teaching methods involved lectures, which had been a proven viable method for years. When he taught poetry, he cited the importance of understanding context and necessity to "have to be thrown into [it] and VR is the only way to remove the ceiling of limitation." Les explained, "Successful pedagogy [happens] when you're blending subject matter."

For the first immersive activity, during an introductory VR activity, Les grouped students into pairs. One student became immersed, while the other took notes. Les explained the intent of these activities generated "transitional linguistic elements by transposing and reformulating the elements." He allotted seven minutes for the immersed student to "describe as many things as you can see" for the partner. However, once students first experienced VR, they caused unintended reactions which resulted in multiple attempts to complete the introductory activity.

Les explained that during the students' introduction to immersion, they became distracted by visual saturation which resulted in Les having to pause and re-explain the lesson. After the initial immersive experience that acclimated students to new perceptions, the second attempt became the actual learning activity. They later switched roles so each student experienced immersion and provide notes for each other. While each student became immersed, Les asked questions to increase sensations by providing prompts. For example, he told students, "imagine the texture of your feet crunching on the surface." Les understood that these encouragements aided students in acknowledging previous experiences with the simulated sensations and generate reactions.

During the second exploratory VR activity, Les immersed students into 1850s London to walk the streets. He "encouraged them to explore" in this student-centered learning approach. He explained, "You give them the objective, and let them do it." He allowed students to follow natural tendencies within the virtual environment to learn more about this time in history. For the third activity, Les created a virtual treasure hunt activity. During immersion, students received clues to determine the combination for a lock. Les explained student testimony from the experience exhibited “total immersive understanding.” Although some students did not find success in completing all task of the activity, they still “used the power of deduction … through their eyes.”

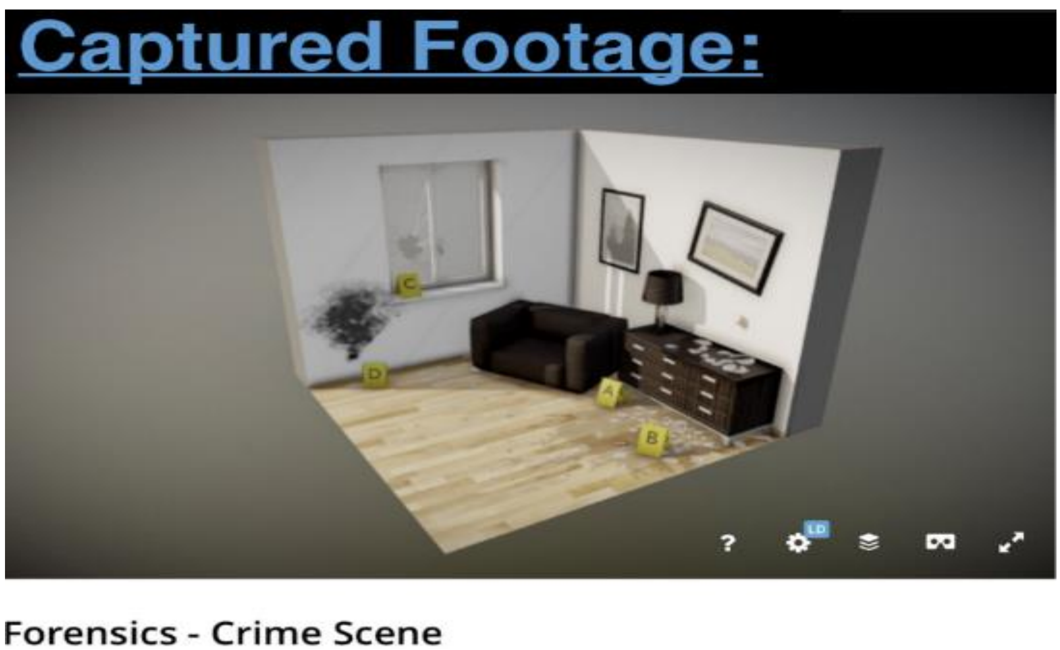
The fourth immersive experience required approval from school management. Les wanted to expose students to feelings of empathy. For the activity, students entered the classroom and scanned a QR code to access the video. From there, they observed a simulated war experience situated in a bunker. Les described the “harrowing” video which brought intense feelings of presence. Les observed students after the experience and realized they “got it.” He acknowledged students “appreciated it” and understood the “appalling and abhorrent” conditions in the trench. Students understood many soldiers died “not from war itself, but life within the trench.” Les “wanted the kids to appreciate” the conditions the soldiers endured during the war. He described the “blended learning” experience with “overlapping subjects and content.”

For the fifth and final activity, Les considered himself “more of a designer of projects” and expounded upon “creating really immersive learning environments.” He admitted being “an avid fan of literature” and loved Sherlock Holmes and wanted his students “to love Sherlock as much as I did.” He speculated, “How do we [teachers] get them [the students] to love something by going page-to-page?” Les understood the capabilities of VR but did not find any resources that met the needs of his students. He decided to use a tool called “Sketch Fab” to recreate a 3D model from a scene of a Sherlock Holmes novel.

Les explained how he spent 15 hours creating an immersive crime scene with the VR design program, “Sketch Fab” (see Figure 8). He selected a location from a murder scene based on dialogue between two characters, Sherlock and Watson. Les designed animated characters, called “avatars,” based on descriptions from the text of the short stories. He recorded audio files to mimic character accents with exact dialogues from the text to “maintain the authenticity.” Les synced and animated the characters’ motions with audio recordings and uploaded the finished video to YouTube. He placed these files in a Google Drive folder and provided access with QR codes.

Figure 8

Crime Scene VR Experience



Note. This photo represents the different elements within the crime scene.

Students scanned each QR code with a mobile device which linked to each characters’ picture and then they observed the incident. While Les facilitated the activity, he provided time windows of five-minute increments which placed students in the crime scene. They listened to testimony and hypothesized what happened and documented details onto a grid. Students tried to solve the murder case with this information. During a debriefing activity, students explained their thoughts and suspicions and later compared the learning activity to an actual police investigation process. Les blended immersive environments with content with the goal of instilling a shared passion for literature. He realized students lacked the ability to empathize with others by reading text and needed an alternative activity. Virtual reality brought Les' students into different situations and generated new perspectives, which he hoped would ultimately translate into higher standardized test scores. Lastly, the intent of these activities not only provided impact to assessments but also connected other important concepts for Les' students.

Connections to the Community

Teachers looked beyond individual lessons or learning targets when designing VR lessons. They considered student interests and also areas of deficit. For example, Alison explained the criteria for incorporating 3D videos within her language learning classes using experiential learning. First, she explained that immersive activities must be completed during a single class period. Class began with a 10-15-minute introduction, 30-45-minutes allotted for the immersive activity, and then 10-15-minutes for closure and cleanup. Alison exhibited a strong understanding of her students and knew they possessed a connection to their Canadian surroundings which dictated the VR topics to pursue. She explained community members embraced agriculture, had been known to cut down trees for firewood, and in one instance, a student drove a tractor to school. She explained many students had not been given the opportunity to travel beyond the boundaries of their community—something that immersive videos could provide.

Alison explained the process and logic of selecting 3D videos, saying, "Sometimes the videos that we select are there to generate another question from the kids but we want them to have a variety of experiences." She explained further, "We know we have a topic; we know we have a goal at the end and we want these videos to help them question and make connections between them." For example, one video included a 360-degree documentary on Chinese fish markets. Another video included a tour of a tractor manufacturing company. After students observed the videos, Alison led a discussion focused on the involvement of technology and then analyzed the impact of wealth for the stakeholders.

Like Les, Alison instructed students to describe what they saw during immersion. For example, one student described the experience while the other documented their journey employing newly learned vocabulary words. After the immersive activity, Alison prompted students to answer a series of questions from their experience, which she termed, "intellectual operations." Through this assessment process, students: (1) explained facts; (2) made comparisons; (3) drew conclusions; 4) identified consequences using new terminologies; (5) explained similarities and differences; (6) provided descriptions; (7) offered further explanation; and (8) contemplated takeaways from the experience. After switching roles, students compared findings with each other to "complete their thinking." The remaining 10-15 minutes closed the activity to collect materials and prepare for departure.

Alison's experiential learning philosophy proved to be successful. Alison exploited student interests and intertwined them with VR activities. The intent of this VR lesson connected student interest with different content areas and increased vocabulary skills used elsewhere in class. After she noticed student reactions and impact from these activities, she decided to continue these practices moving forward. For example, Alison observed an instance when students had freedom to explore other 3D videos. Students discovered other videos and went onto explain concepts with each other without teacher direction. Alison learned students wanted more information which led her to create online additional resources. Rather than identify and collect videos beforehand, she learned students had the ability to complete the same task—not only a timesaving discovery but additional learning opportunity.

Dani also understood the importance of time management when creating 10-minute immersive activities labeled, “VR trips.” She considered VR “important for our students because we could create future scientists because of something that excited them in a different way.” Going further, she continued, “when you drop a kid into the solar system and you see the change (like the sun compared to the earth) and you’re a part of it, it’s kind of mind blowing.” With that level of understanding, she designed procedures to implement VR activities. To save time, she taped QR codes to each student desk that linked to immersive activities. Once seated, students learned about how to adjust VR headsets and expectations for the lesson. Dani also stressed the importance of students to not interfere with each other while immersed and not record videos or take photographs without the consent from those wearing headsets.

For one activity, Dani focused on empathy through an immersive World War I trenches activity. She explained, “I believe that VR is a vehicle for empathy because they get to see themselves becoming part of an event that shaped our history.” While students became immersed in the trenches, Dani instructed them to look at the people around them and asked students what they observed. To add to the effect, she played ambient background sound effects to enhance the realness of the activity. She grouped students in pairs and took turns explaining what they saw to each other. She observed after students switched roles, they did not experience the same events because they had naturally been drawn to different stimuli.

Dani reflected on the experience, “[T]hey are losing their minds! It blows their minds—it really does!” She recorded videos that captured reactions and explained how she edited out the explicatives from the student reactions. She asked them descriptive questions, like what they saw, smelled, and how they felt during a large group discussion. To conclude the activity, students drafted a descriptive essay from the experience. Dani further explained the impact:

> By letting students experience something form the point of view of the actionable people in a story or a moment in history, it builds background knowledge in 10 minutes or less. Some texts are meant to be seen and experienced first (for example, Dr. Martin Luther King Jr.'s speech meant to be experienced by the people in the crowd; not read on a page and analyzed to death).

Dani created a structured learning environment that produced impactful results. She previously taught lessons covering the same topics but did not yield similar outcomes to student learning. She understood the power of VR but went to greater lengths to make experiences better which enhanced the learning environment.

Along these same lines but even considerably more sophisticated, Mike worked alongside a team to design a VR application that merged Chemistry concepts with interactivity. Mike, like others, previously taught chemistry through the use of a whiteboard and manipulatives but sought other innovative methods. In Australia, Mike partnered with a local university which allowed students the use of innovative facilities. This $27 million visualization studio located at the nearby university included a 320-degree enclosure consisting of 72 interconnected LCD panels. Users wore 3D glasses within this immersive environment. They observed and interacted with various chemistry elements when they used this simulator.

Mike took the concepts but wanted to make it available for anyone with a mid-to-high-end VR headset. He continued to work with a team to develop an Oculus-based chemistry application that replicated the experience of the expensive simulator, but available to more users.

Mike explained the goal from the VR chemistry application was to provide students the opportunity to see various chemical elements represented in 3D form. This chemistry application involved students proceeding through an immersive experience with two large screens projected in front of them. A voice guided them through this process and explained what to do and where to go.

The app provided accommodations for natural tendencies with voice guidance. Through the initial design phases of the application, he noticed different reactions based on the guidance or voice inflections. To make the experience better, the team incorporated haptics (synced hand vibrations to increase feelings of interactivity), which resulted in subsequent reactions with the hand controllers. The reactions from those sensations led the user to interact with the simulation. Also during immersion, students pointed to elements and additional information appeared. Through these experiences, Mike explained, “This sense of play comes in,” meaning students enjoyed the experience while also learning. He explained the process involved “actually creating a journey for students that were independently designing and changing what they look at.”

Mike declared value in allowing students to “choose their journey in some way” which he summarized, “that’s what education is about.” He noticed VR “feeding into that natural … wanting to know something that makes us curious.” Mike understood that some learners struggled to grasp complex concepts but VR provided different perspectives and understanding.

In conclusion, level two activities connected to content, but activities only involved consuming information. Restrictions with only having access to lower-level headsets left some participants like Dani, Joe, and Randy absent from level three—the production of VR content. The low-cost headsets only allowed for consuming content rather than creating it. However, teachers who had the ability to blend curricular activities with mid- to high-end headsets also had the opportunity to participate at the third level of learning with creating virtual content.

Level Three: Content Production and Problem Solving

The third level involved VR content creation and interactive problem-solving activities. Participants incorporated tools like Google Tilt Brush, CAD, architectural design, and others. These types of activities could not be completed on lower quality headsets—only middle-to-high-range headsets. Level three activities required additional planning time and became logistically complex to implement.

Participants sought optimal learning environments and designed activities around the best VR applications. To reach the highest levels of implementation, teachers relied on past instructional experiences with these lessons but identified ways to blend VR. They identified when and where to feature immersion while balancing the constraints and nuances of classroom management. They developed and refined these instructional practices unique to their own teaching style and classroom persona. Over time, these trailblazers became experts. However, to get to this level, they learned about the necessity to analyze and omit applications which students might find uninteresting or lackluster. For example, Tomi experimented with a variety of VR applications prior to introduction to students—some good, and others, labelled “bad VR.” If deemed “bad,” students may have encountered unintended consequences or disregarded the original intent. However, participants found that student engagement increased because of efforts to align classroom activities with optimal VR applications.

Connections with Other Tools

Tomi also explained how one learning activity worked well in coordination with other technical equipment in the classroom. This multi-phase activity started with students creating 3D drawings in VR. They would create virtual 3D sculptures and save each file to be used later. From there, they sent the file to the 3D printer which would build a mini plastic prototype of their virtual drawing to take home. Tomi recognized many learning opportunities with empowering students through virtual creation but also rapid 3D prototyping. All of these steps in this activity would provide space to connect other content areas with previous knowledge or even passions.

During this activity, Tomi observed benefits from using VR that included savings from not using consumable supplies and the subsequent efforts to cure the clay. This project also eliminated the task of cleaning up which otherwise took time away from valuable learning experiences. Tomi summarized all of the benefits from the multi-phase activity, stating, “That’s such an easy win for me.” The time efficiencies, budgetary savings, and avoidance of cleaning justified Tomi using VR and other tools for this activity. The ingenuity involved with creating multi-phased lesson design proved to be a successful venture for Tomi.

Community Service Projects

Alison designed a multi-disciplinary project that encompassed community service. One of the conditions for receiving VR equipment funding included stipulations to “give something back to the community,” which this project fulfilled. This multi-curricular activity involved students recording 360-degree videos of local landmarks into a documentary-style artifact. She selected a local church to feature attributes and connections to the community. Alison referred to the church, “the heirloom of the country and the stories behind it … there’s more than just the religious aspect of it.” She explained the goal of the project: “The end result would be shared with the community for historical references.” During the project, students collected elder accounts and letters, along with highlighting architectural features. After completion, student-created videos had been shared with 98 libraries in the province. This pilot project proved to be feasible and served as the foundation for future projects for Alison. This project also fulfilled funding requirements from the school district.

George expanded interests and used the expertise of students. George permitted students to construct a new computer to accompany the new HTC Vive headset. Once complete, students went onto design 3D sculptures in VR and then print off designs with a 3D printer. George created the term “authentic Virtual Reality” which involved students, “creating something” rather than consuming content. To highlight the capabilities of the equipment, George often used a large gathering space to demonstrate the capabilities of VR onto a big screen for all to observe. George welcomed students and teachers to experiment with the equipment which led to the creation of new VR activities.

George spent six weeks designing various VR activities with colleagues. In his role as a technology specialist, he established a scaffolded K-12 instructional framework for VR activities within his school. For example, George explained “Year one students” became exposed to VR through introductory activities and by “year 12,” students had the skillset and wherewithal to create VR video games. George admitted that VR “can be quite overwhelming for kids to actually experience [it].” Knowing this, he wanted younger students to feel safe during immersive activities. For one multi-curricular activity, he introduced students to VR by having them create drawings based on the children’s book series, “The Magic Faraway Tree.” To begin, students created drawing from the book with paper and markers.

Next, students observed how to create virtual drawings and then attempted to recreate drawings in virtual spaces. By the end of the four-week activity, each student drew a “The Magic Faraway Tree” illustration using Google Tilt Brush. When students used Google Tilt Brush, George observed high levels of engagement. George also designed a three-phased activity using VR equipment to enhance an upcoming field trip. Step one involved students researching using the 3D tool Google Earth. Step two involved students documenting various geographic identifiers using Tour Creator. Step three involved students creating virtual drawings using the tool Google Blocks.

Google Blocks is a free creation application for high-end VR headsets like the Oculus Rift or HTC Vive. “Blocks” had been marketed for its simplicity by allowing users to draw with basic shapes but also for sharing designs on the Internet. They could create drawings from scratch or import shapes and make modifications like manipulate size or change colors. This free Google application provided George and his students the means to enhance this learning activity.

Similarly, George also used the free Google VR application Google Earth with this project. Prior to the field trip to nearby Melbourne, Australia, students used Google Earth VR. This tool introduced students to an immersive simulation of what they would experience. Google Earth VR allowed students to interact with natural and human-created features around the world with simulated movement or flying. In VR, students toured St. Paul’s Cathedral and Melbourne Cricket Ground. During immersion, students explained the form and function of buildings and types of exterior materials used. They also examined the geographic location of buildings in Melbourne. The next step involved applying this knowledge when students used “Google Blocks.”

Using Google Blocks, Student drew basic shapes with the eventual goal of recreating iconic Melbourne buildings. This activity required students to understand the functionality of the tool but also geometric knowledge of constructing shapes to replicate buildings. To extend the learning, they designed potential new buildings that would fit within the architectural landscape of Melbourne. This required students to have a general understanding of the characteristics of Melbourne architecture but also the knowledge and creativity to design a building to fit within that assemblage.

George created another project involving the redesign of various parts of the school. George used a drone to fly above the building and capture 360-degree photos. Students transferred that information into the free VR creation tool, “CoSpaces,” where they created new learning spaces based on 360-degree photographs. “CoSpaces” provided a similar creation functionality like “Blocks” but provided an alternative route for students to make designs. They showcased comprehension and knowledge to replicate the school in a virtual environment. The coordinated effort to combine various tools created an enriching learning environment for George and his students.

George comprehended the effectiveness of VR with student learning but he also took the time to advertise student accomplishments. To publicize VR activities within the building and outside of school, George wanted “to actually capture the learning process” and share with others. He used a 360-degree camera and the 360-degree documentation tool “Tour Creator.” He recorded students throughout various stages of a VR activities and provided “storyteller” experiences for parents. They could experience classroom activities by clicking and dragging a computer mouse on the 360-degree images. Google discontinued Tour Creator and Expeditions on June 30, 2021. The reality of abrupt cancellations (like this) proves the necessity that teachers need to stay connected with ongoing daily collaborations on the Internet.

Post-Graduation Preparations

Similarly, Steve understood proficiencies required with the creation of 3D content. He realized students may encounter these types of situations after leaving high school. Steve designed activities not only to fulfill course graduation requirements but also to prepare students for future careers or college. The goal for this project enabled students to earn certification for occupations in information, digital media, and technology. He rationalized the importance of activities, “that involve content production, but not explicitly for a specific industry.” He directed students to record 360-degree videos to simulate a walk-through of homes. After students created various VR content, they placed the finished products onto a digital portfolio using a personal WordPress repository.

Jeanie also asked her civil engineering and architecture students to create VR drawings for enhanced analyzation compared to traditional practices. Students created 3D buildings with 2D CAD software, called “Autodesk Revit,” or “Google SketchUp,” and then imported designs into an immersive environment. This process allowed students to virtually walk-through their designs to gain different perspectives and modify, when necessary.

Students experienced self-actualization phenomena rather than passive analyzation of 2D drawings. They enjoyed this “amazing” experience because they could “fly around the outside where they missed something they couldn’t see on the [2D] computer because they’re actually inside their building.” Students used information to improve drawings prior to submitting; sometimes viewing multiple times if needed. Jeanie later learned these virtual walk-throughs prepared students for modern industry practices. Jeanie explained how this new learning impacted future class activities. This new information guided new discussions on how architecture and design firms used this same process to aid customers in better understanding their projects. Students also began to organically ask fellow classmates to partake in immersive walk-throughs of their designs.

From afar, Jeanie found value with students observing classmates walking through designs and solicited collaborative feedback from peers rather than solely from her. She described her students “becoming their own client” in understanding architectural designs and whether they functioned or not. They gathered feedback and made improvements before submitting for teacher assessment. When students created content, they played an active role with immersive content rather than consuming it.

Craig also taught an architectural design course where students traditionally fabricated various architectural objects built to withstand earthquake forces out of physical materials. In the past, students constructed objects out of wood and duct tape. He felt this type of activity could be bolstered with VR to help students gain different perspectives of their contraptions within a 3D environment. He said, “they could walk around and interrogate their design [which] became way more powerful.”

Craig rationalized, “It [VR] takes complex things and makes them lucid, which is an amazing and powerful tool to have in your classroom or building.” He explained learning in VR provided a better visualization for “how machines can transfer or harness energy changes within a system” compared to traditional teaching methods involving 2D simulations. VR applications like “Gadgeteer” allowed students to problem solve physics challenges or design their own Rube Goldberg contraptions. In this instance, Craig had discovered an application that met learning requirements for this project and expanded the potential for students.

Global Collaboration Potential

Chrissy described an upcoming project that had been paused due to the Covid-19 pandemic. The plan had been named the “International Business Program.” Elementary students would create a global startup enterprise. The end result of the activity involved students creating their own business inside the VR application, “ENGAGE.” Chrissy compared the activity to the Disney World amusement park EPCOT (Experimental Prototype Community of Tomorrow), where visitors toured different countries. However, with this project, students would create a business and host a booth in a meeting space inside “ENGAGE,” similar to the virtual environment.

Chrissy explained, “If I’m an 18-year-old student creating a shoe store with the intent of selling to customers in Hong Kong, there’s going to be certain choices I need to make.” For this activity, students needed a better understanding of different cultures and the purchasing preferences for that geographic part of the world—not just their local community. Chrissy cited the importance of primary sources, “So why would we not teach students about international business from international students?” Chrissy rationalized the lack of understanding of an 18-year-old from China and what they might purchase, “I have no idea, so let’s ask them.”

The goal and anticipated end result of the activity included “learning about international trade currency, cultures, [and] everything.” Chrissy reflected on the original design of the activity and explained, “I just thought of that one night. I don’t know. I’ve just always felt my strengths as a teacher was always coming up with creative ideas for learning and VR just lends itself to that.” In this instance, she understood the potential for experiential learning and designed various activities around the capacities of the tool. Unfortunately, due to the pandemic, this innovative endeavor never came to fruition.

VR Access to the Entire School

Similar to Chrissy, David demonstrated strengths in creating innovative endeavors. David developed a standalone high school VR course after stumbling across a current events article focused on VR. From the beginning, he insisted on the involvement of students in this "democratic process." While he knew that he and his students did not have the ability to create immersive activities, he tasked students to research how to take existing applications to find the best ones "that fit into the educational process." David charged students to become involved in all aspects of designing the VR course. They brainstormed the process from start to finish. He wanted to develop leadership and collaboration skills through this innovative experience.

The first step involved students surveying and testing optimal applications for learning. They researched applications by reading user reviews, studying company websites, and checking the popularity of the application. Next, students spent multiple days becoming "masters" of the various applications. They learned about functionality and how the content could be used for learning. They documented the positive and negative aspects that would be shared at a later time—the final step. Each student group completed this process with multiple applications and created a presentation of their findings.

David and team solicited ways to improve VR experiences by presenting findings in class to students about things liked and disliked about the applications. The rest of the class completed a Google Form to rate feasibility for each application. These results compelled future decision-making processes when selecting new VR applications to offer. Based on student feedback, they wanted VR applications "to be more interactive." David summarized the purpose, saying, "We are there as a resource to the regular classroom teacher, so we use VR to enhance what the classroom is already doing, not necessarily replace it." David continued, "We're hoping to provide experiences and opportunities with the great understanding; maybe it brings some concepts that are a little abstract and vague, maybe it brings them into focus a little bit more." When collaborating on a potential VR activity, students needed to research and study existing applications and make the justification whether a four-minute VR experience would make an impact. David explained that not all VR activities provided stringent experiences. Instead, they used the equipment for other activities. They understood that 360-degree videos had no longer become good enough; now students searched for better immersive experiences. However, those experiences brought additional financial constraints.

During this time, David also started to understand the financial burden of purchasing multiple VR applications. When students proposed purchasing a new application, they went through the process of testing and presenting to the rest of the class, but now David increased the scrutiny to ensure the money had been well-spent. His first year, he dedicated $1,000-$1,500 to purchase applications but after making individual purchases for each of the 15 headsets, costs increased. David explained the nuances of creating a purchasing system. David had to set up “20 (or more) alias email accounts” to purchase each application individually with Visa gift cards. He realized that subsequent fees ranging from $3.95 to $6.95 added up after each transaction. David established this process on his own. He did not have the ability to predict the logistics with running a classroom set of headsets and subsequent hidden fees. He questioned why such a significant amount of the budget had to be dedicated to fees, so he determined a better method. David knew that using a personal credit card would not be an option, nor using a district credit card, so he ended using PayPal for prepaid gift cards. David called this process “entertaining, until they change the rules again” and predicted that it may change in the future, but it had worked for the moment.

David continued to empower students with designing VR course content. He told them, “You guys always say how school is boring. You don’t like the activities that your teacher picks. So, if you were designing classroom activities surrounding this virtual reality experience, what would you do? What would it look like?” For each VR application, David assigned students to design pre-learning activities, tasks to complete during immersion, and a wrap-up activity. He described this collaborative activity where students became "peer-to-peer experts for the technology." Moreover, they had other factors to consider like finding optimal locations for VR setups. Students identified the schools' theater lobby to be the best learning space for VR activities.

Once the class established a variety of VR curricula, they now had the ability to expand VR accessibility to the rest of the school learning community. David wanted to share this resource with colleagues to unleash new learning while also not creating additional work for them. He understood the extra effort and wherewithal needed to implement VR, so this endeavor minimized those elements. In doing so, David created a scheduling system where students from his VR class volunteered to help other teachers use the VR equipment.

Other teachers did not have to know anything about the VR equipment (i.e., how to set-up, troubleshoot, or tear-down) because students took the lead. David explained the philosophy of having his students assist: "It takes the technology burden off of the classroom teacher and puts it solely on us." They designed a system where one student assisted each group that used the fleet of headsets. Students assisted with the physical setup, operation, and tear down. During these classes, they problem-solved glitches when the system crashed. This approach also allowed the teacher to facilitate the learning for other students. Over the course of the school year, students became "very skilled" at verbally walking other students through navigating menus. David explained how students became better communicators and built "soft skills" which produced this "unintentional byproduct." Throughout the school year, they often reflected on the initial goal of the class—to provide immersive, 3D interactive applications for other students using high-end VR equipment. Students solicited feedback from student users from the classes they supported, a trait of quality customer service.

After reflecting on the impact of VR course for students and at school, David stated, “I’m glad to have the freedom to create and put our students in situations to do amazing things.” He cited how students became the technology experts and, in turn, ended up teaching other students. He realized his good fortune of receiving funding and freedom to create these opportunities that other teachers may not obtain. David and team continued to develop new collaborations until work abruptly paused due to the COVID-19 pandemic.

An example of this conceptual idea involved a collaboration with a science teacher. However, David explained they never had the opportunity to fully implement because of the Covid-19 pandemic. In this instance, students had tested an application that simulated color blindness. They remembered a classroom activity from the previous school year when they had taken the course. Students thought a particular VR application might enhance the learning activity for current students in the course. They proposed this notion to David who then formulated a brainstorming process to later present to the science teacher.

David explained how this proposal became “spearheaded” from students. They presented an immersive color-blind application with potential learning objectives to their former science teacher. After receiving approval, students came back to David’s class to continue their work. They developed and designed learning activities which introduced concepts, designed activities during immersion, and identified closure activities. They also considered the requirement to keep 15 students occupied in a headset while the other 15 completed immersive tasks.

From there, students determined periods of the day the teacher would need VR equipment. David coordinated logistics with the team to find volunteers to assist in the delivery of this activity for each period. He mentioned great interest for student volunteers with this project. He realized students had volunteered for multiple sessions throughout the day, which meant they would miss other classes, and create concern with other teachers. He viewed this as a learning opportunity for students to understand and prioritize educational obligations.

Lastly, another activity students created involved the Anne Frank VR experience. After becoming versed with concepts and interactivity within the application, students created a teacher resource page along with a lesson plan. Additionally, they created an assignment for students to complete. Because students created all resources for the activity, they demonstrated the highest levels of content knowledge and the knowledge for understanding how to incorporate VR with learning.

Another application involved third level problem-solving and collaboration. For example, David and Craig used the VR application “Keep Talking and Nobody Explodes,” for communication and problem-solving skill building. David explained how the activity “required effective communication … before the bomb explodes.” He acknowledged negative connotations related to diffusing a bomb for a school-sponsored activity, but continued, “I think there’s a deeper value to it than just a game to play.” Students strategized between sessions and determined the best way to beat the game which required communication methods.

The three levels of VR implementation paved a viable pathway to implement VR. The first level, with the cardboard headsets, provided introductory and basic experiences to demonstrate the concept of VR. The second level continued with low-to-mid level headsets but teachers identified connections to their curriculum. The third level of blending curriculum provided the highest levels of learning through content creation and problem-solving; however, this level also required high-end headsets. These participants could not achieve the third level with entry-level headsets. These teachers provided opportunities for student agency which allowed them to reach the highest levels of comprehension and understanding.

Level one participants found when students experienced VR, they sensed feelings of presence and wanted to tell others. Teachers embraced those reactions and made them a part of the learning activities. They constructed comprehensive lessons that involved introductions, VR activities, and reflection. Prior to implementation, teachers factored headset capabilities, number of students, and time constraints. Pedagogical approaches shifted from the sole provider of information to facilitator of learning.

Level two teachers became more knowledgeable and discovered ways to implement into upcoming activities relating to their content. They understood capabilities of the tool and found optimal ways to use it in class. They did not rely solely on the tool, however; they used VR to enhance the learning experience—especially for visual learners. They balanced instructional time with immersion time and found ways for students to make connections. They analyzed available applications and, in some instances, had to adapt pre-existing immersive experiences with curricular activities.

Level three teachers used VR at the highest level. They understood the novelty with level one and connections with level two but understood the power of creation. High-end headsets also provided the ability to incorporate interactivity. In some instances, they adapted applications to accommodate classroom activities but others provided optimal immersive environments directly connected with their content area. Teachers rationalized third-level activities because students demonstrated a multitude of proficiencies while immersed.

In the third level of VR, teachers incorporated higher-level thinking skills and affect. They incorporated analysis, problem-solving, and advocacy. Through the creation process, students attempted to demonstrate and even achieved proficiency. Students became engaged because of interest and curiosity. They could follow and pursue natural instincts through discovery and play. High levels of interest can be attributed to the teachers' efforts when they created optimal conditions for learning—an educational concept described by Dewey (1923).

The implementation journey varied for each participant. However, from the initial exposure, they saw value to seek out and determine a pathway to bring VR into their classroom, while also tending to other instructional obligations. Most teachers struggle with managing workload and professional expectations, so the willingness of these participants to embark on this new endeavor demonstrated high levels of aptitude. After initial exposure to VR, participants determined they wanted to integrate VR into their classroom. However, they first sought administrative approval and determined viable funding sources. Some participants found this process effortless while others needed to be innovative and persistent. Teachers also created partnerships to navigate the nuances of implementation unique to their circumstance. Each situation proved to be unique based on situation (e.g., content area, grade level, and/or headset quality).

Throughout the implementation process, participants identified optimal VR applications, adapted lesson plans, and altered instructional methodologies. Teachers determined the impact of quality VR applications and how they fit within the curriculum. They managed classroom responsibilities to create a structured system dependent upon the number of students and headsets. They also switched instructional approaches from traditional practices of presenting information to facilitators of learning. Participants relinquished aspects of instructional control and empowered students to control their learning pursuit.

Participants learned alongside students to create optimal learning environments. In most cases, instructional resources had not been readily available, so participants relied on past experiences and instantaneous problem solving. Some participants even embraced students and welcomed their input and technical support. Once teachers observed how quickly students embraced this learning tool, teachers instinctively sought ways to remove barriers and exponentially unleash learning possibilities.

Participants demonstrated an openness to experiment with instructional strategies, which resulted in accidental outcomes. Teachers discovered the unintended consequences created new learning opportunities not previously anticipated. Participants witnessed students following their unique natural impulses in the same VR experience which diverted otherwise planned learning objectives. Some teachers might have perceived these occurrences to be a failure, but participants embraced this revelation.

Additionally, once students became immersed, participants observed positive student reactions and increased engagement. A few participants also noticed an increased sense of classroom community around these mutual experiences. They observed shared excitement with collaboration and an unprompted willingness to assist each other when needed—a utopian accomplishment that many teachers crave.

Lastly, many participants perceived VR to enhance curricular activities and bring a sense of novelty to teaching and learning. Educators realized VR did not replace their role as teacher. They realized VR belonged in their instructional toolbox. In some instances, VR impacted assessments because of improved recall of information as compared to past instructional practices. In other instances, it broke up the monotony of daily practices. VR provided exposure to new places and perspectives. Either way, VR demonstrated another viable learning tool which belongs in the classroom. viability to belong in the classroom. In the next chapter, I further explain Dewey's (1923) experiential learning theory and the TPACK framework (Mishra & Koehler, 2006) to analyze the data.

CHAPTER FIVE: ANALYSIS

Blending Experiences with Optimal Conditions

In this chapter, I analyze major themes in the data chapter based on two theories. I adopted Dewey's (1923) educational philosophy and pedagogy as well as the Technological Pedagogical Content Knowledge (TPACK) framework developed in 1998 (Mishra & Koehler, 2006). Dewey's (1923) theory of experiential learning relating to teaching and learning reveals the dominant philosophy and instructional approaches adopted by innovative teacher using VR for learning. Dewey's philosophy of experiential learning serves as an overarching theory to explain and interpret the themes identified in this study. The TPACK framework reveals the phases in the design process needed to create meaningful teaching and learning activities rooted in the disciplines.

Dewey's (1923) Experiential Learning

Dewey's (1923) theory explained not only how students learned based on this philosophy, but also how teachers learned. Participants embraced Dewey's (1923) experiential learning theories which required significant modifications of instructional practices to successfully make use of VR—not a modest undertaking. Transformational change became evident throughout their journey not only for students but also for teachers.

The first overarching framework incorporated elements from Dewey's (1938) theories for teaching and learning and the relationships between the learner, new content, and the environment. Dewey (1923) explained that teachers' ultimate responsibility essentially blends the ability to provide motives with resources (to students) during a given timeframe. They need to create environments that stimulate thought for each learner (Dewey, 1923). Participants exhibited determination and a willingness to fundamentally transform the student experience in their classroom.

The teaching process involves reciprocity comprised of a giver (teacher) and receiver (student; Dewey, 1923). Further, Dewey (1959) explained, “The only way to increase the learning of pupils is to augment the quantity and quality of real learning” (pp. 135–136). In this instance, VR provided enriched, simulated experiences that traditional teaching and learning activities could not. Participants in this study incorporated many Dewian themes into instructional practices, such as…and then set up what’s coming.

Initial Interest and Intent to Use VR

Dewey (1923) described interest in education to be the “moving force … in any experience having a purpose” (p. 101). Initial exposure to VR for participants created a profound reaction—enough to want to replicate those emotional responses for their students. For example, Tomi first experienced VR at a Japanese arcade. From that first experience, she wanted to continue using VR for entertainment purposes but later pursued implementation for the classroom. Other participants shared similar experiences that generated a “hook” which resulted in them implementing VR.

Participants sought positive VR experiences that contributed to the likelihood of students wanting to learn more. Dewey (1923) explained interest further, “One is identified with the objects which define the activity, and which furnish the means and obstacles to its realization.” (Dewey, 2008, p. 107). Each participant demonstrated the lengths they pursued to obtain equipment and take action needed to bring VR into classrooms. Dewey (1916) said, “When we experience something, we act upon it, we do something with it; then we suffer or undergo the consequences” (p. 44). This statement epitomizes the intent of this study: teachers tried VR, savored VR, pursued VR equipment, and implemented VR with students.

Dewey (2008) explained an educational objective, “dynamic place of interest that leads to considering individual children in their specific capabilities, needs, and preferences” (p. 101). At the time of this study, VR did not have a presence in most K-12 schools and many teachers do not understand the full potential. However, the teachers in this study took action to pursue it further. For example, when Craig used VR with his son at the mall, he quickly saw potential. He did not anticipate the discovery of a new instructional tool while visiting a local mall. Instead, his reaction to the experience instilled a pursuant crusade along with an aptitude to find success.

Participants shared similar mindsets with initial exposure to VR. They may not have known the nuances and intricacies of VR implementation but saw potential. Dewey (2008) explained, “Attitudes and methods of approach and response vary with the specific appeal the same materials makes” (p. 101). Each participant struggled with implementation—some more than others. However, they continued to overcome obstacles and found eventual success. Over time, they developed better understanding and efficiencies for solving implementation barriers. After participants experienced difficulties, they continued to have a vision for the tool and found ways to persevere because of prior success with other technology tools.

Previous experience with technology and student learning provided contextual understanding for potential learning capacity of the tool. Dewey (2008) labeled this state, “natural aptitude of past experiences” (p. 101). Teachers instinctively relied on past instructional experiences to develop an instructional framework that worked for them. They trusted the process and natural instincts. Participants demonstrated open, “can-do” mindsets and a willingness to implement modified pedagogical approaches based on new tool functionalities.

They found earlier success with other technology tools and anticipated that VR could also deliver new learning. Participant interest in VR never subsided because of vast array of innovative possibilities and the desire to provide the best learning conditions.

Creating Optimal Learning Experiences

Dewey (1923) described when teachers select optimal content and experiences it results in essential influence and impact. Virtual reality implementation proved to be successful because teachers took time to find relevant experiences. For example, Tomi described the process of sifting through numerous VR applications to find suitable and practical experiences to bring into the classroom. She excluded applications that did not meet her own stringent requirements. Further, through this process, Tomi complained of finding "bad VR." These sub-par applications offered limited interactivity or did not allow long periods of game play – not ideal for learning.

Participants also weighed negative connotations with VR and gaming. Jeanie enforced a strict policy where immersive activities could not involve any "gaming" themes. Similarly, Craig eliminated applications with "gun play" or insinuated violent themes. However, not all gaming applications implied negative outcomes. For example, David acknowledged adverse connotations with a VR application entitled, "Keep Talking and Nobody Explodes." He explained the premise of the game which involved collaborative problem-solving discussions to diffuse a simulated bomb. During the game, if a user took too long to solve problems, the bomb eventually exploded. He admitted that judgements from afar may have been misinterpreted with violence themes. However, the application of skills along with interactivity provided high levels of engagement and problem solving for students. David explained students understood this immersive experience did not include real life situations and did not encounter harm from simulated explosives. Skills developed in games like this also materialized into other areas of learning.

Likewise, Craig noted when students used VR, it led to improvement of completing tasks in real life. While immersed, his students could make mistakes, practice and repeat tasks, and construct objects under safe conditions. Additionally, Craig explained how he saved resources by not having to purchase consumables. He also found it also spared critical instructional time by not having to clean-up after each experience. For example, in one activity, he tasked students to design 3D buildings built to withstand earthquakes. He explained how some 3D designs defied traditional construction methods which allowed students to “walk around and interrogate their designs which became way more powerful.” This concept connected with Dewey’s (1923) theory which promoted development with predetermined goals because Craig used a VR application that directly connected to his intentionally designed activity. These immersive experiences provided students the opportunity to flourish with creativity and also the space to reflect.

Dewey (1923) also noted the importance of reflection after experiences. Many teachers created immersive learning experiences and facilitated reflective questions immediately after students removed headsets. This instructional sequence allowed students to describe experiences in written and oral practices. For example, teachers placed students in small groups and assigned students to compare experiences after immersion. Participants explained that this led to more impactful conversations. Teachers found they could structure adequate periods of class time with multiple rotations of immersion and then reflect.

Through this pattern, students learned that even though they used the same application for the same amount of time, they experienced different things. Participants instinctively embraced this unanticipated element to enhance lessons rather than force similar occurrences. Many times in education, teachers strive to develop consistency with their instructional practices. They hope students achieve similar results—an attribution of quality control. However, this instructional approach and embracing of differing experiences in VR relinquishes that ability. Participants let students follow natural tendencies and were given the opportunity to discuss.

Another method of reflection entailed teachers requiring students to document experience through writing prompts. Immersive experiences became the instrument to further develop skills. The intent of these written reflection activities increased vocabulary skills. These VR applications had not been designed to enhance reflective skillsets in a school setting. However, teachers found creative ways to implement traditional learning activities like collaboration and reflection. They assessed the landscape with their knowledge and experiences to find a solution.

Creative Virtual Reality Teachers

Participants expanded their skillsets as innovative instructional designers. They created activities to uncover new knowledge which would otherwise not have been possible. Dewey (2015) explained teachers need to remove constraints that otherwise stifled creativity. Once removed, teachers find opportunities and flexibility to fulfill individualized lesson goals (Dewey, 2015). Participants identified applications intended for entertainment but found opportunities to connect their content. In most instances, they customized immersive activities to satisfy learning objectives.

Further, participants created unique immersive experiences because of their understanding of content and knowledge of their student population. For example, Les could not find suitable immersive applications to meet the needs of his students. Instead, he constructed unique immersive environments to reinforce writing composition skills.

Similarly, Chris understood that some chemistry concepts had been difficult for some students to comprehend. Like Les, he surveyed the immersive landscape and could not find a relevant application to assist in exposing these concepts. Instead, he worked with a team from a local university to design an immersive chemistry experience to meet the needs of his students. To that point, no other application existed. In these instances like this, teachers employed VR to make learning better through their own creative ambitions to access new information.

Providing Access to New Knowledge

Dewey (1923) cited “pioneer times” of education when teachers had limited access to books and information. Further, Dewey (1923) explained activities in schools had been based on books due to their prevalence. Inversely, in modern times like today, most students have access to the world’s cumulative knowledge with the device in their pockets. Teaching and learning has become more nuanced because teachers no longer retain the role of the gatekeeper of information. Further, Dewey (1923) explained the primary role of the teacher involved the engagement of students to build skillsets which results in satisfaction from those efforts. These newly formed skills aim to be employed in the future (Dewey, 1923). Teachers must create relevant activities that require higher levels of thinking rather than traditional “fill in the blank” worksheets.

Activities must also be relevant, applicable, and appropriate for various learning levels. For example, Steve designed scaffolded curriculum in his district that began with introductory VR activities in early grades but led to developing skills over time to prepare students for the nearby university or entrance to the workforce. Once students proceeded to the next grade level, they became exposed to higher quality headsets and better VR learning activities. Steve explained that when students left school, they became better-positioned for careers that used those tools.

Similarly, David preferred broad skillset development rather than training students for specific occupations within the VR industry. He said, “What I see myself doing is opening doors and getting them to look at the world a little differently; what opportunities are out there that they maybe didn’t realize existed?” He also predicted that some students may end up working in careers that did not previously exist. David focused on the growth of skillsets rather than the focus on specific devices or headsets.

David understood the power of unleashing student agency. Dewey (1923) explained, “As students grow mature, they will perceive problems of interest which may be pursued for the sake of discovery” (p. 154). David’s students found value with providing VR experiences throughout their school. They saw this opportunity to fulfill course requirements while also reciprocating efforts back into the school community. In their VR course, David created situations where students learned new skills and applied them within a sheltered environment. He coached students to provide high levels of customer service to fellow students and teachers while also persevering through occasional technical hurdles which does not always lead to failure.

Learning through Failure

The implementation of VR allowed participants opportunities to develop new skills and encounter failure for both teachers and students. Dewey (1916) explained the rationale for encountering missteps to be an “… opportunity for making mistakes is an incidental requirement [for learning]” (p. 152). For example, Sally admitted this insight with her students whenever she introduced activities involving new technologies. She preemptively explained they may encounter difficulties and they would persevere, together. This mindset also provided leniency from her students and the autonomy to routinely attempt unfamiliar pursuits. However, many traditional teachers would not be willing to put themselves in such vulnerable positions.

Dewey (1923) explained this “trial and error” method of learning; when a person tried something that may not work, they tried something else and continued until they found success. Through iterative processes, participants learned which actions produced positive results and those that did not. For example, the task of deploying software onto headsets became quite cumbersome for one participant. David had to purchase the same software applications for each headset in his vast collection, which became strenuous. David learned that purchasing choices had been limited for individual headset purchases but not bulk orders. Most VR users only own one headset and the purchasing systems had been built around that scheme. However, after his students found an application to install on the classroom set, it required individual purchases and download onto each unit. Through trial and error, he learned which methods proved to be fiscally responsible and efficient given the constraints of the district purchasing requirements. To his knowledge, David had been the only teacher attempting this type of purchasing process in a K-12 setting.

David attempted to use a prepaid credit card to purchase VR software applications. After he read contractual fine print and fees associated with the purchase, he learned that a certain percentage of funds went towards banking fees. Frustrated, David sought a better method and decided to pursue alternative payment methods that did not require fees which allowed him to further extend the budget. He acknowledged that while he found success with this method, he anticipated other obstacles would likely force him to pursue a new purchasing method. These lengths to which David went just to purchase software demonstrate his ability to understand the complexities of simple tasks but also finding ways to provide new ways to learn.

Experiences in New Learning

Dewey (2015) simplified the learning process, stating, “We do something to the thing and then it does something to us in return: such a peculiar combination” (p. 44). Participants embraced Dewey’s (2015) concept with implementing new technology. They anticipated students would gravitate towards the new tool, but not necessarily the notion that each student would encounter different experiences which resulted in surprising outcomes. For example, Dani overheard a student mention the possibility to pursue a new career after an initial immersive experience. The original intent of the VR activity had been connected to an historical event—not career exploration.

Dewey (2015) explained teachers must intently connect the past with future connections through the discovery process. Through interactions, experiences became developed (Dewey, 2015). Virtual reality provided access to experiences where students flourished because teachers creatively designed activities. Had they not laid a foundation of understanding and provided space for reflection, the impact may not have been successful. They created connections and facilitated experiences. Conversely, a less-capable teacher could have simply provided a headset without any introductory explanation and left the students on their own.

For example, Chrissy understood that most students underperformed on annual standardized tests regarding public speaking. She decided to pursue an application where students became immersed in a simulated public venue. She tasked students to practice public speaking skills in a virtual environment. Students practiced giving speeches in the virtual space and Chrissy provided feedback. Over time, students became comfortable with giving speeches. These focused activities led to higher test scores on standardized state test in that particular area. However, teachers incorporated VR lessons for different purposes, like entertainment.

Learning through Play

Dewey (1923) described the concept of "play" through "kindergarten games" (p. 156) where students become enthralled to the point they become engrossed with the activity. For example, Randy observed students a volcano eruption in VR which yielded positive reactions compared to past instructional methods. He said, "The feedback was amazing and by the next class, they were asking for the VR boxes." He believed their reactions signified a better conceptual understanding of volcanos and they wanted to learn more.

Immersive activities allowed students to become active. Dewey (1923) stated, "When children have a chance at physical activities which bring their natural impulses into play, going to school is a joy, management is less of a burden, and learning is easier" (p. 150). However, besides normal wear and tear, participants did not experience any intentional damage or destruction to VR equipment from students. I inquired with participants if they encountered any issues with students while using VR. Not one participant indicated any intentional mischief that involved the damage of equipment. Students realized this tool provided fun learning activities and did not deliberately break the tool, which sometimes periodically occurs in schools. The loss of instructional control may have given carte blanche for pandemonium but had not been a concern.

Dewey (1923) also acknowledged, "the grounds for assigning to play and active work a definite place in the curriculum are intellectual and social" (p. 150). For example, teachers often could not find adequate VR activities under the "education" section of the webstore. Instead, they found applications under the "entertainment" section where they adapted activities within the exciting experiences. Teachers discovered applications focused on completing challenges and solving problems within stimulating environments. Some participants welcomed gaming applications while others did not. Participants weighed the context of the application and skillsets that had been developed during those experiences to determine eligibility for their class. Often, they focused on those shared experiences and collaborative moments to enhance learning.

Creating Communicative Environments

Participants found ways to have students collaborate. Dewey (1923) said, “To be a recipient of a communication is to have an enlarged and changed experience” (p. 5). The reason participants combined students in pairs became evident because of the lack of headsets for every student. To counteract that nuance, teachers designed activities that created shared experiences and blended immersive activities with collaborative discussions. For example, Joe created activities where students shared headsets and then completed activities, together. Similarly, Sally paired students together through the shared use of a headset to apply recently learned terms. Joe and Sally each created a structure where students worked together to fulfill learning requirements.

Dewey also explained, “Education is thus, a fostering, a nurturing, a cultivating process” (p. 9). Teachers motivated students to be collaborative partners and instilled a positive learning community. For example, Jeanie instructed her architecture students to design 3D buildings and tasked other students to virtually walk-through each other’s designs and share feedback. She coached students how to provide feedback in a constructive manner rather than criticize each other. Jeanie anticipated potential obstacles with peer-to-peer feedback, so she understood the importance of creating a positive intent with their feedback. Dewey (1923) explained, “The experience has to be formulated in order to be communicated” (p. 5). Through these collaborative and shared experiences, students in Jeanie’s classes demonstrated understanding and competency. Through dialogue, students share a “common possession” from the experience, comprised from transactional collaboration (Dewey, 1923). Jeanie understood that her students had better understanding of architectural design after comparing projects—through constructive dialogue. They presented individual designs to share and received feedback which led to eventual improvements.

Dewey (1923) also explained that when each partner feels success or failure, they became part of the learning process. Once emotional learners became involved, Dewey (1923) explained, through this experience, together, they will eventually develop shared sentiments. For example, Joe experience technical issues during various learning activities. Joe explained his students observed the difficulties but also provided encouragement while he solved the issue.

Dewey (1923) stated, "The importance of language in gaining knowledge is doubtless the chief cause of the common notion that knowledge may be passed directly from one to another" (p. 12). Participants created collaborative environments with the use of this tool. They extended the intended use of immersive activities and incorporated Dewey's (1923) theme of experiential learning with collaborative discussions. The learning capacity had been extended through the use of dialogue and teachers used this facet of Dewian theory. They maximized many learning capabilities with the tool by facilitating VR activities

Employing Directives

VR teachers changed the pedagogical approaches to instruction. They shifted away from traditional practices to the role of a facilitator. Dewey (1923) explained, "guidance … best conveys the idea of assisting through cooperation in the natural capacity is of the individuals guided" (p. 19). Teachers adapted instructional practices away from traditional instructional strategies. For example, Craig described his role when students used VR, labeled "guide on the side." He explained the methodology as "coaching kids and facilitating their learning." However, Dewey (1923) explained that teachers need to provide direct instruction to avoid confusing and unnecessary conditions. Teachers shifted away from this concept. Instead, teachers introduced concepts and allowed students to use the VR equipment while they observed from afar, unleashing the possibility for unforeseen outcomes. Traditional teachers avoid situations like this while open-minded teachers welcome this notion. In the facilitator mentality, participants provided feedback (when needed) with periodic reminders to return back to work. They facilitated learning activities different from their other classes.

Dewey (1923) stated individuals remain interested in activities when in control, which may differ with each person, but will also likely lead to a shared interest when learning collectively. This statement epitomizes VR and education. Teachers manipulated classroom environments and instructional approaches to incorporate this tool. Immersive experiences provide individuality and teachers provided the space for collaborative discussions. Student engagement and participation increased with these shared experiences. Some participants took this philosophy one step further and provided opportunities to become engaged in the management of the learning environment.

Deploying Student Assistants

Participants understood that students brought knowledge and interest with technology tools. They realized that students would not impact the hierarchal structure in the classroom setting. Instead, students became assets to improve the learning environment. Dewey (1923) explained, "[C]hildren want to 'help;' they are anxious to engage in the pursuits of adults which effect external changes" (p. 157). Multiple teachers enlisted the assistance of students to assist in classrooms. They realized students possessed understanding and a willingness to help. They deployed teaching assistants or students who demonstrated interest in the technology tools.

Students understood the importance of logistical considerations like safety, along with specific concerns like oversight of cable management. For example, David relied upon the extensive knowledge base of students and digital knowledge and expertise, which he admitted was a shortfall. He realized they brought previous knowledge and understanding. This model allowed David to provide assistance elsewhere and increase instructional efficiencies.

Summary

Whether they knew it or not, VR teachers embraced Dewey's (1923) teaching and learning theories. Virtual reality implementation forced teachers to change. They modified pedagogical approaches by focusing on student engagement and experiential learning rather than traditional instructional practices. Teachers no longer directed learning from the front of the classroom; instead, they transferred the learning process onto students. They empowered students rather than limiting participation through passive transfers of knowledge. Students gained ownership of their learning. In many instances, those experiences made a profound impact which resulted in the exposure to new outlooks on learning.

Technological, Pedagogical, and Content Knowledge (TPACK) Framework

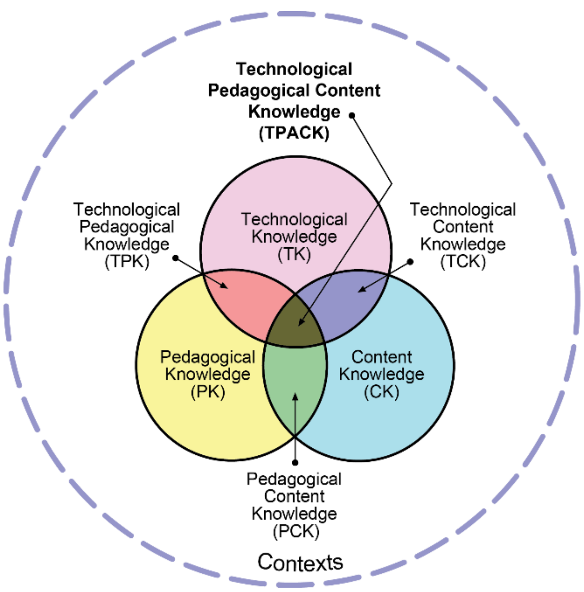
A widely adopted framework for curriculum design, the TPACK framework blends different academic areas: technology knowledge, pedagogy knowledge, and content knowledge (Mishra & Koehler, 2006). TPACK was developed at Michigan State University in 1998 (Mishra & Koehler, 2006). Many teachers use different technologies compared to pre-service trainings and lack a thorough understanding of impactful implementation (Koehler et al., 2013). Sahin (2011) explained that "successful" teachers "need to develop themselves in pedagogy, technology, and their content areas" (p. 97). Sahin (2011) argued that examining teacher perception of each area of TPACK is necessary to determine knowledge within the domains.

Koh et al., (2014) described demographic factors like gender, age, and teaching experience impact perceptions of TPACK.

The TPACK framework (see Figure 9) illustrates the relationships between content, pedagogy, and technology (Koehler et al., 2013). Three contexts include: content knowledge (CK), pedagogical knowledge (PK), and technology knowledge (TK). Further, pedagogical content knowledge (PCK) is the idea that teachers customize instructional practices based on the content area (Koehler et al., 2013). Technology content knowledge (TCK) occurs when teachers understand how technology enhances educational experiences. Technology pedagogical knowledge (TPK) involves impactful implementation of technology tools in a classroom setting (Koehler et al., 2013).

Figure 9

TPACK Framework

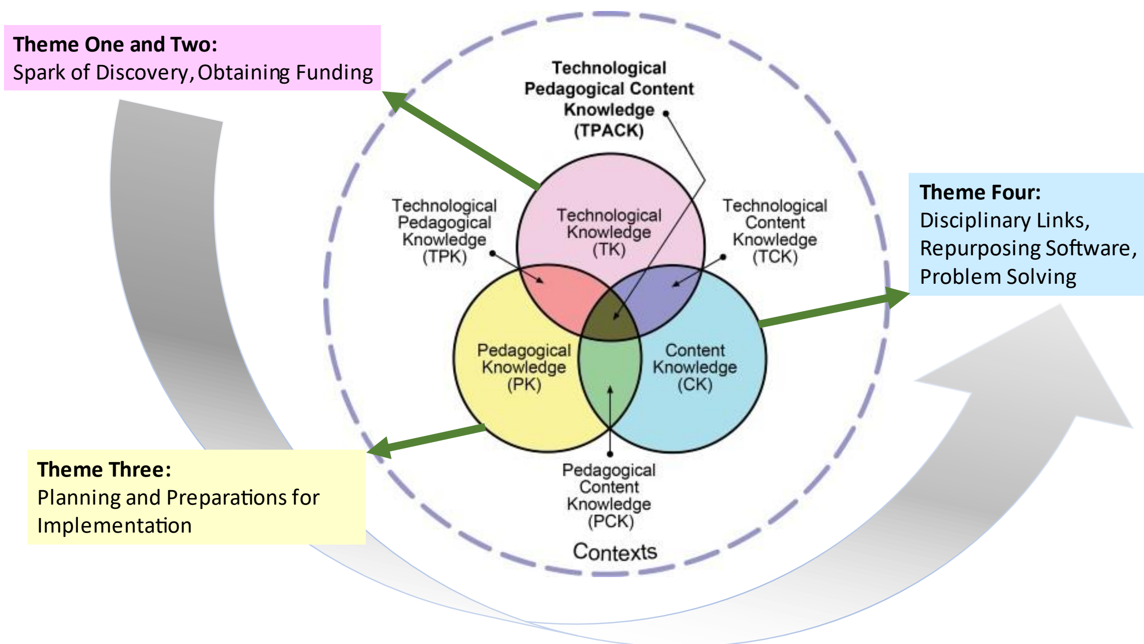


Note. TPACK Framework (Mishra and Koehler, 2006)

To attain optimal levels of instruction in the TPACK framework, teachers strove to balance technological knowledge, pedagogical knowledge, and content knowledge (Magana, 2017). Teachers implement technology at different levels which require understanding of content areas, appropriate instructional approaches, and knowledge of technology tools to ensure

Figure 10

Connections to the TPACK Framework



successful implementation (Mishra & Koehler, 2006). "Master" teachers (like these participants) distinctively blended these areas while they incorporated VR into the classroom (see Figure 10).

Note. *Connections of themes to the TPACK Framework (Mishra and Koehler, 2006)*

Participants demonstrated a willingness to embrace new technology tools, which corresponded with technology knowledge (TK) of TPACK. They contemplated the usability of VR headsets along with learning potential. From there, participants selected devices and determined expenditures. Participants sought funding from various channels which proved to be difficult for some. They partnered with technology departments to ensure compatibility within the school infrastructure which demonstrated an awareness of organizational structures and processes.

Participants adapted instructional approaches when implementing VR, which connected with pedagogical knowledge (PK) section of TPACK. Participants relied on past experiences with technology tools to determine how to implement VR. Participants contemplated changes to instructional delivery or whether an immersive activity provided additional context traditional lecture or discussion could not. They modified physical classroom spaces, adjusted schedules, and altered their role with facilitating learning compared to direct instruction.

Lastly, participants demonstrated strong understanding of content knowledge (CK) when implementing VR. They also understood optimal student learning experiences but had to decipher the impact of the lesson when deciding whether to incorporate VR. The process of analyzing and selecting immersive applications required creativity and flexibility to connect with content areas. In many instances, participants repurposed existing applications and designed alternative activities to meet learning goals at the highest levels. Within those applications, participants with high-end headsets designed opportunities for students to create content and solve problems directly related to their content areas. This example highlights the successful combining of all three areas of TPACK: Technology, Pedagogy, and Content Knowledge (Mishra & Koehler, 2006). In essence, teachers envisioned potential, understood how to incorporate the tool, and evaluated how VR satisfied the area of need. The following sections illustrate the TPACK themes within the data collected for this study.

Early Adoption of Virtual Reality

Participants should be deemed “early adopters” of educational VR given the limited availability of resources and VR education networks. This classification falls under “Technology Knowledge” (TK) of TPACK (Mishra & Koehler, 2006)—the understanding and wherewithal to pursue and obtain technology tools. For example, every participant took initial steps to learn more about VR and demonstrated an aptitude for innovation. They each became introduced to VR through various circumstances , triggering their interest and willingness to pursue VR.

Participants may not have understood all aspects to successfully implement VR, but they saw potential. Teachers anticipated possible risk(s) with introducing new technology tools and hoped for some sort of impact. They relied on curricular knowledge, aptitude to teach students, and a commitment to implement new instructional technology tools. Participants also understood the obligation to adhere to professional protocols and safety concerns that followed district policies to ensure successful implementation. They realized the VR landscape continued to evolve with newer headsets becoming available on the marketplace. However, they did not routinely purchase every available headset. Instead, they continued to refine practices and maximize the experiences that their headsets could provide—essentially plotting their own course.

Willingness to Learn with Technology Tools

Participants demonstrated a willingness to learn more about VR and other technology tools which also falls under TK of TPACK (Mishra & Koehler, 2006). For example, Joe used an iPad to aid in delivery of information. George found ways to incorporate a drone with learning activities. Participants demonstrated an appreciation for innovation after discovering a tech tool and then taking time and energy to connect to student learning.

Exposure to other technology tools proved to be a motivator to take the next steps with learning. For some, this process involved researching various topics or led to the purchase of a new tech tool. Many logistical considerations with implementation did not become present at the onset but would develop later. In some instances, teachers collaborated with colleagues or used the Internet to gather ideas. For example, Craig observed his son use a headset at the local mall and eventually tried it for himself. Had Craig not taken this first step, it likely might have ended his VR journey. His willingness sparked an eye-opening revelation to learn more. A new understanding and learning potential had been created from this random occurrence.

George experimented with many different VR applications. He also welcomed a few students to investigate. Through this process, he observed reactions, and solicited student feedback. Over time, George continued to fine-tune student experiences and narrowed the focus of applications to implement student learning. George and his students learned at the same time. Without student participation, George would not have been able to determine the best applications to use. Their shared willingness to explore and solve a problem resulted in an efficient learning opportunity.

Cost-Benefit Analysis

The amount of time and energy necessary to implement new technology for educators proved to be immeasurable. The process involved researching applications, testing legitimacy, and then introducing VR to students (TK). Teachers weighed potential learning benefits compared to the efforts necessary to implement. In some instances, participants lacked confidence that these efforts would result in impactful learning.

Participants weighed many factors prior to implementation: (1) Analyze past teaching strategies and determine how to blend new tools; (2) Consider number of headsets compared with how many students in class; (3) Accommodate time constraints, both for planning stages and class time dedicated to the learning activity; (4) Anticipate efforts needed to set-up the equipment, maintain headsets, sanitization, and clean-up of the equipment at the end of the activity; and (5) Determine ways collect student feedback and contemplate impact of the VR activity. For example, Jeanie explained how she would have liked to use her HTC Vive headset more frequently but had time and space constraints. She had to set-up the equipment in the nearby hallway for every instance due to space limitations. This process initially became time consuming, but she improved the speed required to set-up and tear-down the equipment. Additionally, the location in the high traffic hallway required constant supervision.

Each time Jeanie considered using VR, she evaluated whether the possible results from using the headset proved worthy of the extra effort. Jeanie described many instances when she declined immersive activities because of time constraints when they would have aided in learning. Like other teachers, Jeanie relied on other instructional approaches and adhered to professional obligations but also turned to social media for new ideas.

Social Media Presence

Participation with social media became a contributing factor to qualify for this study. The quality of their posts or interactions with other teachers demonstrated competencies for VR and student learning. This attribute also corresponded with TK of TPACK (Mishra & Koehler, 2006). Social media allowed instant access to educational technology leaders, authors, and connoisseurs from around the world. Twitter proved to be the most popular communication tool participants used for inspiration. Twitter provided on-demand and focused professional development ideas tailored to any content area. Otherwise, these teachers would likely be the only expert in their building. Prior to the Internet and social media, teachers worked independently and not have easy access to new trends in education—let alone in real time.

For example, Twitter allows users to incorporate hashtags or the pound sign (#) in their posts. Users can search for specific words or phrases. This feature allows users to interact asynchronously and not just during live chat events. They can interact with other Twitter users by “tagging” them, replying directly, or including keywords with a hashtag in the now-grouped discussion for others to see. They can sort various search features such as: recent conversations with those keywords, people that incorporated those words, and searchable photos and videos. Participants became identified for this study because they had previously “tweeted” VR education-related content.

In one instance, Sally explained how she read a post involving a learning activity on Twitter but later realized she could do the activity differently. She later applied that concept in the classroom. Sally described that idea generating process similar to a “spark.” This example demonstrates how Twitter provided on-demand professional development opportunities for essentially any topic at any time and users (like Sally) took what they needed and applied new concepts.

Participants observed others using VR at high levels and took away concepts without necessarily knowing the logistics involved. In some instances, they posted their own student activities and/or participated in focused Twitter chats. For example, Joe used Twitter to collaborate with other teachers and learn new skills. He blended those ideas into projects he designed and returned the favor and shared the activity. This reciprocal process also informed other Twitter users. Joe analyzed other experiences, compared it to his practices, modified it, and then shared results on the platform which exemplified the TPACK framework (Mishra & Koehler, 2006). Without this social media platform, this study would not have involved a global presence.

Similar to Twitter, Discord became an option to communicate in focused user groups, called "Discord servers," where users engaged in conversations publicly or anonymously. This forum allowed users to ask questions, problem-solve, publicize research projects, or share ideas. My involvement with Discord contributed to the discovery of the "Alt Space" VR professional development sessions. Alt Space provided a virtual meeting space of like-minded individuals to collaborate or observe guest speakers.

Scheduled events had been held periodically during the year with different topics regarding VR and education. I observed a guest speaker who showcased how they used VR at their middle school in California. In Alt Space, users create avatars that represents their physical attributes but appear like cartoons. This event began with a warning that unruly guests would be removed and blocked. The speaker had been placed at the front of a virtual stage and started the presentation with a slide deck. Unfortunately, because this event had been available to any user on the Alt Space platform, I observed the downside of this public activity.

I first noticed that other users roamed freely around the meeting space during the session. In one instance, a few users moved directly in front of my view. I reacted by moving to a different location but noticed they continued to follow me. I inspected some of my user settings and learned that I could "block" others, which removed them from interrupting my experience. This led me to believe others in the session did not have the same interest to learn more about VR and education, which became evident soon thereafter.

A short time later, the guest speaker had been interrupted nearly 10 times during the hour-long session by commandeering the audio of the event and played derogatory sound bites on a loop. All participants had been muted and the guest speaker had sole control of the audio. Somehow, other users gained access to audio controls. A facilitator quickly intervened and removed the anonymous user only to have them reappear a short time later and continue with the sound bites, a cat and mouse affair. This could have been a positive professional development session, but it demonstrated the reality of social media nuances.

Another option that continued to gain popularity in recent years involved Podcasts, where users listen to audio recordings related to nearly any topic of interest. The list of podcast genres seems to be endless with nearly every possible topic—VR and education included. Podcasts provide a venue for audio-only experiences that (in most cases) can be downloaded for free. For example, Joe, Craig, and Tomi hosted podcasts relating to technology and VR where they discussed various topics related to education.

Lastly, through the interview process, and unbeknownst to me, I discovered two of my participants, Craig Frehlich and David Kaser authored books relating to VR and education. Craig's book, *Immersive Learning, A Practical Guide to Virtual Reality's Superpowers in Education* was released in the fall of 2020. David's book, co-authored by Thompson and Grijalva, *Envisioning Virtual Reality*, was released in 2019. They conveyed experience and knowledge of implementing VR into a larger, broader scale to share with others in written form. At that time, they observed the lack of available resources for potential VR teachers and created a resource for the larger VR education community.

Developing an Instructional Plan

Whether participants anticipated it or not, they adapted instructional approaches (PK) when they employed this new tool. Teachers established two new protocols within the VR learning environment. For the first protocol, teachers relied on past instructional practices to design and predict how activities would emerge. They had the ability to anticipate how students would interact with technology tools and adapt to the ever-changing learning conditions. This falls under PK of TPACK (Mishra & Koehler, 2006). For example, Craig explained that teachers (with or without VR) need to answer the prompt when designing lessons: “What is it we want our kids to do?” and “teachers need to have learning goals or learning targets [when designing an activity].” Craig relied on 26-years of teaching experience and knowledge of technology tools when designing activities. He said, “[what] inspired me about VR was that it had the potential to be so interactive and experiential.” From there, he designed a stimulating learning environment that used a variety of other technology tools.

Prior to implementing VR, participants anticipated high levels of student reactions. They also knew the probability of encountering technical complications was high. Teachers had to find the balance with time limitations, the number of students, and a limited supply of headsets. They engaged supervisory experience to monitor learning and were quick to change instructional direction. They became observant and adaptable. They provided tech support while also reminding students to stay on task. Some teachers observed student reactions and engaged students’ deeper thinking using high-level prompts.

Another means for adapting pedagogical approaches occurred when teachers experimented with learning activities. This method allowed for organic developments in the learning process. Teachers supplied the headsets along with a variety of immersive applications to try and then observed what happened next. This spontaneous approach allowed students to pursue experiences based on personal preference and natural tendencies. For example, Dani taped a paper “playlist” comprised of QR codes with various 360-degree videos onto each student’s tabletop. The QR codes linked to different immersive experiences. Dani understood the easiest method for students to access different links rather than other alternatives like manually typing the link or accessing from another tool. Students selected which experiences to pursue from the menu. Once students became immersed, she walked around and checked to see if headsets fitted properly and comfortably to ensure a successful experience. During immersive activities, she continued to walk around the room and inquired about what they saw. After a few minutes, she instructed them to remove headsets and supplied reflective questions based on their experiences. Students connected literature with the 360-degree videos and applied this new knowledge.

Another example that exemplified the development of an instructional plan involved Les teaching literature using VR. He quickly determined that initial plans required modification after students became immersed for the first time. He felt that he provided adequate forewarning and allowance for the activity but learned that once students became immersed for the first time, those plans proved to be unsuccessful. He allotted seven minutes for students to tour the immersive environment and anticipated this would have given students enough time to complete the activity. However, students became over-stimulated to the point they had forgotten prompts and became focused on the experience. From that introductory activity, Les observed the reactions which resulted in changing an instructional adjustment. Moving forward, Les provided time for an introductory experience for seven minutes. This additional time provided an opportunity for students to become familiarized with the immersive environment. After a exploratory immersive experience, students removed headsets, and Les formally introduced the learning activity.

Teachers created well-intended strategies for the delivery of content but plans often changed. They anticipated and considered possible interruptions but knew they would have to adapt. Teachers realized they could not "force" well-thought, pre-planned activities that may not work. Instead, they observed student reactions and adapted to circumstances. This level of understanding, along with receiving student feedback, resulted in the identification of new, modified pedagogical approaches. For "traditional" teachers, even the consideration of unanticipated actions like this might be too much risk for them to consider this type of methodology.

The loss of instructional control became evident for some teachers when they implemented VR. For "traditional" teachers, this could have been major barrier for them to want to pursue new technologies with students. For example, teachers could not view what students experienced on their headsets, nor could they control where students looked. Following natural tendencies resulted in different user experiences. Teachers had to anticipate the possibility of these unexpected results. For those teachers who require complete instructional control, this element could be a "deal breaker." Otherwise, adaptable teachers could exploit this aspect and focus on new learning opportunities and further extrapolate the differences.

For example, Sally observed students experiencing different encounters while using the same application. Sally had assumed that each student would observe the same encounter, which they had not. This provided new knowledge and understanding, so she adapted and viewed the opportunity to have broader class discussions that highlighted the differences. Similarly, Dani observed students in the same 360-degree program and learned some students only looked in one direction and had missed the other half of the experience. She capitalized on this opportunity for students to share differences with each other. Students became storytellers from their unique experiences. Dani did not have a mindset that feared lack of instructional control, rather one that embraced unexpected behaviors—a risk that some teachers may not be willing to consider.

Willingness to Embrace Student Input

David acknowledged and highlighted that he did not grasp the intricacies or nuances with computer processors but knew he could engage students for those details. David had previously designed new courses by himself and understood the process but sought student input. Their contributions helped to influence decisions along with problem solving. David saw value with including students, which unleashed opportunities for new learning. This approach falls under the PK section of TPACK (Mishra & Koehler, 2006). He realized by giving students ownership with decision-making processes, they became stakeholders, whether the course would be successful or not. This level of instructional aptitude demonstrates a complete understanding of optimal learning conditions. David realized his digital-native students brought expertise and might have willingness and aptitude to assist in the process. He explained the vision, but not necessarily how to get there. He relied on his years of experience and problem-solving capabilities to start the process to acquire some headsets. David possessed an open mind and a willingness to expect the unexpected in the development of this course.

Similarly, Craig described looking for new tools when he stumbled across VR. He said, “I was really looking for something like that [VR].” He had expertise of the technology tool landscape with other computer-based simulations but acknowledged that nothing came close to what VR provided. With technological understanding, he said, “[H]aving that in the back of my head, I was armed with looking at a lot of these [VR programs].” He concluded after trying VR, “I was just excited to understand and learn more about the potential that VR has in learning because it was so believable.” Craig did not require concrete examples of VR applications to demonstrate impact within a learning environment. Instead, he saw potential and had a willingness to make this technology operational. He instinctively knew his students would also become inspired with this new tool and make an impact on their learning –different from past learning activities.

Adapting Classroom Practices

Participants realized bringing in this new tool would change instructional methodologies. Teachers planned and predicted student actions prior to allowing them access to the tool. This factor falls under PK of TPACK (Mishra & Koehler, 2006). Participants no longer provided traditional, teacher-led instruction from the front of the classroom with students sitting in desks throughout the room. Instead, they facilitated different learning strategies and adapted to the changing environment.

Participants strategized the implementation process to ensure success by changing instructional delivery models. For example, Craig described the method as a “circus act,” where he “juggled” the responsibilities to facilitate learning and provided individual coaching sessions. Similarly, Jeanie introduced lessons and created a rotation system that allowed students to cycle through the VR equipment. This system allowed her to move throughout the classroom. Jeanie provided individual support while others waited to use VR. She also employed teaching assistants in the nearby hallway to facilitate others while they used the equipment.

Similarly, Tomi viewed VR activities to be an incentive within the classroom. When approximately 35 students completed various tasks, they earned an opportunity to use the equipment. This reward system required additional monitoring because students needed verification that they completed previous assignments prior to accessing the equipment. Tomi explained the tendency of students who needed reminders to complete assignments rather than going directly to the VR station. From a classroom management perspective, this undertaking required multi-tasking and organization.

Craig described the various design aspects of his learning environments as "pieces of a puzzle" that intricately fit together to complete. Similarly, when David designed his standalone VR course, he considered himself a project manager and tasked the students with various aspects of instructional design throughout the planning phases. Rather than complete all tasks during the creation stages of a new course, he involved students through this process. Relinquishment of traditional teaching practices exemplified all three components of TPACK—Technology, Pedagogical and Content Knowledge (Mishra & Koehler, 2006) —but in a safe, protected fashion.

Risks Involved

Joe demonstrated PK when students experienced technical difficulties and did not have other available headsets. Instead he used an iPad and presented the same experience onto a large screen. This ensured students could still fulfill learning experiences and not be impacted by technical issues. Joe relied on technical expertise to solve problems without elevating the unplanned incident.

Teachers explained instances when students used VR and onlookers presumed learning conditions might not to be legitimate. From afar, they observed students wearing a headset and, at times, laughing. They assumed students had been playing games and not learning. To combat concerns and observations, teachers saw this opportunity to inform and engage in conversations to quell misinformation. In one instance, Joe explained how an administrator made this assumption. Magana (2017) explained the difficulty for administrators to gauge accuracy with teachers' technical knowledge. However, after a conversation with the administrator, and their own immersive experience, the assumption changed to that of an advocate for the tool. Efforts like this example demonstrate the necessity to advocate for the tool and expand access to all levels of stakeholders—while simultaneously managing other professional responsibilities like student safety.

Safety First

The potential risk for students to become dizzy or unintentionally collide into each other and/or objects necessitated that teachers ensure student safety. This falls under "Pedagogical and Content Knowledge" (PCK) of TPACK (Mishra & Koehler, 2006). For example, Tom, David, and Jeanie used other student leaders to assist in monitoring the areas around the headsets so immersed students would not injure themselves. Craig labeled the student safety helper, "the spotter." Teachers also mentioned these safety protocols aided in protecting the immersed students who did not have the ability to see immediate surroundings. These added safety measures provided enhanced support for students when needed.

Teachers also established individualized guidelines (specific to their learning environment) for students to follow. For example, Dani established a rule where students could not be photographed or recorded while immersed without their prior knowledge and permission. This safeguarded students' online persona while immersed and vulnerable. She also did not allow students to physically interact with each other while immersed.

Next, teachers shared concerns about having students immersed for extended periods of time, so they created time limitations. The initial rationale existed for equitable purposes to ensure each student received equal opportunities to be immersed. Each teacher established a timeframe that limited the amount of immersive time. Bailenson (2018) recommended a “less is more” mentality with VR activities, to limit immersive experiences between 5-10 minutes (p. 258). However, many participants noted student enthusiasm to continue beyond their time limit, but teachers enforced strict time restrictions. Otherwise, allowing additional time would have impacted other instructional plans later in class. These decisions had been made often in the moment and the teacher weighed future consequences to determine the best use of time –after they obtained administrative approval.

Seeking Permission

Teachers sought permission prior to the adoption of VR and could not attempt this endeavor alone. In a few instances, teachers facilitated exploratory immersive activities with school administrators to gain approval—and in some cases, set a “hook” to secure permission (PCK). Other teachers proposed innovative ideas to district level committees for consideration. For example, prior to launching VR in the district, Chrissy explained complications when selecting which headset to purchase, either Oculus or HTC. She explained one aspect that caused confusion to gain approval from district level administration when considering Oculus’ age recommendation. She explained the source of concern when analyzing the details of legal guidelines regarding age restrictions for some headsets:

> This random non-research, non-medical research supported a 13-year-old recommendation. And coincidentally, you have to be 13 to get a Facebook account. And coincidentally, VR is not safe for kids under 13 for our recommendation, however “we” sell [VR] apps specifically rated “E” for everyone specifically rated 10 and up.

Chrissy detailed some challenges with the Oculus recommendation. Inconsistent verbiage prompted one district administrator to nearly shut down the proposal due to the Oculus study and limited restrictions to users aged 13 and above. However, Chrissy continued to analyze Oculus' age-recommendation study. She explained to the administrator, "They straight-up said there's no data to back-up this random age recommendation." She further explained to the administrator how the data could have been mis-represented by Facebook which prompted a pause for consideration. The confusion with age recommendations for Oculus caused the district to select HTC Vive equipment, which did not provide specific age recommendations.

However, this process prompted Chrissy to require all students submit a completed consent form prior to accessing equipment. Without a completed consent form, they would not be able to use headsets. This consent form provided acknowledgment that VR activities might cause potential safety concerns. However, Chrissy provided alternatives for students who did not return completed forms. These barriers further complicated the process to launch VR in the classroom.

After receiving approval, participants pursued various funding sources to obtain equipment. Some teachers formed partnerships with technology departments to ensure they purchased appropriate peripheral equipment. This essential partnership ensured devices functioned within school network infrastructures which may have otherwise blocked unique devices like VR headsets. Most organizations require an authentication to access network functionality which limits the possibility of misuse or damage to the infrastructure.

For example, Sally worked with network specialists to ensure devices connected to the network without disrupting other Internet users in the building. Additionally, Jeanie collaborated with network specialists to access the gaming webstore Steam. Without authorization, Steam would have otherwise been blocked in the school setting. Jeanie explained that most gaming websites had been blocked for students and staff unless otherwise cleared. Once teachers gained approval and authorization from the district, they turned their attention to other stakeholders who would be impacted by this venture. Without permission or awareness of potential concerns to student learning, teachers may have encountered issues.

Teachers also realized once the tool became operational, the next step involved securing consent from parents and guardians. Participants wanted to provide better understanding and explain VR and how it would be used in class. They communicated home with a brief overview of the tool. For others, it involved welcoming families into the classroom to experience VR firsthand. Teachers who took these steps experienced tremendous support from families.

For example, Randy faced initial scrutiny when implementing VR. He explained that parents considered this tool “too advanced.” He experienced success after meeting with individual parents and show them the tool firsthand. He explained, “Believe me when we do [that], we get a ripple effect such that it was the parents to proselytize to use the VR boxes. Our kids need these VR boxes.” Some parents also inquired about purchasing a headset for home. Their firsthand experience changed perceptions compared to initial reactions from the explanation.

Similarly, Keith found success after hosting nightly events throughout the school year. These events strengthened family partnerships and boosted public relations accessibility. These events broadened understanding of classroom practices while getting access to the tool. Whether these teachers learned this partnership model from others or developed the practice instinctively on their own, they laid a successful foundation with these promotional efforts.

These endeavors reveal significant commitment beyond traditional teacher expectations to provide VR access to their students. These safety practices had been self-generated due to the lack of national guidelines or recommendations. Teachers put thoughtful efforts to ensure successful implementation. They developed innovative experiences that fit within guidelines now that they had received authorization to have students use VR.

Pioneers in Virtual Reality Education

One might label these participants as "pioneers" because of how they created innovative VR learning practices. This idea corresponded with PK of TPACK (Mishra & Koehler, 2006). Teachers experimented with various aspects of technology and instructional approaches. Once participants became familiarized with VR, they created instructional systems for students. However, this also relates to TK of TPACK (Mishra & Koehler, 2006). where teachers specifically understood capabilities of VR. They used VR to aid with instructional delivery of content—not serve as a surrogate for the teacher.

Teachers realized the tool did not replace their role in the classroom. They understood it had a place in their instructional technology "toolbox." They considered implementation as an alternative method to deliver content. However, to ensure success, they needed to find optimal experiences for upcoming learning goals. The common complaint for participants included the lack of adequate applications within education sections of VR webstores. However, to find success, participants needed to be creative to make connections with content.

Participants searched the "education" categories of Oculus and Steam webstores but available applications paled in comparison compared to other categories like entertainment or gaming. For example, Chrissy acknowledged that other VR teachers complained about the lack of immersive activities. However, she pushed back and provided a different perspective. She said teachers needed to be more creative to identify and establish learning connections. Through this development process, it became apparent they had begun taking steps in becoming a pioneer in

VR education. They realized that to find success, they needed to survey the landscape and determine how to make connections unique to their circumstance.

For example, some teachers used pre-existing immersive applications to connect specific learning activities while others retrofitted applications to meld activities. This falls under "Content Knowledge" (CK) section of TPACK (Mishra & Koehler, 2006). For example, Dani found 360-degree videos related to wartime literature covered in class. The application replicated experiences of soldiers in a trench and Dani linked to the reading activity. Luckily, Dani did not need to extend far to connect the immersive experience with the lesson in this instance.

Similarly, Sally discovered 360-degree videos intended for stress relief but found a way to connect to assist students with building vocabulary skills. Sally analyzed this application and created a process for students to apply new vocabulary terms. In both examples, each identified an application that connected learning targets. This required extra effort and inspiration to make curricular connections because the VR landscape did not provide content-specific experiences.

Origins for Inspiration

The origination for participants began with the desire to blend VR with areas of expertise. This approach connects with CK of TPACK (Mishra & Koehler, 2006). In two instances, Dani and Les had a deep personal passion for their content area and the desire to pass onto students. Dani participated in historical reenactments and Les had repeatedly read Sherlock Holmes novels. However, both teachers realized many students did not share similar sentiments towards content but hoped VR could change perceptions. Dani and Les taught for many years and observed some students struggle or disengage with the activities. They considered VR to be a tool that brought novelty and different perspectives traditional teaching and learning did not provide. They viewed VR as a possible gateway that might spark interest. Through immersive activities, their students could experience and connect to the content.

Similarly, David felt a connection to his students and interests. He realized experiences and engagement decreased over time from kindergarten through high school. He wanted to see if he could interrupt that belief. Up until that point, he had not used VR but after reading an article that demonstrated the capabilities, he brainstormed some possibilities with some nearby students. As a big thinker, he thought of the idea to empower students in the development of a new VR course where they would have creative control. The VR class would be the "vehicle" for creating new learning opportunities. In a few instances, David became reliant on student expertise in areas where he knew they presented pre-existing knowledge: a demonstration of humility and leadership.

Instructional Leaders

Each participant analyzed and identified how and where to implement VR within their curriculum (CK) and make changes when necessary. They felt comfortable altering instructional methods if it improved student learning because of their familiarity with the curriculum. For example, some participants had the ability to distinguish the appropriate periods to deploy VR in class. For others, it took time to discover optimal times and conditions to use VR. For instance, Tomi taught math and had interest with instructional technology. Tomi described herself as "a gamer," which led to teaching a math lesson in a VR game. This random incident while at home occurred after noticing whiteboard markers in a game. She grabbed a marker and attempted to try to write on a nearby window. In that moment, Tomi realized potential learning capabilities of this game.

Tomi instinctively knew the topic of upcoming learning activities, so she started to record gameplay in that moment—from the comforts of her home. She started simulating the lesson knowing students would watch in the future. She combined the instructional understanding of the upcoming lesson with the capabilities of the video game. Tomi realized that this experience might connect with learners and present a novel way to teach a new concept.

Les understood the high stakes with literature students before they took annual competency exams. He also recognized the difficulties with teaching specific concepts and students making connections to literature. Les identified the most difficult concepts to teach and incorporated VR into lessons through the creation of immersive, problem-based simulations based on Sherlock Holmes novels. He explained the limited availability with a VR application that did not provide meet the needs of the class, so he designed custom experiences.

Les created VR simulations that directed students using prompts. They traveled through immersive environments that connected various features of reading assignments. His thorough understanding of content and expectations for student achievement drove him to design optimal learning experiences for students. After experiencing these activities, students had a better understanding of storylines and connected themes with the characters. Les blended technology, pedagogy, and content knowledge in this activity which verified understanding and support of immersive learning and demonstrated leadership. Les designed learning activities that resulted in students meeting learning goals by solving problems in a custom learning environment.

Participants distinguished themselves as effective teachers whether they knew it or not. They did not seek notoriety or approval within the VR education community. Instead, they sought ways to help their learners. Teachers obtained this level of expertise from a blend of ambition and personal inspiration that guided them; all participants shared aspects of their journey on social media.

Participants viewed VR to be another "tool" in the instructional toolbox. None of the teachers explicitly documented the exact amount of planning time or the steps to establish VR in the classroom. Through the learning process, they each realized the best way for students to use VR in class. For example, students used headsets in "short bursts," meaning that instructors regulated the time when students became immersed.

Teachers weighed learning goals when compared with the time commitment of the VR activity. Through this process, teachers individually developed a system of classroom practices that fit within the curriculum and daily schedule. This allowed teachers to use the tool for student learning in an effective manner. Over time, teachers continued to modify instructional approaches with hopes of making it better.

Participants demonstrated an artful blending of content, transformative pedagogy, and immersive learning. The analysis of the TPACK model (Mishra & Koehler, 2006) reinforced the legitimacy and effectiveness of the participants. Teachers relied on their past experiences to develop effective activities with an open mindset. This process required an evolving mentality, spontaneous change to pedagogical methods, and a willingness to enhance skillsets to successfully implement this tool. Many of these traits also directly relate to Dewey's (1923) theories on experiential learning. I considered other instructional technology frameworks for this study, TPACK (Mishra & Koehler, 2006) provided the optimal selection.

Summary

Participants inadvertently fused Dewey's (1923) experiential learning theories along with the TPACK framework (Mishra & Koehler, 2006). They reflected on the initial reaction to VR and sought ways to generate those emotions back in their classroom. Participants embraced experiential learning and innovation—even with risks involved. Successful VR implementation required additional efforts above and beyond traditional teacher obligations.

Teachers analyzed the VR landscape and selected optimal conditions—to make learning better. Participants sought ways to increase engagement and allow students to connect previous knowledge with new content. Teachers forfeited past instructional practices to adapt to their students and implement new methodologies, often without warning. This intuitive approach provided optimal learning conditions - something that traditional pedagogies do not always offer. Participants embraced transformational teaching and learning, leading to higher levels of student engagement based on novelty and the value of learning. By participating in this study, teachers shared a willingness to tell their story for the next generation of VR educators.

Changes to instructional approaches did not happen spontaneously. Innovative teachers explored modern technologies to incorporate in classrooms to prepare students entering the global economy (Van der Heijden et al., 2015). For example, Tham et al. (2018) predicted communication professionals will use VR in future workplaces. If this prediction proves to be accurate, more educators will need to expose students to this type of technology by using effective pedagogical approaches. Teachers need to acknowledge instructional practices will change and require revisions.

When implementing VR, teachers need to possess a strong pedagogical understanding of the curriculum. This proved challenging when shifting from a traditional teacher-led instructional model to a student-centered approach to learning - something which proved difficult for some new teachers (Englund, 2017). Teachers regarded VR to be another tool in their instructional toolbox that required additional planning time and effort and questioned the added value it brings to the classroom (Stojšić et al., 2019). Ren et al. (2015) acknowledged the positive impact on student learning when incorporating VR but insisted on blending other instructional strategies to produce the best learning outcomes. Ultimately, this transformational shift (of bringing VR into the classroom) impacted teacher pedagogical approaches and philosophies. In the last chapter, I summarize the study, discuss implications of my findings, and recommend areas for future studies.

CHAPTER SIX: SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

Because of the rapid changes in technology, studies like mine will likely be generated forever. My focus involved analyzing how and why innovative educators used virtual reality. My study plays a key role in my field because the early use of any innovative technology requires a period of experimentation and instructional transformation. My study found promising practices and new or innovative pedagogical approaches after incorporating VR in the classroom.

I investigated how 15 pioneering K-12 educators use virtual reality for student learning. Because VR is a relatively new technology, teachers may not want to modify instructional methodologies for fears of losing control (Kluge & Riley, 2008). My purpose involved investigating how active VR educators modified and adapted VR technology for various disciplinary purposes. I adopted a qualitative methodology and a case study approach to conduct my study and interviewed participants from five different continents to learn more about their practices from across the globe. Locating the participants required a creative approach; I described the methods for recruiting participants in Chapter Three. Most educators who responded to my call to participate made the commitment to continue.

I soon learned participants' commitment to adopting a new technology showed a passion for students learning and a desire share the exciting experience of using VR with their students. They adopted this new technology to enhance learning and keep the students engaged and generate excitement for their content. I collected and analyzed data, identifying the common themes emerging from the data. I ultimately identified four major themes, including: (1) Exploring to VR; (2) acquiring funding; (3) preparations; and (4) three levels of implementation. Exploring VR refers to the initial discovery of the technology, the spark of excitement with the first use, and the decision to go forward with trying to bring this technology home to their students. Acquiring funding proved quite difficult for most. Teachers wrote grants, sought donations, made budget requests, and more.

Perhaps the most difficult phase involved implementing VR for student learning. This involved creating a structure for student learning and adapting the structure based on student needs and ongoing challenges. Implementation also required curriculum design and instructor flexibility to ensure they met the needs of students based on their instructional plan and management concerns. For example, some teachers might ask two or three students to share one headset—a logistical nightmare! Teacher planning revealed teachers used their knowledge and creativity to make curriculum and plan learning activities. The TPACK model (Mishra & Koehler, 2006) justified, for the most part, the design process followed this model, even though teachers did not necessarily refer to it.

A fascinating discovery involved the dominant educational philosophy of VR teachers; surprisingly, their philosophy matched Dewey's (1923) theory of experiential and project-based learning. Adopting this philosophy means a decided shift in teacher-student roles. The teacher served as a coach and guide and not as a lecturer with information to share. My research study explored the journey of 15 participants, and the lessons learned from their experience. The findings may affect educational practice going forward. In the next section, I describe the implications of this study and recommend educational practices to move the field forward. After describing the implication theme by theme, I then conclude this chapter with recommendations for further studies based on the questions raised by my study and my analysis of the unanswered from the literature review.

Implications

Explorations

Multiple factors (see Figure 11) must be considered prior to implementing VR in schools. Teachers most often gain exposure with VR through professional development conferences. Teachers need hands-on experiences with quality, immersive experiences to understand limitations and capacities. I found teachers required a "spark" of excitement from initial discovery to bring VR into the classroom. Those lasting impressions will create an influx of ideas to ponder future possibilities. Professional learning networks (PLNs) also offer additional resources and support systems. Teachers should consider participating in professional associations and online professional learning networks to engage with other content-related educators. They can learn from other educational leaders and interact in real-time global collaborations.

Figure 11

Implications to Consider

Note. *The steps to consider prior to implementing VR.*

School districts should invest in innovation and support inspired teachers. For example, districts should fund pilot teacher-sponsored projects to examine new tools and practices. Teachers seeking opportunities to revolutionize instruction need to be supported, not ignored. When they submit requests to pursue professional development, administrators should make reasonable attempts to approve them. Validation of those efforts demonstrate a willingness to endorse. These teachers identified a need and took the necessary steps to seek permission to pursue and districts should embrace these types of innovation.

Incorporating VR into the classroom involves commitment. This decision commands an understanding of the learning potential along with an awareness of liabilities. Teachers need to understand the susceptibility of risk involved with pursuing VR—even without knowing possible impact. This requires operating above and beyond professional obligations to learn more about optimal implementation.

Teachers saw value with learning through experiences, which VR provided. However, they should look beyond the initial novelty of this tool. Teachers need a strong understanding of curriculum and a willingness to creatively find ways to blend it with instruction—even without previous experience. An open mind and ambition aid navigation of the various stages of implementation.

Acquiring Funds

Teachers need to be aware of available funding sources. However, this indicates the additional efforts on the journey of implementation. Participants should devise creative means to obtain funding. Traditionally, most teachers access limited funds for consumable materials but not high costs items. Instead, for those out-of-reach projects, districts should find ways to support those ideas. Exploration beyond their school budget and inquiry with district level technology department or teaching and learning department should be considered.

Some districts partner with philanthropic organizations to support various initiatives. For example, traditionally, athletics align with parent booster organizations that raise funds to offset costs. These parent/teacher organizations (PTO) solicit memberships from families and support various initiatives within the school. These organizations may be a possible avenue for teachers to pursue additional funding.

Another option involves crowdsourcing websites, like “Donor’s Choose.” These campaigns can be shared with friends, families, or anonymous users on the Internet. Teachers should research how other teachers have used this website and inquire with their district business department to seek approval prior to launching crowdsourcing campaigns.

Teachers often overlook the availability of various types of grants: local, state, or national. Often, many grants align with innovative ideas or proposed projects. Districts lack support systems for teachers pursuing grants. Instead, they should emulate practices at higher level institutions that aid in researching available grants and providing assistance with applications. If awarded, recipients should remember that acknowledgements and gestures of appreciation are essential.

Fundraising in the digital age provides a significantly different pathway than the traditional practice of venturing door-to-door. Teachers should consider exploring this domain with district approval. Past practices, understanding limitations, and acknowledging competition with other organizations may prove to be detrimental. However, teachers can create “wish lists” from online marketplaces for parents to donate. Additionally, some resourceful teachers have turned to social media and requested popular users to repost their supply list. They hope the person shares their wish list link to expand the reach and generosity of Internet users.

Lastly, teachers may have the ability to provide insight with district-level budget processes. Districts often do not provide high levels of transparency with these types of stakeholders. Traditionally, budget decisions and practices typically occur at the district level without the input of teachers because of instructional responsibilities. Perhaps teachers can better understand the priorities of their school or district by analyzing and contributing their voice to the allocation of funds. This would allow teachers to better understand the processes and potentially offer guidance from a granular, classroom perspective.

Preparations

Participants revealed the nuances pertaining to implementation of VR. One might understand that teachers already have a substantial workload trying to get through daily activities even without employing innovative instructional practices. Bringing new technologies into the classroom requires additional effort and creativity. Teachers contemplating implementing VR need high capacities and aptitude for technology tools. They need to be ambitious and acknowledge the unknown possibilities of implementing a new learning tool.

New VR teachers should be prepared to face scrutiny or resistance. These situations are opportunities to inform. To counteract these concerns, open house events yielded positive impact. Teachers should host special events after school hours to quell misnomers and create allies. Rather than navigating innovative classroom activities alone, partnerships with families proved to be an easy solution. If resistance continues, research-backed articles may help to justify the benefits of VR and learning. Teachers need to prove adequate safety measures have been established. However, if they still encounter opposition from families, teachers should acknowledge and respect their decision. In lieu of VR activities, alternative arrangements must be provided without penalty or repercussions.

Teachers pursuing VR need access to dependable infrastructure and be able to generate partnerships. High-speed Internet and accessibility to resources proved to be essential components of implementation. Teachers need a general understanding of the school network and obtain permissions to access specialty software. For the high-end headsets, teachers will likely need access to the gaming webstore STEAM, which may be blocked on school networks due to disruptive capabilities. Additionally, for lower-cost headsets, the impact of having a classroom set of smartphones accessing wireless access points will generate additional traffic on the network.

Whether teachers used low or high-end headsets, each presented different responsibilities and managerial requirements. Teachers cannot pursue this endeavor alone. Instructional coaches should be available to collaborate and problem-solve issues. Those types of supports help to alleviate unanticipated strains on teachers which, in turn, allows them to focus on students.

Implementing innovative practices into the classroom included the following insights. One, teachers attempted to stay relevant with making connections to real-world experiences. Teachers should prepare students for upcoming assessments or even possible career trajectories while blending their curriculum with VR. Two, they wanted to integrate skill-building activities into curricular activities that enhanced foundational understandings relevant to the course. The teacher should identify a problem-solving game and find connections with learning targets. Three, it seemed that teachers became bored with traditional instructional practices and viewed VR to be another tool to increase engagement. The realization that they can teach digitally native students should encourage new approaches for learning. Four, participants met students at their level while they introduced cutting-edge tools with the curriculum and learned alongside. Virtual reality provides opportunities to connect students with past experiences while navigating immersive activities. And, finally, five, teachers anticipated the unknown. Spontaneity provides opportunities for new learning. Rather than retreat from issues, teachers should pivot and incorporate those missteps into problem-solving experiences.

Participants developed procedural accommodations for their headsets. Minimizing access and limiting headset availability reduced depreciation. The consideration of using trusted student helpers to retrieve and distribute headsets decreased the likelihood of accidental damages. Classroom learning environments and the type and quantities of headsets determined these practices. Low-end headsets did not require significant storage space; however, teachers should provide adequate space for students to stand up and turn their head while immersed. Conversely, high-end headsets traditionally required a dedicated space for the computer processor and sensors placed away from obstacles. Most VR manufacturers recommend dedicating a space of at least 6 feet by 6 feet. If possible, designated VR spaces do not require continual set-up and tear-down after each use. Newer headsets like the Oculus Quest or HTC Vive Focus eliminate a tether and the necessity of a dedicated space.

Participants relied on previous experiences to predict how to deploy VR learning. Dewey (1923) explained teachers use “powers to transform” environments and provide new stimuli which results in development (p. 38). However, each participant understood using VR in class would not be sustainable by handing out headsets without any introduction or background knowledge. Establishing protocols and expectations for appropriate use differs from teacher to teacher. Crafting lessons differs based on type of headsets, content, number of students, and time constraints.

Teachers determined expectations and practices while implementing VR in class. One successful collaborative activity involved pairing students together for learning activities. One student will be the “eyes” and “ears” for the immersed student. They will notify the other student of possible hazards or may assist with cord management, if applicable. Establishing digital expectations protects immersed students from unapproved photos or video recording. Teachers need to explain the rationale for this type of protection and be relentless in upholding these practices.

Conversely, teachers should realize that “digitally native” students can offer tech support. These “assets” often demonstrate a willingness to help others even without direct supervision; an implication that may have previously gone undetected to some. Misinterpretation of student assistance might be viewed as an infringement against instructional authority. However, past classroom experiences provide better contextual understandings to welcome these supports rather than to fend them off.

Teachers should also understand when to step back and allow the tool to govern. Relinquishing themselves to a facilitator role rather than the sole provider of information is necessary. Instead, teachers need to balance supervisory obligations with immersive guidance. Student behavior generates feedback through comments and expressions. Student reactions should dictate where they go and what comes next.

The management of learning when students use VR becomes significantly different than traditional methodologies. Previous experience with VR and applications assisted with navigating problems. Teachers should consider themselves to be a restaurant server, ensuring that each student leaves feeling satisfied. Establishing classroom expectations prior to handing out headsets ensure that students understand the learning goals of the activity.

Energetic student reactions will likely intensify beyond traditional noise levels. Feasible enhancement of learning experiences included dimming classroom lights and playing background sound effects. Teachers need to move around the classroom and periodically check-in with students during immersion. Prompting higher level questions during immersion will cause students to think critically and might connect with the learning target. Those audible cues might generate and precipitate proficiency.

Students should reflect and apply new ideas immediately after immersion. Teachers should find varying ways to have students connect to content and the learning targets. Comparisons from experiences through collaborative dialogue allow students to learn from others rather than from the teacher. From there, an example of higher-level thinking includes asking students to predict what might happen next in that immersive environment. Teachers might also challenge students to brainstorm ways to come up with designing a better immersive experience from what they just observed.

Balancing instruction with immersion is critical. Teachers should understand that this tool did not solve every issue with teaching and learning. Oversaturation causes deficiency; students will become bored if provided too much time with VR. To counteract this issue, teachers should intentionally leave students with the impressions of wanting more. These "short bursts" generate optimal learning conditions that, in turn, enhance other instructional methods. However, to obtain high levels of proficiency, teachers often encounter impediments.

Teachers should also plan for worst-case scenarios. For example, but not limited to, they should anticipate headsets not turning on, disagreements on the first person to use the headset, and not being able to access the application. Natural educator instincts help drive decisions when to halt VR lessons and readily accessible, non-VR activities ensure optimal use of instructional time.

Virtual reality does not replace the teacher. Instead, the tool provides brief experiences that bolster other instructional practices. At the end of the immersive activities, adequate time for clean-up ensures opportunities for closure routines. For example, using exit tickets provides evidence of learning from the experience. Additionally, another important closing task involves preparing headsets for the next users.

In the Covid-19 era, schools must provide cleaning solutions, disinfectant sprays, or alcohol wipes to wipe down headsets before, during, and after each use. Lenses will likely become smeared with fingerprints so teachers should consider having microfiber cloths available. Teachers may also want to consider purchasing disposable VR face covers, depending on the type of headsets. Necessary hygienic practices from this pandemic may prompt teachers to continue this procedure into the future.

Implementation

Teachers created a system to a path of least resistance to communicate the steps of a VR lesson before students become immersed. Given the complexities involved with immersive, haptic controls, and a new 3-D environment chalk-full of stimulants, this proved to be a difficult task. Participants found that VR learning brought increased engagement. However, the range of learning experiences became dependent on the quality of headsets.

Low-cost headsets provided a sense of immersion and novelty to learning concepts that students would not otherwise experience. However, lower cost headsets did not provide opportunities to create or solve complex problems. Conversely, the highest levels of learning meant students produced immersive content and interacted with virtual surroundings. Due to the challenges of procuring pricier headsets, the scalability of that latter option proved not to be an option for all.

Low-cost headsets provided an entry point to use VR for participants with a minimal budget. Today, most 6-12 grade students carry a smartphone. All K-12 teachers should consider keeping a few low-cost headsets on hand to be used in instances when students need breaks or need a behavioral "reset." A recent search on a popular e-commerce store provided many VR cardboard headsets options to purchase for less than $10 (US). Compared to higher end headsets that provide enhanced experiences, less-expensive headsets surpass traditional learning activities and students may appreciate the opportunity. For example, a few participants found success for some students in crisis through the uses of calming applications. Creative ventures like this demonstrate some of the endless possibilities from this learning tool.

Higher quality headsets provide better learning experiences. They also require more work to acquire headsets and increased difficulty to manage. However, teachers should gain exposure to both levels of headsets to better understand the differences of materials but also the quality of experiences and learning potential. Some sort of acknowledgement of the anticipated ownership costs and a comprehension of the efforts are necessary before pursuing.

One method to inform includes exposure to case studies from VR teachers in various educational settings. These case studies may provide recommendations for navigating those possible implications. Interested teachers pursuing VR should have easy access to see other teachers using the tool and have opportunities to engage with these experts. Virtual reality educators, like these participants, not only demonstrated a willingness to revolutionize their classroom on behalf of their students but also illustrated a commitment expand the VR movement.

Recommendations for Further Research

Further research regarding VR and education should be considered for many reasons. First, the complexities of the Covid-19 pandemic and distance learning demonstrated disparities with video conference instruction. A pilot study comparing the impact between VR learning and video conferences in a distance learning situation should be explored. Further, the exploration of determining optimal instructional approaches with VR in a distance learning context might lead to new insights and possible expansion.

Second, new headsets will continue to become available on the marketplace which should lead to increased access. To grow this movement, VR manufacturers should create turn-key classroom sets for teachers from around the globe to pilot research-backed curricula. Outcomes from this cohort could provide insights for implementation on a larger scale and increase the presence of VR in education. The results of these efforts should be studied.

Third, researchers should investigate all content areas of K-12 education to identify optimal pedagogical approaches and conditions. Larger sample sizes, distinctions between elementary and secondary levels, different data collection methods, and varying global circumstances should be explored. Given the complexities with this ever-changing technology, the foci should be on instructional practices and not with specific hardware. Opportunities to study VR with education may only be in the infancy stages with much more to discover.

Acknowledgements

This study uncovered many new understandings. I appreciated the opportunity to interview VR-teacher pioneers to learn about their practices. They reignited my enthusiasm as an educator. I genuinely admire their accomplishments. Participants demonstrated generosity, authenticity, and a willingness to contribute to the continued growth of this movement. The

future of education is in good hands with teachers (like the participants) who are willing to surpass traditional methodologies. My hope is that other educators will learn from this study and consider exploring the requisite measures (see Appendix D) to implement VR.

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Appendix A: IRB Approval

UNIVERSITY OF
St.Thomas

All for the Common Good™

Date: March 27, 2020

To: Timothy Berndt

From: Sarah Muenster-Blakley, Institutional Review Board

Project Title: [1583053-1] How do pioneering K-12 educators use Virtual Reality for student learning?

Reference: New Project — Action: Project Approved

Approval Date: March 27, 2020 — Expiration: March 26, 2021

Dear Timothy:

I have reviewed your protocol and approved your project as reflected in the application that you submitted. Please note that all research conducted with this project title must be done in accordance with this approved submission.

Please remember that informed consent is a process beginning with a description of the project and assurance that the project is understood by the participants and their signing of the approved consent form. The informed consent process must continue throughout the project via a dialogue between you and your research participants. Federal law requires that each person participating in this study receive a copy of the consent form. All original records relating to participant consent must be retained for a minimum of three years upon completion of the project.

Amendments to targeted participants, risk level, recruitment, research procedures, or the consent process as approved by the IRB must be reviewed and approved by the IRB prior to implementing changes to the research study. No changes may be made without IRB approval *except* to eliminate apparent immediate hazards to the participant.

Any problems involving project participants or others must be reported to the IRB within one (1) business day of the principal investigator's knowledge of the problem. A problem reporting form is available in the IRBNet Document Library or on the IRB website and should be submitted to muen0526@stthomas.edu. Any non-compliance or complaints relating to the project must be reported immediately.

Approval to work with human participants with this project will expire on **March 26, 2021**. Please direct questions at any time to Sarah Muenster-Blakley at (651) 962-6035 or muen0526@stthomas.edu. I wish you success with your project!

Sincerely,

Sarah Muenster Blakley

Sarah Muenster-Blakley, M.A., CIP
Chair, Institutional Review Board

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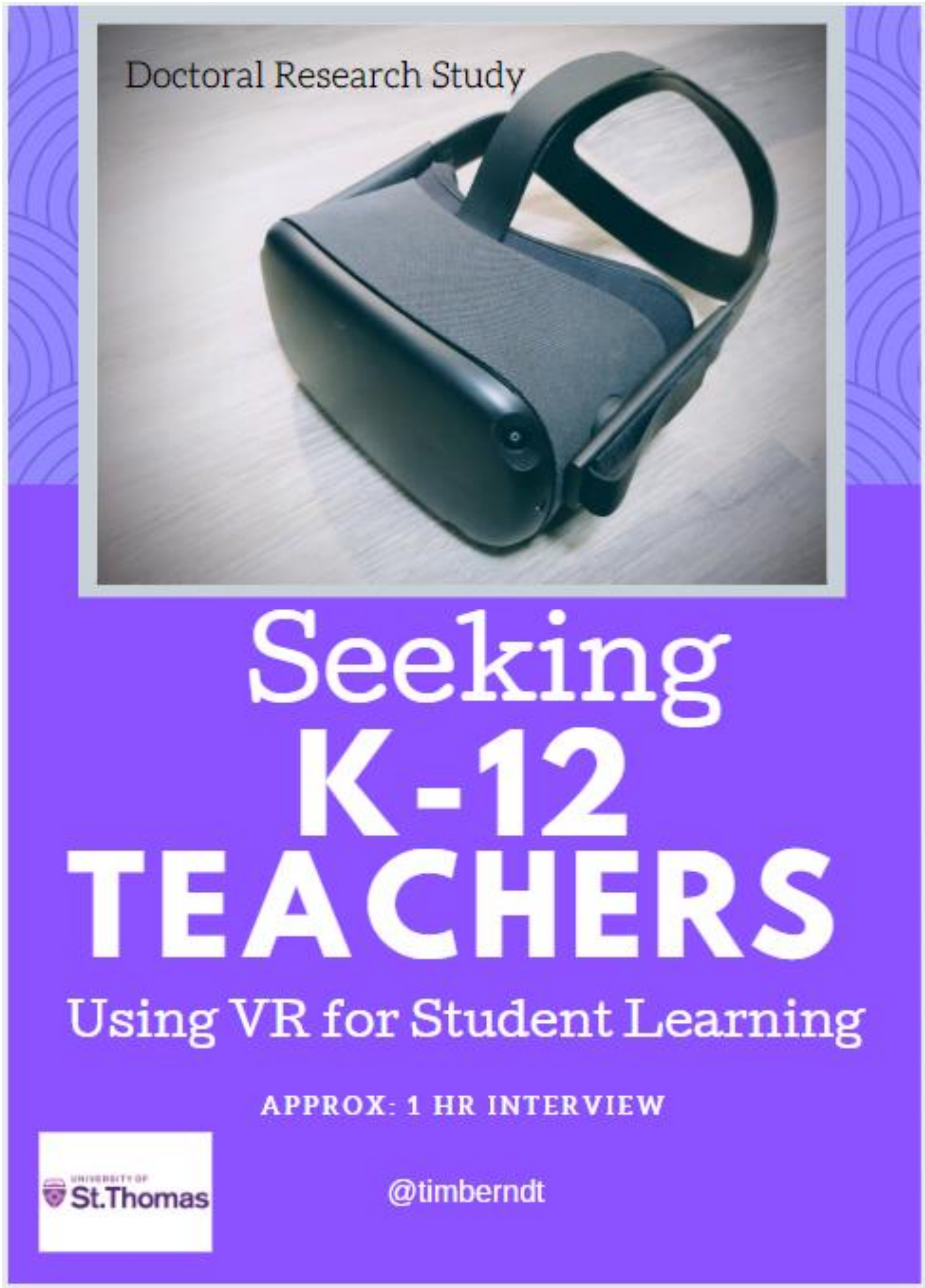
Appendix B: Interview Questions

1. What and where do you teach?
2. Tell me your VR story. How did you first get introduced to VR?
3. Describe your VR setup and how did they acquire funds for equipment?
4. What do you think students enjoy most about using VR for learning?
5. How do you use VR for learning? Successes? Failures?
6. Best applications for student learning?
7. What is next for you and VR?
8. What is the easiest/hardest part of using VR for teaching and learning?

Appendix C: Advertisement for Study



Appendix D: A "Playbook" of Considerations to Bring VR into K-12 Classrooms