Seeing All the Facts You Learned: The Lived Learning Experience of Students in a Pedagogically-Focused Virtual Reality Experience

by

Michael MacKay

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Royal Roads University
Victoria, British Columbia, Canada

Supervisor: IRWIN DEVRIES
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COMMITTEE APPROVAL

The members of Michael MacKay's Thesis Committee certify that they have read the thesis titled Seeing All the Facts You Learned: The Lived Learning Experience of Students in a Pedagogically-Focused Virtual Reality Experience and recommend that it be accepted as fulfilling the thesis requirements for the Degree of Master of Arts in Learning and Technology:

Dr. Paula MacDowell [signature on file]

Final approval and acceptance of this thesis is contingent upon submission of the final copy of the thesis to Royal Roads University. The thesis supervisor confirms to have read this thesis and recommends that it be accepted as fulfilling the thesis requirements:

Dr. Irwin DeVries [signature on file]

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Abstract

This thesis aimed to explore presence and learning in virtual reality through a qualitative lens. A virtual learning environment was designed and constructed that accurately mimicked the local solar system to facilitate this inquiry. Five grade nine participants were selected purposefully based on the sample criteria. Data were collected primarily through semi-structured interviews and analyzed using interpretative phenomenological analysis methodologies.

Four themes arose from the analysis, leading to the discussion of three significant findings and recommendations. A tiered approach to presence is suggested to solve the conflicts between contemporary presence and learning, where presence can be viewed as the cognitive acceptance of a virtual event, not as real, but as a reasonable facsimile. The concept of autonomy illusion is introduced, in which learners experience a sense of autonomy empowered through the virtual environment. Finally, it is recommended that the K-12 system embrace non-symbolic knowledge to help re-contextualize learning.

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I want to thank Dr. Irwin DeVries specifically for his advice and understanding throughout the writing and data collection process. I feel we overcame a lot together, and he helped me improve as a researcher and person. Thank you. Likewise, I would like to thank my committee members, such as Dr. Paula MacDowell, who not only took the time to read this thesis and give valuable feedback but also incorporated me in external presentations and conferences. Finally, I thank the MALAT 2020-2022 cohort, who put up with my idiosyncrasies, discussed various ideas, and encouraged my development. Thank you all.

Dedication

I dedicate this thesis to my late grandfather, William (Bill) McPhee. His selfless acts, understanding, and guidance have enabled this achievement.

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Chapter 1: Study Background

Background

Since 2012 I have been employed as a K-12 teacher working in a small rural division. Due to the limited expertise available in the local workforce and my willingness to take on any challenge, I have fulfilled many different roles and have taught various subjects from grades four to twelve. This experience has afforded me a solid working knowledge of the K-12 field and insight into common roadblocks that impede student learning. Through this experience, I identified two critical roadblocks that permeated grade levels: (1) the separation of the learning objective from the context it is instantiated in, and (2) the abstract nature of the symbolic structures that create artificial barriers for student understanding, for example an algebraic equation. Starting in 2016, I began to explore different technologies and methodologies to create a more context-specific learning experience. Such explorations led me to virtual reality, and I have been developing and utilizing virtual reality-based applications in some capacity in the classroom following this initial exploration.

Virtual reality (VR) is a technology that utilizes a computing device to create interactive, immersive experiences that envelop the user's senses. Many devices are closely associated with or share the moniker VR; however, I will be employing the head-mounted display (HMD) variant for this research. HMDs are a piece of hardware worn on the head with built-in displays that produce three-dimensional (3D) graphics to simulate virtual environments (Kamińska et al., 2019). Furthermore, the recent commercial success and increased availability of high fidelity HMDs paired with lowering costs have increased the feasibility and lowered the barrier of entry for VR-based usage in the classroom (Cipresso et al., 2018; Facebook Technologies, n.d.; HTC VIVE, n.d.).

One compelling application of the technology came when teaching the space units in grades six and nine. Both curricula have learner outcomes that deal with the scale or size of the universe by requiring students to understand the distances between celestial bodies and the distribution of matter. An understanding of these outcomes is traditionally expressed through abstractions such as numbers. For example, a learner would demonstrate their knowledge of the solar system's scale by stating the distance between the Earth and Sun is about one hundred and fifty million kilometres; and while this is undoubtedly true, it calls into question whether or not the learner truly understands that statement. A learner may understand the value of the distance and the size of each kilometre, but they would struggle to relate to the enormous quantities involved because it falls outside the scope of their everyday lives.

These struggles made me ponder how to normalize such abstractions by creating experiences that simulated the vast scale the learner outcome is attempting to convey. Of course, the best solution would be to have learners experience the scale by travelling from the Earth to the Sun in some spacecraft. Sadly, the cost and safety risks associated with such an endeavour make this experience impossible in the current school system. Bailenson (2018) suggests that VR technologies are best used when experiences are impossible through other means, too dangerous, counterproductive, or too expensive. By utilizing VR to reach this outcome, students can simulate travelling from the Earth to the Sun from the safety of their classroom at a vastly reduced cost. Furthermore, such an experience aligns with Bricken's (1990) *direct experience computational environment* in which VR is utilized to generate a simulated situation where students and teachers could manipulate symbolic abstractions for the purposes of teaching. Bricken's computational environment has transformed into the modern 3D virtual learning environment.

A 3D virtual learning environment (VLE) distinguishes itself from a virtual environment by extending beyond simple 3D depictions by providing salient perceptual criteria permitting the natural aspects of human perception to perceive 3D-generated images, which extends the visual information a user perceives. Furthermore, 3D VLEs facilitate the direct manipulation of the environment through natural actions rather than computer command structures, supplementing 3D information with other stimuli or visual changes (Dalgarno & Lee, 2010; Wann & Mon-Williams, 1996). Other VLEs, such as learning management systems like Moodle, distribute and enable information and interactivity via computer-based interfaces and command structures, for example, viewing two-dimensional diagrams or facilitating communication through message boards. Moreover, Winn (1993) argued that immersive 3D VLEs could remove the need for symbolic knowledge, the knowledge needed to understand the context of the concept, such as algebraic symbols in mathematics, by providing first-person learning experiences that mimic the natural course of learning.

As learners experienced travelling from the Earth to the Sun in VR, it was evident that they understood the vast distances between the celestial bodies. However, during provincial examinations, the question arose, requiring them to describe the distance from the Earth to the Sun using kilometres. Despite their first-person knowledge of the distance, this question was outside the scope of the experience. This requirement of the curriculum created tension in my pedagogical process. A learner who experienced the VR simulation would have a richer understanding of the learner outcome but could miss out on the symbolic abstractions used for examination. Likewise, a learner focusing on the symbolic abstraction, the distance represented in kilometres, would fulfill the provincial requirement but most likely lack the understanding the first-person account would provide. The tension between experience and abstract knowledge further narrowed my focus. I questioned how learning occurred in 3D VLEs, and how I could expand the VR-based learning domain through research.

At the start of my research journey, I knew that I wanted to explore tangible methods that would result in pedagogical recommendations or frameworks that the willing educator could invoke. In truth, it would be much simpler to follow the confirmatory research doctrine. In this scenario, as Winn (1993) argued, I could test whether or not VR enables learners to remove the need for symbolic knowledge. Unquestionably, looking back at my students travelling through space in VR, there is evidence of this phenomenon, albeit circumstantial, and if I were to explore this branch of research, I would have defined end-goals that are easily predictable. However, the problem arises when discussing why VR enables this experience. Why or even does VR empower learners to circumvent symbolic knowledge, and how do educators ensure that abstract learning can occur? To answer these questions and clarify Winn's argument, the foundation of VR learning needs to be established, and I hope that by examining the unique properties of virtual environments, such as presence, a better understanding of learning in VLEs can be achieved.

Purpose of Study

I finally acknowledged that to discover the truths behind how learners experience VR learning, I had to examine what makes a virtual learning experience different. One concept that kept surfacing indirectly or directly in the literature was the notion of *presence*. In its current iteration, presence is the psychological reaction to the virtual environment, resulting in the perceptual acceptance of the simulation (Slater, 2018). For example, a user who encounters a VR-based activity would most likely know the experience is not real; however, they accept the interactions within the environment as *true* and enable learning opportunities through this acceptance. The concept of presence could have profound impacts on VLE as and according to Dalgarno and Lee (2010), the predominant feature of 3D VLEs would be creating a sense of presence through natural interactivity and smooth temporal representations of the environment. It would seem that with presence, I had found one of the key concepts I needed to establish a foundation for understanding learning facilitated through VR.

The purpose of this thesis is to "move away from research that starts with an analysis of the technology then seeks to derive learning benefits" (Fowler, 2015, p. 420) by examining the learner's experience through a phenomenological lens. Such a lens starts with the unique phenomenon that enables virtual experiences — presence. A richer understanding of virtual experiences can be derived by investigating this unique phenomenon, leading to a better understanding of how learning occurs in 3D VLEs, allowing VR-learning to move beyond technological novelty by enabling informed, practical applications and future research. Given my experience as a K-12 educator, I chose to focus on the experiences of grade 9 students.

For this research, participants were involved in a first-person exploration of the local solar system facilitated through VR. The exploration aimed for participants to experience a sense of presence and accept the simulated experience as true. Each participant was evaluated through a debriefing to tie the learning experience to the learning outcome. Furthermore, open-ended questions attempted to investigate the phenomenon of presence through a hermeneutic interpretation. Data was gathered and analyzed following the interpretive phenomenological analysis methodology Smith et al. (2009) outlined. However, looking back at the initial concerns that started this journey, separation of context and abstract symbolic structures, it is evident that this research was only a tiny step into easing these roadblocks. It was my hope that a richer understanding of presence would establish a foundation for future research. I view this as the start of an exploration that takes a bottom-up approach, understanding how and why a VR learning experience can be successful rather than looking for causal patterns in individual learning methodologies.

Research Questions

The following question was used to support this inquiry: How do grade nine students experience presence in a virtual reality educational activity? Three sub-questions will be used to further this inquiry:

1. What design factors contribute to a sense of presence in VR simulation?
2. How do students experience presence in an educational VR space simulation?
3. How does presence contribute to learning in a VR simulation?

Definition of Key Terms

While some definitions may be generally recognized, descriptions explicit to the context of this research have been provided.

Three-Dimensions (3D)

Three-dimensions refer to a computer-created image utilizing three spatial dimensions (x, y, and z).

Three-Dimensional Virtual Learning Environment (3D VLE)

A three-dimensional virtual learning environment capitalizes upon the natural aspects of human perception to supplement sensorial information and enable users to interact with the environment through other stimuli or temporal changes (Wann & Mon-Williams, 1996, p. 833).

Head-Mounted Display (HMD)

A head-mounted display is a wearable hardware encompassing the head and eyes, including lenses and displays, often enabling virtual environments through first-person perspectives.

Immersion

Immersion is the measure of the technology's capabilities to present an immersive world to the sensorimotor systems (Slater, 2003; Slater, 2009).

Immersive Virtual Reality (iVR)

Immersive virtual reality is a subset of virtual reality that uses a head-mounted display or similar technology to entirely encompass the user's spatial perception to become part of the simulation.

Presence

Presence is the cognitive acceptance of the virtual world, accepting learner interactions as a suitable substitute to real-world interactions (Slater, 2009; Slater, 2018).

Simulation

"Simulation is an activity that represents real or potentially real-world activities" (Tun et al., p. 161).

Virtual Learning Environment (VLE)

A virtual learning environment is a virtual space where participants are active and present actors in the learning process through the co-construction of the virtual space (Dillenbourg et al., 2002).

Virtual Reality (VR)

Virtual reality is a broad term for computer-based graphical applications that allow users to explore and interact in a simulated environment (Winn, 1993).

Chapter 2: Literature Review

Introduction

In this section, I examine the relevant literature to address the research questions adequately. First, due to the generally unfamiliar nature of VR technology in education, I discuss its history, focusing on initial innovations and paradigm shifts to establish the state of modern VR technologies. To remove any ambiguity, I subsequently considered other closely related technologies to inaugurate what VR is in the context of this research. Next, I investigate literature related to presence and immersion, focusing on the evolution and need for two different concepts. Subsequently, I discuss immersive VLEs and how presence is perceived in these environments. Finally, I delve into possible models for learning in VLEs, establishing the value of presence in these models through the examination of the cognitive mechanisms that "strengthen the alliance between constructivism and technology [by] creat[ing] virtual environments" (Aeillo et al., 2012, p. 319).

A Brief History

The first contemporary immersive VR-based technology was formulated within Sutherland's (1965) paper and realized through an HMD called the *Sword of Damocles* (Sutherland, 1968). Sutherland's Sword of Damocles signified a surge of innovation in VR-related technologies that continued to the early 1990s. During this time, many innovative VR-based technologies were birthed from "the degree of excitement, creativity, speculation, visions of a positive future, [and] belief in the near-term mass availability of VR" (Slater & Sanchez-Vives, 2016, p. 3). The educational potential of VR was soon apparent. For instance, the US Airforce developed the V*isually Coupled Airborne Systems Simulator* (VCASS) in 1982, which acted as an advanced flight simulator where fighter pilots wore an HMD to view targeting and flight path information (Mandal, 2013). Furthermore, medical fields have embraced VR technologies for training because they enable an environment where students have the freedom to make mistakes (Ruthenbeck & Reynolds, 2015). Likewise, in 1992 Cruz-Neira et al. developed the *Cave Automatic Virtual Environment* or *CAVE* system, an alternative immersive VR system that projected images onto multiple walls of an enclosed cube to surround the user in a 3D world, much like HMDs (Cipresso et al., 2018; Dalgarno & Lee, 2010) and was referred to as projection-based displays (Feng et al., 2018).

After the initial surge of VR technologies, the field shifted to other extended forms, such as mixed reality (Cipresso et al., 2018) and desktop-based virtual environments (Ai-Lim Lee et al., 2010; Robertson et al., 1997). Expressed by Pausch et al. (1996) and still true today, VR is in a paradigm shift as researchers need to develop a new standardized syntax and discover methods of engaging learners in a way that takes advantage of the medium's unique characteristics (Slater & Sanchez-Vives, 2016). VR's current transitional state is further cemented by Weller's observation that when "new technolog[ies] arrive, [they] tend to be used in old ways" (2020, p. 64). A more recent second wave of interest in VR technologies has been fueled by the sudden mass availability of lower-cost commercial HMDs and substantial investments from companies like Facebook, Sony, Samsung, HTC, and Google (Cipresso et al., 2018). However, despite this recent abundance, there has been "limited research on [the] effects [that VR has] on children and its application to learning in actual classrooms" (Southgate et al., 2019, p. 20).

Mixed and Virtual Reality

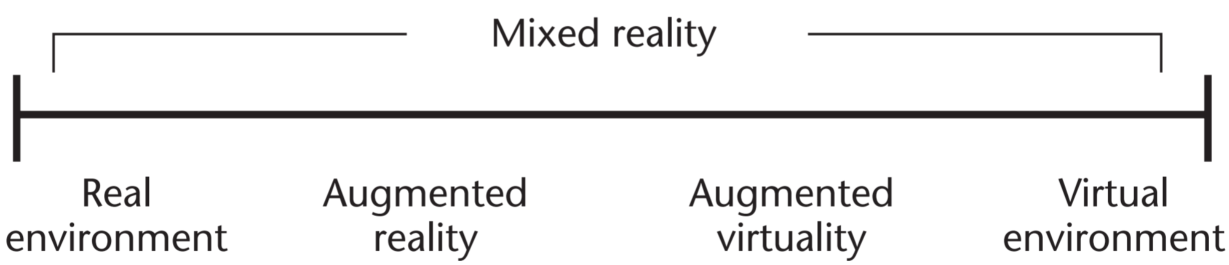
This section helps situate and establish the limitations of VR in this thesis by examining other closely related paradigms. By comparing and contrasting these similar technologies, particularly mixed reality, an explicit boundary can be defined that helps situate VR as predominantly a virtually induced learning experience. This boundary is a delimiting factor for this research as it constrains its exploration of presence and learning to the virtual.

Much like its multidisciplinary roots, the term VR has been associated with a variety of technologies. Pioneering endeavours first concentrated on defining visible confines focused on the levels of technological immersion the equipment offered, differentiating the VR system into three categories: (1) *non-immersive* or *desktop VR systems*, sometimes referred to as the *window on world* systems, was a lower-level system that had the user view the virtual world through one or more computer screens; (2) *semi-immersive systems* or *fish tank VR* supported head tracking creating a more immersive experience but often lacks sensory inputs; (3) *immersive systems* made use of an HMD to position and orientate the user as well as making use of other sensory inputs, specifically, sensory-based interfaces and was considered the apex of virtual reality (Cipresso et al., 2018; Mandal, 2013; Mazuryk & Gervautz, 1996; Metzger, 1993).

Milgram and Kishino (1994) argued that the VR label is often used with a variety of environments in which total technological immersion may not take place, creating "parallel problems of inexact terminologies and unclear conceptual boundaries" (p. 2). To help establish these conceptual boundaries, Milgram and Kishino (1994) suggested adopting a new taxonomy called mixed reality. As the name suggests, the term mixed reality involved merging virtual and real worlds and gave rise to the virtuality continuum (see Figure 1). The virtuality continuum helps describe the degree of virtual envelopment a technology affords, with the left of the continuum solely consisting of real objects or objects that have a genuine material existence (Milgram & Kishino, 1994). Progression from the left side to the right of the continuum involves more objects being simulated until all objects are simulated within a virtual environment (Azuma et al., 2001; Milgram & Kishino, 1994).

Figure 1

The Virtuality Continuum



Note. The virtuality continuum describes the degree of virtual envelopment derived from the use of virtual reality-related technologies. From "Recent advances in augmented reality," by Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B., 2001, *IEEE Computer Graphics and Applications, 21*(6), 34-47. (https://doi.org/10.1109/38.963459).

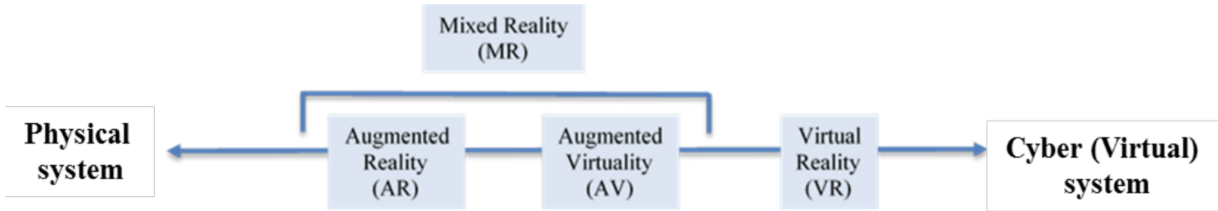
Contemporary developments have given rise to an extensive array of VR-related technologies. One of these related technologies is mixed reality. Mixed reality is a nomenclature used to describe various technologies that incorporate elements of the physical and virtual worlds with differing degrees of virtual envelopment and can be simplified into two taxonomies: *augmented reality* and *augmented virtuality* (Azuma et al., 2001; Fast-Berglund et al., 2018; Milgram & Kishino, 1994). *Augmented reality* combines real-world and virtual objects, running in real-time to seamlessly integrate interactions with the real and virtual spaces, often being used for remote guidance and visualized instructions through phones or other handheld devices (Fast-Berglund et al., 2018). For example, Lai et al. (2020) developed an instructional system that uses computer models imposed on real-world objects and written directions to visualize the instructions required to assemble a device. Augmented virtuality builds upon augmented reality by utilizing a higher degree of virtual entanglement as more elements are synthetic (Fast-Berglund et al., 2018). The critical difference between augmented reality and augmented virtuality is augmented reality integrates the real world with related digital information, while augmented virtuality creates computer-generated scenarios augmented with real and virtual objects (Farshid et al., 2018). By Farshid et al.'s (2018) definition, Pokémon Go (Niantic, n.d.) is an extraordinary example of augmented virtuality because it blends a fictitious world with the actual world. Furthermore, the Microsoft Hololens (Cipresso et al., 2018; Microsoft, n.d.) exemplifies augmented virtuality devices and is commonly confused as the sole mixed reality (Fast-Berglund et al., 2018).

Consequently, virtual reality would be situated outside the mixed reality taxonomy because as users immerse themselves in the environment, their perception of the physical world is replaced with an artificially simulated one (Feng et al., 2018). This notion is supported by Fast-Berglund et al.'s (2018) adapted model (see Figure 2), which builds upon Milgram and Kishino's (1994) and Doil et al.'s (2003) work to express the relationship between the diverging technologies as they transform from real to virtual environments. The term extended reality (XR) was adopted to refer “to all real-and-virtual combined environments and human-machine interactions generated by computer technolog[ies] and wearable[s]” (Fast-Berglund et al., 2018, p. 32).

This research will only examine virtual reality considering an HMD will simulate the environment and all objects within it.

Figure 2

Extended Reality Systems



Note. This figure represents the extended reality technologies based on the degree of virtualization, with physical or real systems on the left and virtual systems on the right; likewise, VR is placed outside mixed reality. From "Testing and validating extended reality (xR) technologies in manufacturing," by Fast-Berglund, Å., Gong, L., & Li, D., 2018, *Procedia Manufacturing, 25*, 31–38. (http://dx.doi.org/10.1016/j.promfg.2018.06.054).

Presence and Immersion

The concept of immersion is the strongest argument for the advocates of VR in education (Dalgarno & Lee, 2010; Hedberg & Alexander, 1994; Makransky & Petersen, 2021; Whitelock et al., 1996; Winn, 1993) because immersion can bridge “the technological, psychological, and pedagogical experiences of learning” (Fowler, 2015, p. 416). However, despite its advocacy, the concept of immersion has a degree of ambiguity attached to it.

Generally, two diverging opinions have formed. Slater and Wilbur (1997) argued for immersion to be viewed as a technological quality, whereas Witmer & Singer (1998) viewed immersion as the psychological phenomenon subjective to the individual's beliefs (Radianti et al., 2020). Furthermore, some early writings used immersion and presence interchangeably (Dalgarno & Lee, 2010).

Accordingly, Slater (1999, 2003, 2009, 2018) argued for the separation of the term presence from immersion. He viewed presence as the subjective perception of *being there* brought on by the objective manipulation of the sensorimotor modalities through an immersive system. Strictly speaking, immersion would be a measure of the technology's capabilities to present an *immersive* world; likewise, presence would be the psychological reaction to the virtual environment or the *qualia* associated with the illusion (Dalgarno & Lee, 2010; Slater, 2003; Slater, 2009). However, this does not mean presence is the cognitive suspension of disbelief, but an illusion where the environment looks and behaves within the expectations of the user's perceptions (Slater, 2009). "It is a perceptual but not a cognitive illusion" (Slater, 2018, p. 432).

This illusion can be further broken down into two subsects: *place and plausibility illusions* (Slater, 2009). A place illusion is a type of presence enabled within the sensorimotor systems as it is fed varying degrees of stimuli (Slater, 2018; Slater, 2009), "it is the strong illusion of being in a place in spite of the sure knowledge that you are not there" (Slater, 2009, p. 3551). Likewise, plausibility illusion reinforces place illusion through the realistic and expected interactions within the environment even if the user is not the direct driver of such events (Skarbez et al., 2017; Slater, 2009); it "is the illusion that what is apparently happening is really happening (even though you know for sure that it is not)" (Slater, 2009, p. 3553).

Furthermore, place and plausibility illusions help bridge the roles for building a sense of presence in immersive learning environments. A place illusion is facilitated through the graphical, audio, and kinesthetic fidelity the technology can supply; in this view, place illusions are primarily empowered through technological capabilities in VR. Likewise, plausibility illusions are enabled through the design choices of the virtual simulated program and whether or not the user deems them within the realm of acceptable or believable behaviours.

Virtual Environments

The virtual environment is an amorphous space. It can take the shape of whatever need may arise. Designers of these spaces can create vast landscapes and unbelievable occurrences.

Through interaction, rather than predetermined sequencing, VLEs can take on the same characteristics of physical learning environments, designating new experiences that can be reshaped in the context of learning (Aeillo et al., 2012). This section explores the role presence plays in a virtual environment, how a sense of presence can be achieved, and how this could be related to learning. While not all terminologies perfectly align, Table 1 attempts to overview this section, demonstrating how VR-based learning and presence have grown over time.

Table 1

A Timeline of Presence, Learning, and Virtual Reality

Timeline	*Author(s)*	*Presence in VR*	*Learning in VR*
1993	Winn	The conviction that the virtual world is valid through total immersion	Constructivist first-person experiences through size, transduction, and reification
1994	Hedberg & Alexander	Defined as immersion, enabled through the sensory-motor system, acceptance of the virtual world, and motivation	Situated learning achieved through active participation, representational fidelity, and immersion
1996	Whitelock, Brna, & Holland	A combination of sensory cues that result in internal conceptual processes	Measurable through autonomy, interaction, and presence
1999 - 2005	Riva	Presence is the result of embodiment, resulting in the virtual environment being perceived as the physical environment	Can occur through bodily action, first-person interactions, and embodiment
1999 - 2018	Slater	Presence is a human or emotional reaction to an immersive system created by place and plausibility illusions	Implicit learning can occur through the appropriate embodiment of a virtual body
2010	Dalgarno & Lee	The technological characteristics, representational fidelity and learner interaction create a sense of presence	Learning is achieved through a combination of the technological and psycho-social characteristics

2015	Fowler	Presence is the state of mind that can be enabled through technological characteristics	Built on Dalgarno and Lee's work by situating it in a pedagogical methodology
2021	Maskransky & Gustav	Ties presence to agency which arises from immersion and interaction within the virtual environment	Created the Cognitive Affective Model of Immersive Learning (CAMIL), stating the instructional method dictates learning rather than the technology

Note. This table represents a quick at-a-glance overview of how presence and learning has changed over the last thirty years.

How Presence is Created in Virtual Environments

In this section, I explore how presence can be obtained in a virtual environment through the manipulation of the sensorimotor systems and thoughtful design of the learner interactions.

Sensorimotor Systems

A pivotal viewpoint of learning in virtual environments is the cognitive exercise enabled through the interactions within the environment that transform the learner from a mere observer to a living actor of that world (Riva, 1999; Riva, 2005). These exercises are deeply connected to the sensorimotor system, allowing bodily interactions in the environment that stimulate conceptual understanding and rational thought (Lindgren et al., 2016; Riva, 1999). For example, if a person were going to learn how to paint in a virtual environment, they would need tactical and visual feedback to develop the mental concepts of how different brush strokes can result in different textures.

The physical world does not constrain the virtual environment. Even though interactions within the virtual environment are primarily enabled through sensory-motor feedback, these parameters are programmable, meaning this sensory-motor feedback can be altered to experience stimuli outside the domain of normal functions through a process dubbed *transduction* (Winn, 1993). One example of transduction that will be utilized in this research is the manipulation of *size*. Manipulating the size of virtual objects in the virtual space will create a sense of scale that would be difficult to replicate by different means. This process aligns with Winn's (1993) concept of *reification*, which is a process of designing and teaching in virtual environments that focuses on the learner's participation through size and transduction rather than strictly simulating real-world means. Today, many researchers have utilized Winn's characteristics to explore abstract concepts in first-person scenarios with varying degrees of success (Bertram et al., 2015; Marks et al., 2017; Youngblut, 1998; Zinchenko et al., 2020).

The sensorimotor systems play a vital role when developing a sense of presence in a virtual environment. Whitelock et al. (1996) viewed representational fidelity through different sensory cues as the driving contributor to presence because it creates the technological interface that learners accept the simulation based on their belief that it is possible and familiar. Riva (1999) believed that the sensorimotor system is the substance of the experience and driving factor of presence in virtual environments because embodied actions are self-organizing sensorimotor processes followed by cognitive conceptualizations. Dalgarno and Lee (2010) state that sensory stimuli drive technological immersion, the measurable properties of a system, such as graphics and audio fidelity, that lead to a sense of presence (Slater, 1999; Slater, 2003). I concur with these authors; viewing the sensorimotor input enabled through the technology as essential to establishing place illusions which are a component of presence (Slater, 2009; Slater, 2018).

Learner Interactions

While sensorimotor input helps define the physical acceptance of a virtual environment, interactions with the environment and its actors help determine the psychological acceptance of the learner. To Riva (1999), a functional virtual environment needs the learner to recognize its limitations and expectations; likewise, the environment needs to be designed to "incorporate some information about what the [learner] 's goals and behaviours are likely to be" (Riva, 1999, p. 89). As such, the purpose of a virtual environment would be the immersion of the learner which can be achieved through the following design principles: (1) *designing a space for bodily actio*n by allowing the user to interact with the environment in ways the learner expects, (2) *design of other intelligent beings* by allowing other users to express themselves in believable ways; and (3) *design of the represented body* to create a sense of embodiment and ground the user's interactions within the environment (Riva, 1999).

Both Hedberg and Alexander (1994) and Whitelock et al. (1996) describe this type of immersion through active participation and immediacy of control. Active participation and immediacy of control focus on the learner's interactions within the environment through naturalistic interfaces rather than traditional computer-based command structures in recognizable ways to the learner (Hedberg & Alexander, 1994; Whitelock et al., 1996). Using this philosophy, a virtual designer must mimic real-world interactions to ensure the learner accepts and participates within the environment. However, following Winn's (1993) concept of transduction, there is the plausible possibility that virtual environments will explore concepts outside the scope of the learner's expectations. Looking at Slater's (2017) plausibility illusions, the role of the environment is to generate and respond to the learner's actions in valid and spontaneous ways that depict possible real-life events or at least in ways that could be perceived as accurate to the learner. Thus, for learner interaction to occur in a virtual environment that endorses presence, care must be taken to design the interactions within the space to the perceptions and understanding of the participant.

Learning in Virtual Environments

A learning environment informed through a constructivist lens must recognize the potential of invented realities and how these realities are informed by the individual's capacity and perception (Aiello et al., 2012). Previously, I have discussed the importance of presence, how it is attached to an individual's perception, and how to achieve a sense of presence in a virtual learning environment. However, further exploration into the unique learning capabilities in VLEs will be needed to "understand the pedagogical underpinnings that inform the design and use of these VR systems" (Fowler, 2015, p. 412). Table 2 helps organize the broad themes that arise and connect them to the theoretical frameworks that ground this research.

Table 2

Constructivism and Experiential Learning in Virtual Environments

Author(s)	*Theme*	*Constructivism*	*Experiential Learning*
Winn	• Non-Symbolic First-Person Knowledge	[x]	[x]
Hedberg & Alexander	• Situated learning	[x]	[x]
Whitelock, Brna, & Holland	• Framework for learning in VR	[x]	[x]
Riva	• VR as a communication tool through sensorimotor manipulation		[x]
Slater	• Embodiment and Implicit Learning		[x]
Dalgarno & Lee	• Technological affordances of VR	[x]	[x]
Stolz	• Embodied Learning	[x]	[x]

Fowler	• Pedagogical requirements in VR	[x]	[x]
Maskransky & Gustav	• CAMIL model for learning in VLEs	[x]	[x]

Note. This table explores the different themes authors contributed to virtual-based learning, exploring which themes connect to the theoretical backing of this research.

Non-Symbolic First-Person Knowledge

One of the first themes that demonstrated possible educational benefits of learning through VR is first-person interactions. Winn's (1993) work argued that VR could facilitate constructivist first-person non-symbolic experiences intentionally designed to achieve a learning objective (Mikropoulos & Natsis, 2011). First-person knowledge results from the direct interaction with the environment without conscious thought, resulting in knowledge that is "direct, personal, subjective and often tacit in the sense that we often do not know that we know something" (Winn, 1993, para. 8). Likewise, third-person experiences result from the vicarious knowledge filtered through a symbolic, explicit representation of the event; and it is often the means of knowledge acquisition used in schools today (Winn, 1993). First and third-person accounts of the same experience would vary. For instance, if I were to give a first-person account of burning my hand on a stove, I would express the pain I felt. Likewise, if I gave a third-person account, I would discuss how the vibrating molecules transferred energy from the hot metal to my hand. Looking at the third-person account, both parties, the transmitter and the receiver of the knowledge, need to understand the symbolic representations used to describe this event. Specifically, the individual would need to know what a molecule is and have a working conceptualization of energy and how it is transferred; this required information to understand a concept is an example of symbolic knowledge.

VR removes the need for symbolic knowledge by allowing the learner to interact with the environment directly, for instance, reaching out to rotate an object rather than specifying a view on a coordinate system (Bricken, 1994). In a traditional classroom, mastery of the symbolic systems is necessary but not always sufficient to incite learning (Winn, 1993). Winn (1993) explains this phenomenon through learning algebra in schools, in which learners are forced to symbolize their experiences so a teacher can understand their work, stating this process can get in the way of the natural course of learning. Furthermore, authors like Hedberg and Alexander (1994) have expressed frustrations over imparting these abstract concepts as independent fixed entities explored through textbooks and examples, raising doubts about the transferability of classroom learning to real-world applications. Consequently, learners could use VR to understand the conceptual basis of algebra without knowing the conventional symbolic symbols through first-person interactions in a naturalistic virtual environment; if needed, these symbolic symbols can be addressed once the learner has a solid foundation of the concept (Winn, 1993). Through a constructivist lens, the removal of symbolic knowledge to enable a conceptual understanding of a concept could profoundly impact learning by providing a means to construct meaning through one's own experience (Aiello et al., 2012).

To Hedberg and Alexander (1994), much like Winn's (1993) rationale of first-person experiences, the fundamental feature of immersive virtual environments was an intuitive and naturally transparent interface with which users could directly control virtual objects within the context of the virtual environment. This view was foundationally held through situated learning. Situated learning is the perception that learning and knowledge are context-specific and for learning activities to be effective in achieving relevant learning outcomes, they must be situated and framed in the culture, environment, and activity (Chang et al., 2013; Dunleavy et al., 2009;

Hedberg & Alexander, 1994). Traditionally, situated learning pedagogies are rooted in apprenticeship programs that require learners to articulate their knowledge with an expert or master and explore the boundaries of this knowledge through individual-based problem-solving (Hedberg & Alexander, 1994). Such a perspective tends to agree with views of embodied learning. Embodied learning, often referred to as embodied cognition, suggests meaning is not solely contrived from a dualistic representation of the physical and mental characteristics of actions; instead, it proposes that meaning is made through the embodiment of the intertwined relationship between physical and mental perceptions, which are instantiated and shaped by the environment (Shapiro & Stolz, 2019; Stolz, 2015).

Model of Learning in Virtual Environments

Dalgarno and Lee (2010) expanded and coalesced concepts from the previous literature to conceptualize a virtual learning environment through the technological characteristics that drive a learning experience. They divided the distinguishing technological characteristics into two broad categories: *representational fidelity* and *learner interaction* (see Table 3). Representational fidelity regards how the user perceives and interacts with the technology, primarily through their sensorimotor systems; likewise, learner interaction considers how the technology-enabled embodied, first-person actions fit within the boundaries of the learner's expectations (Dalgarno & Lee, 2010).

Table 3

Distinguishing Characteristics of Immersive Virtual Learning Environments

Category	*Characteristics*
Representational fidelity	● Realistic display of environment ● Smooth display of view changes and object motion ● Consistency of object behaviour ● User representation

	● Spatial audio ● Kinaesthetic and tactile force feedback
Learner interaction	● Embodied actions including view control, navigation and object manipulation ● Embodied verbal and non-verbal communication ● Control of environment attributes and behaviour ● Construction of objects and scripting of object behaviours

Note. This table lists the unique technological characteristics of an immersive virtual learning environment. From "What are the learning affordances of 3-D virtual environments?" by Dalgarno, B., & Lee, M. J. W., 2010, *British Journal of Educational Technology, 41*(1), 10–32. (https://doi.org/10.1111/j.1467-8535.2009.01038.x).

Furthermore, Dalgarno and Lee (2010) viewed the technological characteristics of representational fidelity and learner interaction as catalysts for psychosocial characteristics that describe a learning experience characterized as *construction of identity*, *sense of presence*, and *co-presence*. Construction of identity utilizes Riva's (1999) work to describe how a virtual identity could be constructed through visual representations and the embodiment of actions (Dalgarno & Lee, 2010). Further, sense of presence, correlating with place and plausibility illusion (Slater, 2009), would be described by the psychological state of *being there*, and co-presence can be represented as the state of *being there together* (Dalgarno & Lee, 2010). In this perspective, the technological characteristics stimulate the mental illusions of presence, leading to learning affordances or benefits unique to virtual reality (Dalgarno & Lee, 2010).

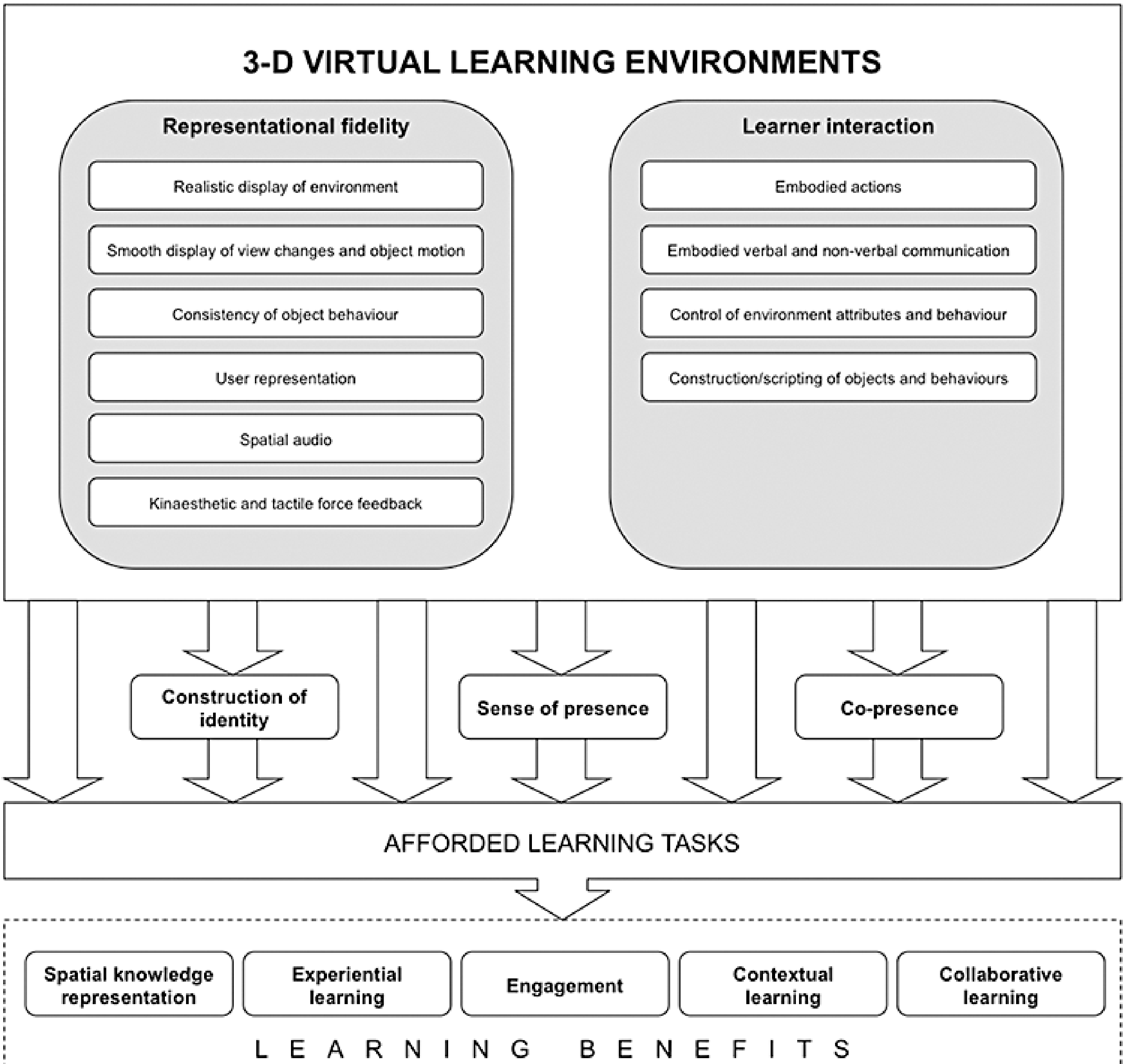
Pedagogically speaking, "design and development efforts in this field are largely hit-and-miss, driven by intuition and 'common-sense' extrapolations rather than being solidly underpinned by research-informed models and frameworks" (Dalgarno & Lee, 2010, p. 25). As such, Dalgarno and Lee (2010) identified five affordances based on the aforementioned learning benefits unique to virtual environments that they hoped would lead to more informed models:

- *spatial knowledge representation* refers to the virtual learning environments' ability to manipulate and position objects to facilitate learning tasks;
- *experiential learning* represents the unique ability of virtual environments to enable learning tasks that would be impossible or impractical in the real world;
- *engagement* describes the phenomenon in virtual environments that can cause higher levels of learner engagement because learning tasks are personalized through first-person experiences;
- *contextual learning* illustrates that realistic activities in virtual environments should transfer into improved knowledge and skills because learning would be contextualized; and
- *collaborative learning*, in multiuser systems, represents the potential for higher levels of collaborative activities compared to 2D alternatives.

Using these five learning affordances and building upon the unique characteristics of virtual environments, Dalgarno and Lee created a learning model specific to virtual learning environments (see Figure 3).

Figure 3

Model for Learning in Virtual Environments



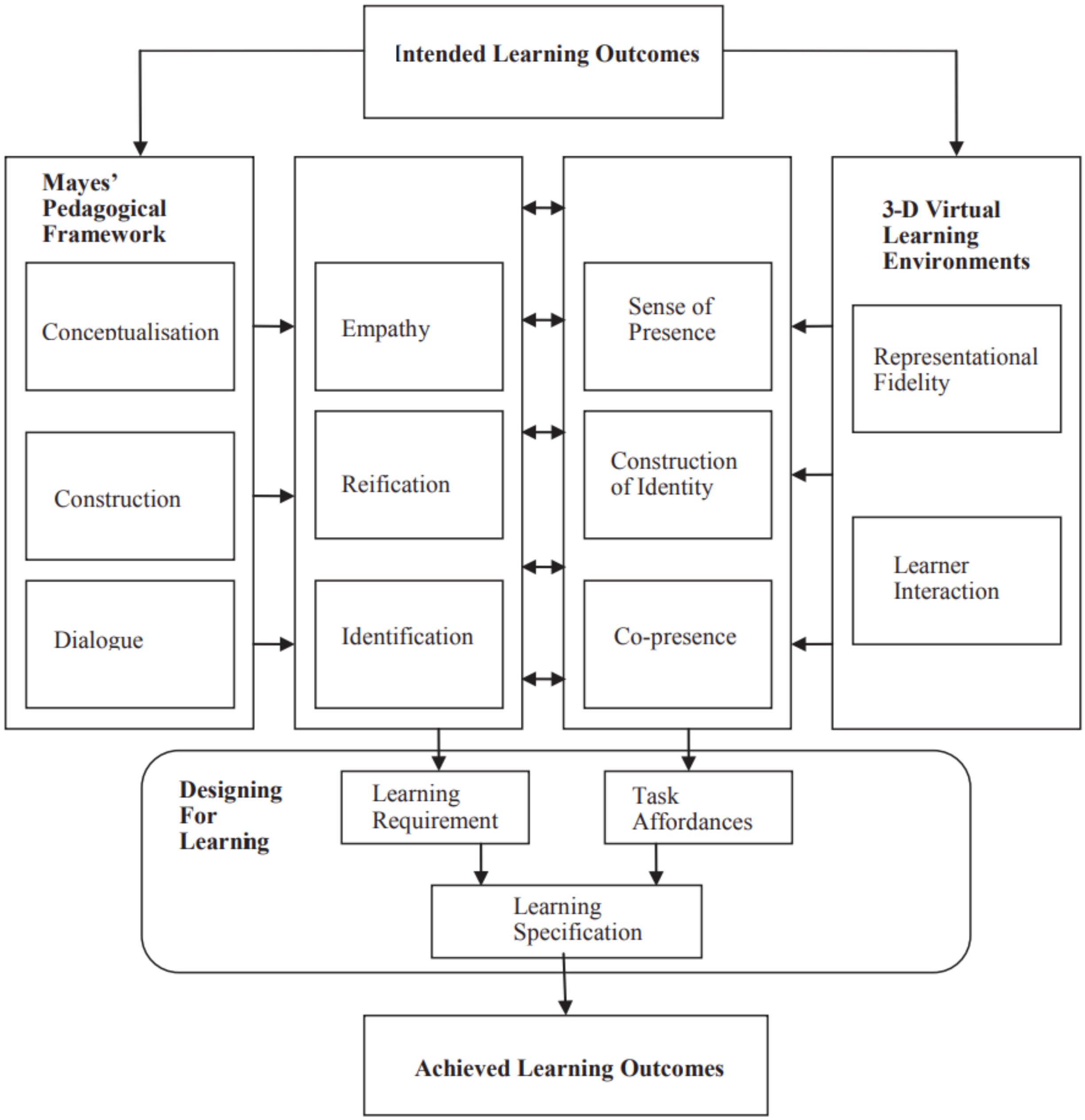
Note. This figure represents a learning model for virtual environments that uses virtual reality's technological and psychological characteristics to derive possible learning benefits. From "What are the learning affordances of 3-D virtual environments?," by Dalgarno, B., & Lee, M. J. W., 2010, *British Journal of Educational Technology, 41*(1), 10–32. (https://doi.org/10.1111/j.1467-8535.2009.01038.x).

However, Fowler (2015) argued that Dalgarno and Lee (2010) concentrated excessively on the technological perspective, specifically when deriving the learning affordances inherent in virtual learning environments. He posits that many technological characteristics are not relevant to specific learning contexts and advises that learning models must incorporate the pedagogical requirements to describe learning experience. As such, "the practitioner must design a specific learning experience [to best meet] the pedagogical needs of the learner" (Fowler, 2015, p. 415).

Like previous authors, Fowler (2015) cited immersion as a vital characteristic when teaching in virtual learning environments, stating that immersion can bridge the technological, psychological, and pedagogical states of a learning experience. Furthermore, Fowler (2015) suggested that any learning model should begin with the *intended learning outcomes* rather than viewing the technological characteristics in isolation. As such, he proposed the union of Dalgarno and Lee's (2010) model of learning in virtual environments with a pedagogical framework to determine the learning requirements and task affordances filtered through a design for learning methodology (see Figure 4). Designing for learning is a pedagogical approach to instruction that involves taking the "general contextual description of the teaching and learning environment through a set of... requirements based on defining what stage the learner is at and what learning outcomes have to be achieved by undertaking a given set of learning activities" (Fowler, 2015, p. 419). The results of these endeavours would be a learning specification that can manifest in a variety of forms; however, regardless of the form, the learning must "explicitly incorporate pedagogical considerations into their specification" (Fowler, 2015, p. 420).

Figure 4

Enhanced model of Learning in Virtual Learning Environments



Note. This figure represents an enhanced model of learning in virtual environments that incorporates the pedagogical requirements. From "Virtual reality and learning: Where is the pedagogy?," by Fowler, C, 2015, *British Journal of Educational Technology, 46*(2), 412–422. (https://doi.org/10.1111/bjet.12135).

Recently, Maskransky and Gustav (2021) suggested the *cognitive affective model of immersive learning* (CAMIL). The CAMIL model follows a similar theoretical methodology to Dalgarno and Lee's (2010) model as it focuses on the technological affordances of the technology and learner agency to derive possible psychological characteristics and cognitive benefits (Maskransky & Gustav, 2021). The goal of the model was to provide a better understanding of learning in virtual environments by facilitating how specific technological characteristics and affordances interact with different instructional methods (Maskransky & Gustav, 2021).

Virtual reality has a long, rich history that spans multiple disciplines. Despite this history, it is still in a state of flux, where terminology, methods, and theories are still contentious today. Nevertheless, as shown by Maskransky and Gustav (2021), there seems to be a growing consensus on the driving factors behind technological immersion that enable presence in virtual environments. For this reason, this thesis acknowledges Dalgarno and Lee's (2010) view of a virtual learning environment, in which the technological characteristics drive the psychological means of presence. Furthermore, this view aligns with Slater's (2009, 2018) assertions that place and plausibility illusions are driving forces behind presence, as place illusions are primarily concerned with the sensorimotor systems that are controlled through the technological characteristics, and plausibility illusions focus on realistic or believable interactions within the environment driven by learning interactions.

Even so, there has been limited research on presence, specifically in the educational domain (Freina & Ott, 2015; Mikropoulos & Natsis, 2011), where presence seems to play a vital role in the learning experience (Dalgarno & Lee, 2010; Fowler, 2015; Maskransky & Gustav, 2021). As Dalgarno and Lee (2010) stated, "much of what has been published about educational uses of [VR] technologies is largely 'show-and-tell,' presenting only anecdotal evidence or personal impressions that cannot be usefully generalized beyond the local context" (p. 23). The conceptual generalization of presence and its possible applications in learning requires the suspension of technocentric views as they risk the emulation of current practices rather than innovative pedagogically composed methodologies (Fowler, 2015).

Chapter 3: Research Methodology and Methods

For this study, the interpretative phenomenological analysis (IPA) methodology (Smith et al., 2009) was applied to explore how students experience presence and learning in an immersive virtual reality-based learning activity. This section presents the theoretical frameworks and methodological approach for this study, including the rationale behind its use. Furthermore, it discusses the methods of data collection and analysis, outlining the possible limitations and delimitations. Finally, the section closes by discussing the ethical considerations.

Theoretical Frameworks

This research was guided by the following theoretical frameworks: constructivism and experiential learning. Constructivism posits learning as the active construction of knowledge based on the contextual experiences of the learner (Bada & Olusegun, 2015; Cooper, 1993; Rannikmäe et al., 2020). Since learning exists in the human mind and, through extension, the body, learning experiences do not necessarily need to correspond with real-world realities (Bada & Olusegun, 2015); therefore, invented realities can strongly influence the situated perception of learning (Aiello et al., 2012). For example, a learning experience simulated through a VLE could parallel the needed context for the active construction of knowledge. The process of construction and interpretation is driven by personal experiences, which are deeply rooted in the learner's real and simulated contexts (Aeillo et al., 2012). In a constructivist learning experience, learners attempt to update and reflect on their mental models by perceiving each new experience, contemplating new stimuli and information to make contextual mental constructions of reality (Bada & Olusegun, 2015). Likewise, educators practicing a constructivist paradigm play an active role as facilitators, mentors, or coaches (Cooper, 1993; Rannikmäe et al., 2020) in the application of knowledge to enhance learning objectives through realistic activities that mimic real-world counterparts (Huang & Liaw, 2018). Therefore, a constructivist perspective defines the educator's role and how learning could occur within a virtual environment.

Experiential learning views learning as "the process whereby knowledge is created through the transformation of experience" (Kolb, 2015, p. 49). Being derived from constructivism, experiential learning emphasizes learning within the construction and reflection of knowledge through environmental interactions and perceived experiences (Fenwick, 2001; Mughal & Zafar, 2011). Nevertheless, whereas constructivism tends to focus on social-cultural interactions (Mattar, 2018; Rannikmäe et al., 2020), experiential learning as per (Kolb) focuses on individualistic constructions of knowledge through reflections (Mughal & Zafar, 2011). Kolb (2015) furthers this argument by viewing learners as autonomous; therefore, social relationships and interactions through language and cultural practices are not part of knowledge construction.The model of experiential learning theory describes learning through a circular model of four opposing modes:

- *concrete experiences* focus on undergoing and participating in an experience;
- *reflective observations* conclude and learn from an experience through reflection;
- *abstract conceptualizations* assimilate conceptual concepts based on reflections; and
- *active experimentations* test new abstractions, which guide additional experiences (Kolb, 2015; Kolb & Kolb, 2009; Lehane, 2020).

For this reason, in relation to virtual environments, experiential learning clarifies the function of the environment as a place of concrete and active experimentation, authentically leading to reflective observations for new conceptualizations.

Methodology

Interpretative phenomenological analysis is a form of qualitative research. The concept of the lived experience is a vital element of IPA. An IPA approach to research is committed to investigating how people make sense of significant life experiences and is rooted in phenomenology, hermeneutics, and idiography (Smith & Shinebourne, 2012; Smith et al., 2009).

Phenomenology, at its core, "is a philosophical approach to the study of experience" (Smith et al., 2009, p. 15). However, two diverging strands of phenomenology permeate contemporary literature: descriptive phenomenology and hermeneutic phenomenology. Descriptive phenomenology often uses a bracketing technique to isolate the phenomenon's essence with the sole goal of identifying the correlation between the *what* of an experience and *how* it is experienced; likewise, hermeneutic phenomenology focuses more on the researcher's interpretation of the data by searching through themes without a formalized analytical method allowing the context of the phenomenon to drive data analysis (Sloan & Bowe, 2014; Smith et al., 2009). The IPA methodology follows the hermeneutic strand of phenomenology as it attempts to make sense of the whole experience through interpretation rather than isolating the phenomenon to discover its essence (Spiers & Smith, 2019).

While IPA focuses on the experience and its meaning, it recognizes that first-person accounts cannot be transparently extracted for third-person, symbolic analysis; as such, the translation from the first-person experience to text, language or some other symbolic understanding requires the researcher to engage and interpret these accounts (Smith &

Shinebourne, 2012). Consequently, IPA utilizes hermeneutics or the theory of interpretation to examine how a phenomenon appears (Smith & Shinebourne, 2012; Smith et al., 2009).

Finally, idiography helps constrain an IPA approach to the particular. This commitment operates on two levels: (1) the depth of analysis and detail and (2) understanding how the participant experiences a particular phenomenon in a specific context (Smith et al., 2009). However, the commitment to individual experiences does not abstain from generalizations as examinations of each experience can lead to generalizable themes, offering a novel way of establishing generalizations (Smith & Shinebourne, 2012; Smith et al., 2009; Bloor & Wood, 2006).

These foundations enable the IPA researcher to interpret the participant's lived experience through an idiographic commitment to each case and a hermeneutic interpretation of each participant's account. A vital aspect of this research is the relationship between psychological presence and technological immersion. The concept of the lived experience explored through an IPA-based methodology aligns itself with the original research question because "presence is context-dependent and draws on the individual's subjective psychological response to [virtual reality]" (Dalgarno & Lee, 2010, p. 13). As such, an IPA methodology permits the tools for the researcher to explore presence through the interpretation of the participant's experience, enabling a richer understanding of presence in virtual environments by looking for diverging and converging themes in each individual account (Spiers & Smith, 2019).

Methods

This study utilized qualitative methods. Qualitative methods are best "used when little is known about a topic or phenomenon... [and] [i]t is commonly used to understand people's experiences and to express their perspectives" (Johnson & Christensen, 2014, p. 33). Unlike quantitative methods, which primarily focus on confirmatory research using the collection of quantifiable data, qualitative methods are exploratory, where the researcher constructs knowledge from data collected during fieldwork (Johnson & Christensen, 2014).

Data Collection

Unique to this study was the addition of a first-person oriented learning experience facilitated through virtual reality. The novel state of virtual reality required such an experience to be tailored to the needs of the participants. Likewise, the experience was developed in the Unity game engine (Unity Technologies, n.d.) and facilitated through the Oculus 2 (Facebook Technologies, n.d.) stand-alone headset. However, the headset was tethered to a computer to increase graphical fidelity. One virtual experience was planned that allowed participants to explore a one-to-one representation of the local solar system. Methodologically, the experience was primarily constructed following Fowler's (2015) *enhanced model of learning in 3D VLEs* (see Figure 4) because intended learning outcomes must be defined and incorporated into all developmental stages of the activity. Fowler's (2015) approach helped orient the experience by giving clearly defined goals through the intended learning outcome, reducing the theoretical boundaries of the research by constraining examinations of presence to an educational context. The experience was negotiated with the grade nine science teacher at J.C. Charyk Hanna School, the site of this study, and aligned with the grade nine Alberta curriculum, in which students explored the size and scale of the solar system through a semi-guided tour of the local celestial bodies in VR.

Another unique technological contribution to this study was the ability to record experiences from multiple perspectives. This approach to video recording was enabled through an inherent recording ability in the headset and a design approach that supports virtual cameras that can navigate the same virtual space as the participants. These videos enhanced semi-structured interviews by giving participants tangible points to jumpstart and enhance hermeneutic interpretations. For example, a participant and the researcher could watch a specific recording of their VR experience before an interview to help recap the experience; likewise, specific timeframes of experiences can be identified and elaborated upon through video analysis. Furthermore, it can be argued that such an approach encourages the participants to explore their understanding through multiple perspectives, which "can help the IPA analyst to develop a more detailed and multifaceted account of [the] phenomenon" (Smith et al., 2009, p. 53).

True to most IPA studies, data were collected primarily through in-depth one-on-one semi-structured interviews that allowed participants to talk in detail about their experiences (Smith et al., 2009). Interviews were video recorded, and various open-ended questions were used to connect the experience to the research questions and ensure an extensive array of rich data was accumulated. Both the interview and the learning activity took place in a private room within the school. Interview questions were broken down into three categories that mimic the simulation's debriefing process: (1) identifying and describing the encounter, (2) describing the emotional response or relation to presence that may have arisen, and (3) analyzing the experience (Fanning & Gaba, 2007). Some examples of broad questions used were:

- If you could describe this experience to a friend, what would you say?
- How did it feel to explore the solar system in this experience?
- How do you view the scale of the solar system?
- If you could experience this again, what would you do differently? What would you repeat?

An interview schedule was constructed in advance to help focus interviews. However, the schedule was flexible by nature, encouraging participants to be open and talk at length (Smith & Shinebourne, 2012). Each interview was about one hour in length; however, depending on the participant's engagement, this varied dramatically up to a maximum of eighty-four minutes, the time allocated for the final two periods of the school day. One interview and member check were scheduled for each participant. The member check was used to enhance the validity of the research (Koelsch, 2013) by allowing the participants to comment, correct errors, clarify their responses, and volunteer additional information (Lincoln & Guba, 1985). Member checking "...is a process in which collected data is *played back* to the informant to check for perceived accuracy and reactions" (Cho & Trent, 2006, p. 322). However, an edited video of the previous interview paired with a transcript was used to allow participants to understand the original context of their response.

Data Analysis

Data analysis was primarily concerned with information contributed through interviews. The first step of the analytical process was becoming immersed in the data by watching interviews multiple times, listening for subtle changes in tone or pace, where I took notes and added detailed interpretations later (Smith & Shinebourne, 2012; Spiers & Smith, 2019). Each interview transcript was constructed and analyzed independently to ensure an idiographic commitment, and each transcript was read and reread to deepen the sense of immersion with the data (Smith & Shinebourne, 2012; Spiers & Smith, 2019). Next, three categories of annotative notes were taken: (1) *descriptive notes* that helped describe the experience or what was going on for the participant; (2) *linguistic notes* that examined prominent uses of words looking for metaphors or phrases that have multiple meanings; and (3) *conceptual notes* that "...move[d] towards a deeper, more conceptual level of interpretation" (Spiers & Smith, 2019, p. 7).

Subsequently, the next stage of analysis was the collimation of these notes into broad emergent themes. The goal of these themes is to "allow the reader, as closely as possible, to step inside the experiences of the participant" (Spiers & Smith, 2019, p. 9). Converging and diverging themes were broken up and clustered into groups until each theme told a cohesive story about the lived experience of that participant (Spiers & Smith, 2019). This process was repeated for each participant, with every effort made to view each case independently. Finally, once each individual case was completed, a master table of themes was constructed for the entire group by looking for converging and diverging themes across all cases (Spiers & Smith, 2019). Major themes relevant to the majority of participants were used to define conclusions by creating a dialogue between the findings and related literature (Smith & Shinebourne, 2012; Spiers & Smith, 2019).

Limitations and Delimitations

IPA research tends to focus on people's experiences or understanding of a particular phenomenon leading to open research that is exploratory, not explanatory (Smith et al., 2009). These open questions can lead to problems when setting up the boundaries of the research and determining what defines success or constitutes failure (Salmon, 2003); as such, it is vital to acknowledge the theoretical boundaries of this study imposed through limitations and constructed through delimitations. A limitation identifies the weakness of potential studies outside the researcher's control (Theofanidis & Fountouki, 2018). Likewise, delimitations are restrictions imposed by the researcher to set the "boundaries or limits of their work so that the study's aims and objectives do not become impossible to achieve" (Theofanidis & Fountouki, 2018, p. 157).

One crucial methodological limitation of IPA research used in this thesis was the double hermeneutic effect. This effect is produced by the researcher "trying to make sense of the participant trying to make sense of what is happening to them" (Smith et al., 2009, p. 9). Meaning the researcher was playing a dual role, co-constructing the experience with the participant through their interpretation of it (Smith et al., 2009). The co-construction of the experience requires the researcher to establish rapport with the participants to ensure accurate depictions of their experiences (Smith & Shinebourne, 2012).

The research for this study was conducted at J.C. Charyk school in Hanna, Alberta. J.C. Charyk is part of the Prairieland School Division, which encompasses a large, rural region. The vast geographic landmass and scattered population will limit potential participants outside of the local community due to the vast distance they will need to travel to engage in the study. For this reason, participants were limited to students enrolled at the J.C. Charyk school.

Likewise, research was limited to regular school hours. A sample schedule can be viewed in Table 4; however, outside commitments, school activities, and other external factors greatly affected scheduling. Data collection and interviews were limited to the final two periods of the typical school day because these periods do not include any core classes, resulting in a daily eighty-four-minute time frame to collect data and administer possible testing.

Table 4

Preliminary Two Week Schedule

Monday	*Tuesday*	*Wednesday*	*Thursday*	*Friday*
● Activity for participant	● Debriefing participant	● Member Check	● Activity for participant	● Debriefing participant

• Member Check	• Activity for participant	• Debriefing participant	• Member Check	• Flex Day to catch up if needed

Note. This table represents a two week schedule that follows the idiographic style of IPA and plans for unpredictable issues.

Due to the nature of IPA and its association with idiography, a homogeneous convenience sampling method was used to determine participant suitability. Using a purposely selected homogeneous sample increases the likelihood that divergent experiences will result from individual differences rather than socioeconomic ones (Spiers & Smith, 2019). Likewise, a small sample size of about five participants was used because of IPA's elaborate and time-consuming data analysis (Smith & Shinebourne, 2012), aligning with Smith et al.'s (2009) recommendation of three to six participants for a Master's level IPA study. Due to the nature of the research question and the limited population pool, all willing participants were accepted based on the following delimiting criteria stated below:

- participants must be currently enrolled in the Prairie Land School Division;
- participants will need to be in grade nine;
- participants will need previous experience with virtual reality and not experience motion sickness while utilizing the technology;
- participants and their guardian(s) will need to agree to audio and video recording of the learning activity, group discussions, and interviews;
- participants and their guardian(s) will need to agree to the publication of data collected in this study.

A limitation discovered throughout the data collection phase was the possibility for the program to behave outside the scope of its design. While every effort was made to test and confirm interactions between different systems, it was probable that the complexity of this experience would have interactions that were not intended. An example of this that arose during data collection was how real-time light interacted with dust particles, refracting the light and creating a purple hue, a visually stunning but unintended interaction. The introduction of these unintended interactions may skew the experience for the participant.

Furthermore, there are many limitations to the hardware and software utilized throughout this study. This study did not attempt to recreate photorealistic representations despite Dalgarno and Lee's (2010) argument that greater representational fidelity will lead to higher degrees of immersion and presence. However, it did create high-fidelity graphical representations that closely resembled their real-life counterparts. The rationale for this approach is twofold: (1) the study used a tethered headset that was limited by the graphical capacity of the host computer, and (2) each activity should be designed with the pedagogical need in mind, requiring a more dynamic approach to the technological characteristics, questioning whether or not, or to what degree each characteristic will be needed to insight learning (Fowler, 2015).

Ethical Considerations

This research involved minors. Thus tremendous care was taken to reduce the risk of harm to participants. While there was limited physical risk to participants, one vital acknowledgement was cybersickness. Cybersickness, sometimes referred to as motion sickness, is the sense of discomfort, disorientation and nausea that some users may experience as they immerse themselves in immersive virtual environments (Munafo et al., 2016). Furthermore, cybersickness has been more prominent in female users (Makransky & Petersen, 2021; Munafo et al., 2016). Two strategies were used to contain and limit the risk of cybersickness: (1) participants had previous experience with virtual reality and did not experience cybersickness during its use, and (2) activities were designed to mimic traditional movements when possible and reduce visual stimuli if not possible. Finally, participants were able to remove themselves from any activity, and this right was clearly communicated to them. In the worst-case scenario, participants had access to the school's infirmary; however, this was never needed.

Likewise, transcripts of each interview and their recordings were stored on an external hard drive in a locked office. No external software was used to transcribe interviews. Anonymity was maintained by assigning a pseudonym to each participant. Consent from guardians was required for participants to take part in the study. Participants were able to remove themselves from any questions or activities. Likewise, if the participant or guardian wished, removal from the study could have occurred at any time; however, this right was never utilized. Finally, to limit the risk of communicable infections, diseases, or viruses, each participant received their own headset for the duration of the study. Furthermore, each headset was disinfected after use, and all necessary COVID-19 protocols were maintained throughout the study.

This study followed Yardley's (2000) criteria to ensure, assess, and validate the quality of the research through four principles: *sensitivity to context*, *commitment and rigour*, *transparency and coherence*, and *impact and importance*. Sensitivity to the context in an IPA study occurs at all stages of the research. According to Smith et al. (2009), it begins with purposeful sampling, moving towards an empathetic recognition of the interactional difficulties inherent in the interview process. Furthermore, the researcher must navigate the analytic methods through immersive and attentive interpretations of the participant's experience; and, finally, write up findings that are aware of existing literature, incorporating them into the discussion. Commitment is primarily expressed through "the degree of attentiveness to the participant during data collection and the care with which the analysis of each case is carried out" (Smith et al., 2009, p. 177), while rigour is demonstrated through in-depth engagement with the topic through all stages of the research (Yardley, 2016). Transparency and coherence were demonstrated through the methods described in this chapter and reflexive journaling (Spiers & Smith, 2019) during data collection and analysis. Finally, impact and importance were addressed during the study's write-up by connecting the literature to the findings (Spiers & Smith, 2019, Yardley, 2000).

Chapter 4: Findings

After interviews were done, cases were analyzed individually and cross-referenced to determine converging and diverging themes. Four themes emerged from the data: (1) a sense of presence, (2) a sense of learning, (3) a sense of autonomy, and (4) active engagement. This section explores each theme and its subsequent sub-themes (see Table 4), focusing on how they were formed through a hermeneutic interpretation of each participant's lived experience using interviews and observations. To ensure accountability, quotes from participants include the line numbers corresponding to interview transcripts.

Table 4

Themes

Group Themes	*Sub Themes*
A Sense of Presence	● Initial Impressions of the Virtual Experience ● A Feeling the Experience was Real ● Manipulation of Senses and Fostering Presence ● Interactions with the Environment Fostering Presence ● The Tension between Realism and Ease
A Sense of Learning	● How Learning was Perceived ● Conceptualization of the Learning Outcome ● Impression from First-Person Learning ● Articulation of First-Person Learning

A Sense of Autonomy	• Comparisons to Contemporary Instruction • Feeling of Exploration • Pedagogical Autonomy
Active Engagement	• Fun and Motivation • Dilation of Time • Curiosity

Note. A quick at-a-glance overview of the group and sub themes that arose from the data.

To better understand the subjective nature of learning and develop a foundational understanding for interpretations, each participant was asked to describe how they approached learning. While there were some overlaps, each learning account was unique to the individual and created insight into each participant's methodological approach to learning, often framing their learning through different modalities. Adam discussed how he focused on absorbing knowledge through videos, active participation, and exploration. *"I like visual things, I like doing things too, I like exploring things on my own, and I kinda like to see things... [I] watch videos of things because it helps me understand the learning that I am doing"* (Adam, 16). Like Adam, Frank and Netta believe they learn best through active engagement. Frank cites projects as his preferred approach, *"[I] prefer actual projects as opposed to just answering questions..."* (Frank, 11), while Netta likes *"...working with stuff"* (28). Both Sonia and Zara discussed more traditional approaches to learning. Sonia remarked she learns best through traditional classroom means, *"I learn better in lectures... I actually retain things if we're reading from textbooks..."* (Sonia, 11). At the same time, Zara spoke of her struggles to learn, often employing memorization techniques like flashcards to retain information for assessment.

A Sense of Presence

To better understand the lived experience of the participants, it is essential to explore how they experienced presence which is examined in chapter two. Consequently, the first group theme to be discussed is *a sense of presence.* This initial exploration helps frame later themes as many are closely related or directly resulting from the participant's conception of presence. Five sub-themes helped illuminate the experience of the participants:

- Initial impressions of the virtual experience,
- A feeling the experience was real,
- Manipulation of senses and fostering presence,
- Interactions with the environment fostering presence, and
- The tension between realism and ease.

The notion of Slater's place and plausibility illusion (2009) helped inform the state of presence, focusing on the envelopment of sensory-motor senses and interactions in the environment.

Initial Impressions of the Virtual Experience

All participants experienced presence; however, the degree and contributing factors seemed to vary depending on their familiarity with the technology and qualia associated with the experience. Frank and Netta, having far more experience using VR applications, focused on the similarities between this specific experience and their past experiences using the technology: *"I didn't feel like I was at school, I felt like I was... at home, and I just finished sideloading a big program and I was just having a ton of fun with it"* (Frank, 202). Likewise, Netta associated the experience with a game, stating, *"[i]t was like getting into a new game, you don't know what is going on yet, until you start looking around and then you figure it out"* (350). Adam, having some experience using the technology, compared the initial experience to other learning-based endeavours, focusing on the freedom and sense of learning; he remarked: *"I felt more... almost informed and free to do whatever I want, I had more freedom"* (Adam, 183). Zara, having the least experience and seeming overwhelmed, spoke to the manipulation of her senses, "*It felt a lot* *different than just like looking in the classroom, it was a lot darker, and it was in a different place… than I am used to"* (370). Sonia was more hesitant to express her initial reactions; instead, reflecting on the matter, declaring, *"I feel like everybody who used the VR... would... see it differently because there is different aspects and different things they could have explored"* (Sonia, 250). These different initial impressions of the environment help highlight how the participant's familiarity and beliefs impact the acceptance of the virtual experience.

A Feeling the Experience was Real

Even with various initial impressions, all participants stated they, at some point, believed the experience was genuine. Nevertheless, a diverse set of individual accounts informed this sense of realism. Adam focused on the technology stimulating his senses, *"...you can actually see with your own eyes, it's actually realistic"* (258). While Frank focused on how he interacted within the environment, *"...I actually thought I was traveling around space…"* (401). Others like Sonia and Zara spoke of a general sense of realism derived from the environment, *"I guess it felt really real"* (Sonia, 552). Finally, Netta explained, *"...you do forget sometimes that you are not actually there.. then you remember that you are not"* (400).

Netta's comment highlights the transient nature of presence. The concept of presence is often distilled to a static, binary state; either the virtual environment arouses a sense of presence or not. Such conceptualizations oversimplify presence to a particular state brought on by the virtual environment, leading to technocentric views such as presence being brought on by how well the environment simulates real-life through high fidelity graphics or how specific interactions mimic their physical world counterparts. These views ignore the individual's role in their conceptualization of the virtual space. While high fidelity graphics and realistic interactions can contribute to a sense of presence, the individual's preconceptions and emotional state are the foundation that enables their conceptualization of the environment. The individual processes each stimulus and interaction, contributing to their overall acceptance of the environment, which we define as presence.

Furthermore, this acceptance is ongoing, which is emphasized when Netta's virtual ship's interface stopped responding in the middle of her experience. Remarking, it *"...definitely took you out of it, and then we restarted, right, and then I got back into it"* (Netta, 747). Frank further comments on this phenomenon, *"that's more what it took me out... when I took my headset off for like a minute to get my water bottle"* (600). Others like Adam, Sonia, and Zara did not directly comment on their suspension of presence; however, it was observed that outside stimuli, like students over-zealously changing classes, school announcements, and bells seemed to remind students of the virtual nature of their experience, making them temporarily question their environment. Interestingly, Frank and Netta, having more experience in virtual environments, could verbalize their suspension directly, while others with limited experience did not comment or even acknowledge it. The differing reports on how different participants felt presence allude to presence being both a conscious and subconscious negotiation. However, since this phenomenon was outside the scope of this study, more research will be needed to identify and verify such claims. Nonetheless, presence is an ongoing negotiation between the participant and the virtual environment.

This negotiation was observed in some capacity with all participants. Frank, who had a vast array of experience in VR-based applications, struggled the most to control his spacecraft as he navigated the environment. Given Frank's experience, I was initially shocked, but as I observed his interactions with the ship, which itself was designed to simplify, yet mimic a possible space-faring craft, he was attempting to move the vessel by using the the buttons on the controller rather than interacting with the joysticks and controls in the virtual space. He was attributing this experience to the other programs, forcing himself to break a well-established habit consciously through actively engaging with the controls in the virtual environment rather than through the physical controllers. However, Frank viewed the controls as realistic despite his struggles, commenting, *"I think the controls would be pretty similar"* (456) when asked how this experience would compare to an actual spacecraft. In contrast, with minimal VR experience, Zara picked up the controls quickly, effortlessly moving between different celestial objects. These contrasting individual experiences help highlight how each participant navigates not only the environment but their particular interpretation of it, emphasizing the subjective nature of presence and how an individual's previous experiences, attitudes, and beliefs help guide their perception of their virtual space.

Manipulation of Senses and Fostering Presence

The ability for a virtual experience to envelop one's senses has often been touted as vital to fostering a sense of presence. Dalgarno and Lee (2010) focused on representational fidelity, the ability of the virtual environment to envelop the sensory-motor system to represent reality which they state should "...lead to a greater sense of presence and consequently, greater transfer" (p. 25). While, as noted above, my findings do not reinforce this statement, it is clear that how the virtual environment is represented plays a vital role in how a person interprets the virtual space, which, undoubtingly, leads to their construction of presence. The VR experience in this thesis focused on representing three senses in the virtual space: visual, auditory, and kinesthetic. The degree each sense was enveloped varied, with visual representation being near or total envelopment and kinesthetic limited to haptic feedback on the controllers.

Unsurprisingly, all participants cited the visual representation of the space, alluding to its vital role, though the degree this representation played did vary with each participant. Adam spoke of a sense of awe facilitated through the visual representation of the environment, *"I would say awestruck... because of the views honestly"* (216). Further elaborating, *"[t]hat is one thing that took me was the views - it was very beautiful"* (Adam, 130), reinforcing *"... it's more realistic, it gives more of a 3D world"* (Adam, 151). Concurring with Adam, Netta remarked that it was *"...interesting and... like beautiful, it was - like space is beautiful to look at"* (388). Further connecting the visual representation of the environment to her learning, *"...the facts that you learned and you had to memorize in grade six you could actually.. see them"* (Netta, 316). Frank and Sonia spoke of memorable experiences, *"I would... try [to] get some cinematic views of the planet in perspective with the Sun and the satellite and everything... because that's the... stuff I am going to remember, is those shots because... they just are more memorable…"* (Frank, 1116). *"I really liked going to Saturn.. because of the rings, that was really cool"* (Sonia, 329). Zara, rather than speaking to graphical representation, noted the scale of her experience, *"everything is a lot bigger.. or smaller, in some ways that I thought it was, like the scale.. of it all"* (674).

While visual representation played a vital role in constructing presence, manipulating other senses contributed to the experience. *"I had the feeling of.. sound and sight.. because I could hear what was going around me, I could hear, like, the spaceship moving, I could hear the voice when I, you know, went around in the orbit thing"* (Adam, 559). Others noted that other senses did not add to the experience, but the lack of certain aspects removed them from it. *"Like, in VR you can see that your ship is shaking right? But... if you were actually in the spaceship you would actually be shaking around..."* (Netta, 375). Likewise, Zara spoke of disconnection from the experience because she felt gravity, *"...you wouldn't have any gravity and it would just kinda be floating there"* (434).

Some spoke to manipulation of senses outside the scope of the experience, which speaks to the mind's power to invoke senses to align with expectations. When discussing the virtual Sun, Sonia said, *"I didn't realize it was that bright and that dangerous and hot"* (1016), further elaborating when questioned about feeling the heat of the Sun, *"I was kinda relating that to.. how it looked on the VR and then how it would actually feel in life"* (Sonia, 1030). Zara further stated, *"you were driving and stuff like that... the motions that you felt"* (181); when questioned, she asserted, *"...you could feel like.. moving almost"* (188). While these findings are outside the scope of this thesis, they speak to the subjective nature of presence, enforcing the individual's importance when constructing a sense of presence.

Interactions with the Environment Fostering Presence

The subsequent essential component in the construction of presence is the virtual environment's ability to behave within the participant's expectations. These expected behaviours are often signalled to participants by manipulating their senses, creating an integral link between believable interactions and the manipulation of the sensory-motor system when developing a sense of presence. However, participants seem to be less aware of this component of presence, tangentially speaking of its existence when it conducts within their expectations, with Zara exclaiming her favourite moment was *"...flying fast around all the planets"* (785), which itself was a complex interaction between her physical movements and the manipulation of three-dimensional space in response. Adam particularly relates the manipulation of the spacecraft to a submarine, explaining, *"...you get to control it... and with VR it feels more lifelike, you feel like you are actually on the controller and you feel like you're actually in the spacecraft"* (459).

Both Frank and Netta focused on their ability to manipulate the environment to create visual interactions that became memorable moments. *"[T]he dark side of Neptune... was really cool because... there is no... reflection of any other satellites that you can see on the other side of the planet, so it just looked like a big black circle"* (Frank, 359). Frank was explicitly speaking about the total darkness on the night side of Neptune resulting from it being the farthest planet from the Sun, which resulted in fewer light rays interacting with the planet, creating an abrupt contrast between the day and night side of the planet. Netta furthered this interaction, speaking of the manipulation of the Sun's size as they travelled around the solar system, "the Sun... was tiny, when you were out at the outer planets…" (176).

Other times participants spoke about spontaneous moments that captured their imaginations. *"I really liked going to Saturn... because of the rings... and... I don't know if it was the asteroid belt or if it was just ice... but when we found that purple area"* (Sonia, 329). In Sonia's case, she is speaking to two different interactions that embedded a sense of presence: (1) her spatial interaction with the rings of Saturn and (2) the interaction of light with these same rings. The first case focuses on an intentional design element of the VR experience in which Saturn's rings were developed to mimic billions of particles of dust which gave the impression of being solid from a distance, progressively becoming more granular as the participant closed the distance until it was transparent with small particles haphazardly scattered in the immediate vicinity. This process was designed to mimic Saturn's real rings; however, an unexpected side effect resulted from this when combined with real-time lighting, which led to Sonia's second case. When the light from the Sun hit the small particles in the ring, it would scatter at specific angles to create a purple hue that showered the surrounding area. The interaction between the artificial light and dust particles was not intentionally designed; it was unexpected and beautiful.

However, it is unlikely it mimicked the exact relationship between light and solar dust in its real-life counterpart. Nevertheless, this interaction incited wonder in the participant, further demonstrating a tension between realism and behaving within expectations.

The Tension between Realism and Ease

Currently, most of this section has focused on specific moments that have helped contribute to a sense of presence within participants. A comprehensive array of different moments and interactions have enabled this sense at an ostensibly random diffusion. While, in the broadest strokes, it can be stated that higher graphical fidelity creates a sense of presence, it ignores that presence is formed in the interactions with the individual. The individual defines their acceptance of the environment. Realistic representations and interactions that align with the individual's perceived acceptance of our current reality help create parallel connections between reality and virtual space. These connections allow acceptance of the virtual, not as real, but as a reasonable facsimile.

Adam discusses the concept of realism in virtual environments, focusing on what he believes would change if he experienced a similar lesson in space rather than in a virtual environment, *"I think the fact that one it is realistic and it's more real-life would change… [VR is] very close but they're [not] exactly pinpoint to real-life"* (234). Unpacking Adam's statement reveals his understanding of the virtual space, and despite *"...deeply recommend[ing] it... [because] it's a very immersive experience and you learn a lot"* (Adam, 89), he is aware that it is not real. This statement brings up a paradoxical divide that many have in the perception of immersion and presence. Often, "...virtual reality [is] ...defined as an environment created by a computer system that simulates a real situation" (Fernandez, 2017, p. 2); however, this confines virtual environments to reality and restricts all virtual experiences through these perceptions.

Virtual environments can move beyond the scope of reality into the bizarre and unexplainable, yet, it is still possible to experience a sense of presence in these environments. Such experiences are possible because "...presence is not even about realism" (Slater, 2018, p. 433). Slater (2018) further clarifies presence as an illusion of being there. While I acknowledge this perspective illuminates the perception of the virtual environment, I propose that the illusory nature removes the role of the individual in their construction and, hence, acceptance of the environment. The individual defines their illusion of the virtual space, either through conscious or subconscious means. While manipulating senses and believable interactions help facilitate this illusion, the individual must accept it. When considering a virtual environment for learning purposes, this view compels me to believe that presence is more an acceptance of the illusion than an involuntary reaction to external stimuli (Slater, 2018). The cognitive system needs to agree with the perceived stimuli to accept the illusion. However, this acceptance does not translate to the approval of the environment as real but a reasonable facsimile.

Let us examine some individual accounts to understand the subjective nature of presence and the tension between realism and ease. As discussed earlier, Frank had trouble controlling his vessel even though he had the most experience manipulating virtual environments because he had been trained to use external controls rather than manipulate items in virtual space. Despite his issues, he felt the control system was similar to an actual spacecraft, further elaborating, *"...the two joysticks, I know you probably wouldn't be controlling it with just one joystick, you obviously would need two"* (Frank, 457). In Frank's case, he had to fight against his natural inclinations and align them with, at least in this case, a more realistic alternative. This seemingly benign interaction exposes how environments can supersede established norms if the new reality aligns with an individual's expectations of what *should* be true. Emphasizing the individual's role in accepting the virtual environment and further postulating how virtual experiences outside the realm of traditional reality could become an adequate venue for learning.

Other participants remarked on how they manipulated their spacecraft and how it aligned with their preconceptions. Sonia concentrated on her shocked state of how easy it was to control, stating, *"I almost felt like it was going to be a lot harder than it was… like, in life, it's hard to drive a car, it's hard to drive a quad, it's hard to do all of that"* (571). Sonia felt the controls did not align with her concept of what should be true, momentarily, causing her to reflect on her experience and question its validity: *"And that could be because it was VR and obviously wasn't.. right?.. the real thing, but it felt easier almost"* (580). It is at this moment, when Sonia is reflecting on the experience, that she begins to question its validity as her previous experience tells her that she should have struggled more to control her ship. Curiously this questioning seemed to be isolated to this individual circumstance, not causing her to question the validity of the experience as a whole but that specific interaction; when later asked what would be the same between VR and an actual spacecraft, she commented, *"...you would obviously still be in space... you would still... be able to go wherever you wanted..."* (Sonia, 680). Zara, like Sonia, compared the controls of her spaceship to another, more relatable, real-world equivalency, a plane. However, she did not question these controls as likely the connection to something familiar was enough to placate any doubts. *"[I]t felt like you were.. in a plane almost… like the way you were driving and stuff"* (Zara, 172). Furthermore, Netta, having previous experience designing and constructing electronics and robotics, viewed the controls as something that could be created: *"…if you are saying that the spaceship will be the exact same then the controls will be the same and all of that, obviously"* (411).

When it comes to presence, especially presence for learning, the individual plays a vital role in accepting the virtual environment. Initially, this section discussed the tension between realism and ease in VR experiences. However, as alluded, it is more of a tension between the individual's perception and ease of use. The goal of the virtual learning experience should be to create an authentic enough facsimile to align with the expectations of the targeted participant or group. Photo-realistic graphical fidelity and full-body haptic feedback can, in many cases, help induce a state of presence; nevertheless, this presence is predicated on the approval of the individual. If the particular interactions within the virtual space do not align with the perceived reality, they will be ignored as they are not credible in the individual's mind.

A Sense of Learning

An intriguing development enabled through presence was a profound sense of learning in all participants. This sense of learning expanded on the traditional accumulation of knowledge, often resulting in an experiential understanding of a concept rather than a symbolic representation. To sufficiently comprehend the empowerment and struggles of each participant's learning, four sub-themes help inform their experiences:

- How learning was perceived,
- Conceptualization of the learning outcome,
- Impressions of first-person learning, and
- Articulation of first-person learning.

Winn's (1993) interpretation of learning through first and third-person means will heavily influence this section as it became a prominent struggle for participants as they attempted to express their learning. Symbolic knowledge results from the third-person engagement of specific symbolic structures that help define a concept, for example, language or mathematical formulas

(Winn, 1993). Likewise, first-person learning results from direct interaction with the environment, resulting in the construction of non-symbolic knowledge (Winn, 1993).

How Learning was Perceived

The goal of the virtual experience was for participants to have a more robust understanding of the scale of local space, moving beyond symbolic representations to non-symbolic knowledge. Specifically, a to-scale virtual solar system was constructed that mimicked real space to facilitate this understanding. Participants expressed their learning in this environment through various means, yet a sense of adjustment and confusion permeated most accounts.

Sonia, who felt traditional lecture-style education was the most effective, was dumbfounded to explain her learning experience. *"It's different, but I don't know how to explain it"* (311). Furthermore, Sonia described her struggles with project-based learning, *"I can apply [learning] to hands-on things when we do that after, but if they give me a project... that I don't know anything about what I suppose to be learning ... I don't really learn"* (14). It is evident through Sonia's account that she views learning as the accumulation of symbolic knowledge that can be easily expressed and demonstrated. This view put her at odds with her virtual experience, as she felt like she was learning but could not directly articulate it because it was primarily focused on the experiential or first-person domains.

Netta depicted a state of bewilderment when describing her learning; however, unlike Sonia, she attached an emotional quality to the activity. *"...[T]o experience space like that was.. I don't know how to explain it, like.. you were just in... awe..."* (Netta, 271). Later, when asked to precisely describe what she learned, she immediately became anxious, nervously laughing out, *"[o]h god, now you are testing my knowledge"* (Netta, 291). After reassurances that I was not looking for random facts, she described her experience, stating, *"...you could... see... all the facts that you learned"* (Netta, 309). This exchange encapsulates the current state of learning in K-12 systems. Netta initially expressed awe as she explored the virtual space. However, when asked to depict what she retained, she reverted to symbolic knowledge despite being a primarily first-person experience, demonstrating the scarcity of significance allotted to non-symbolic knowledge in the current education system.

Much like Netta, Adam attached an emotional attribute to his perception of what he learned. *"I would probably explain it as a way to have fun, yet... still learning…"* (Adam, 332). Adam's fixation on the fun of the activity was brought on by comparing it to traditional classroom lessons, *"I always thought that... you know... schoolwork, was just, school work... you know?"* (377). He elaborated on the learning, stating it's like *"...seeing things from a different angle..."* (Adam, 61) that leads to *"...a great[er] perspective, it's fun, it's all those things"* (Adam, 340). From Adam's perspective, first-person learning seemed vital as it helped create a more engaging experience, leading to more enjoyment.

Frank and Zara, who earlier expressed that they struggled to retain knowledge in school, had a more grounded interpretation of how they were learning. Frank discussed his learning as *"...catch[ing] on to what's going on... and not even knowing it, and that is more fun"* (688); additionally elaborating, *"I [was] just subconsciously taking in what's happening"* (696). Likewise, Zara viewed her learning as *"...more me learning myself and like, figuring it out as I went"* (563). Both participants' responses suggest a form of comprehension of how they were learning, conflicting with other accounts. While outside the scope of this thesis, it is easy to imagine that this familiarity with first-person learning is a direct response to their struggles with the symbolic nature of education, causing them to be saturated in more exploratory means of learning that result in non-symbolic knowledge.

Conceptualization of the Learning Outcome

Despite many participants struggling to express how they learned, all exhibited a greater comprehension of the learning outcome. As the scale of the local space is related to previous learning they have done, participants compared their new, first-person conceptualizations of the outcome to their prior symbolic knowledge. *"[I]n grade six, it was kinda like — oh yeah, planets are huge — but I couldn't tell how big they actually were until this experience"* (Sonia, 885). Agreeing with Sonia's assessment, Adam explained, *"I view it as a lot larger than I used to think. I used to think that it maybe was... big — but I never imagined it was that big..."* (309); with Zara concurring, *"...a lot of the planets are bigger and smaller than I expected, when I actually flew around them"* (228). Frank attempted to quantify the experience, resulting in a seemingly hyperbolic statement, *"I thought it was large before now [and now] I know it's like.. probably eight hundred-thousand times larger than I thought it was..."* (728). Finally, Netta discussed the disconnection she had with her previous learning, *"I felt really small... all the planets were so much bigger than I expected and... you learn [about] the size of the planets in kilometers, but you can't really... think of it, like you can't visualize it"* (148).

Visualization through a sense of being there, or presence, became central to this new understanding of the outcome. Instead of each planet being an abstract notion that participants simply acknowledged as existing, they became a unique, relatable entity, with different *"...sizes and everything, [in which] you could tell the difference when you were actually there"* (Sonia, 367). It became clear that symbolic structures, such as numbers that saturated participants' previous understandings of the outcome, created little to no connection when they constructed their knowledge. *"Like in a textbook, it's hard because — oh it's this big, the size of three football fields — but, it is hard to visualize that... [u]ntil you're actually there and can actually... look at how big it really is..."* (Sonia, 369). Likewise, in some cases, these symbolic structures created misconceptions, *"I know this sounds funny, but I always thought the planets were quite close together... [because] they don't actually put, you know, how far apart they are on maps of the solar system"* (Netta, 529). Later she expanded this thought, *"...they might put a distance between the Earth and the Sun, or the Earth and the Moon, but like, you can't comprehend that either, and... you just expect them to be close..."* (Netta, 548).

It is unlikely that any participants could give a detailed explanation of the solar system's scale that would convey the breadth of their experience. Yet, a similar disconnect is present in the symbolic expression of knowledge which can be illuminated by diving deeper into our understanding of symbolic knowledge. When someone states that the solar system is enormous, it is easy to agree without further exploring its meaning. However, the word enormous is subjective to the individual expressing it. We could ask for clarification, such as an expression in a specific metric or further postulating their definition of it.

Nonetheless, as we construct new symbolic structures to make sense of a given concept, it is often futile for many as no previous knowledge can act as an intermediate that creates a relatable schema while attempting to understand this new notion. This issue becomes evident when exploring symbolic representations of specific scenarios that fall outside the scope of ordinary human existence. *"[T]hey tell you and say — oh, it's however many million light-years away — but you don't really know that until you are actually there experiencing it... [and] I didn't know... what a light-year was..."* (Sonia, 891). Traditionally, I would explain to her that a light-year is nearly ten trillion kilometres, yet this quantity is so large it is hard to comprehend, and this became evident when she was asked to explain a light-year, and she responded, *"[w]ell, do I even know now?"* (Sonia, 902).

As participants explored the virtual solar system, they created new connections that laid the foundation for new knowledge. Unlike purely symbolic means, this experience gave them a first-hand account of their learning, filling an intermediary gap and giving participants a relatable point to build new knowledge. However, these first-person accounts are solely unique to the individual, informing a different perspective on learning that was often outside the norms of most participants.

Impression from First-Person Learning

Understanding first-person learning was relatively problematic for most participants. It is hard to specify the cause of such troubles accurately; nevertheless, it is likely a skill underutilized in the participants' daily lives. However, examining participants' impressions of their learning can lead to a better understanding of first-person accounts, which could help inform future experiences. Through this virtual experience, a growing consensus discussed by most participants formed: a shift in their perspective helped shape their learning.

Evidence of this shift can be found in statements like, *"[i]t's more of a realistic stand-point [for] that piece of information"* (Adam, 103); it is like *"...seeing things from a different angle"* (Adam, 61). The different angle that Adam discussed could be viewed as simply a spatial change, in which he was allowed to see various celestial objects from differing angles; however, it is unlikely this conveys his intention. *"[T]his program was something that honestly really changed my mind and my viewpoint about the solar system"* (Adam, 514). Furthermore, Zara tackles this perspective, *"I think that, like VR, it helps me because I can see it in different* *ways and [from] different perspectives... [r]ather than just seeing it on the board or in a textbook... it's just something different"* (688).

Frank echoes this diverging view, *"...it definitely felt a lot different... than just, learning.. what the solar system was"* (375). *"[I]nstead of being told... this is the colour of this planet or this is... what the rings are made out of... I am just exploring the rings... I can tell [what] it's made of... it's kind of observing things..."* (Frank, 711). The notion of observing things aligns with Winn's (1993) views on non-symbolic interactions in which the participant can act with the virtual space through natural means, which allows the construction of knowledge to be formed contextually.

A more contextual learning process allows possible learners to approach the concept through various methods, providing autonomy over their learning. *"[W]hen you see things in person... you can have your own thoughts on it... when I went in the VR space... I got to make my own opinions on it"* (Netta, 925). Netta's view came from an acknowledgement that she was not being told facts; instead, she *"...figured them out, and... just saw everything"* (643). Sonia described a similar process, *"I... went to every planet and it was the same, but it wasn't... when we went there it was always cool to find something... new... [a]nd look at... everything that's different about each individual planet"* (353).

In the constructivist framework, learning is best defined through the active exposure to the original materials' environment, allowing the learner to engage in the world directly and derive meaning from it (Bada & Olusegun, 2015). By examining the data, it became clear that the virtual environment created for this experience was a suitable substitute for the world. Considering the original research questions, mainly how presence contributes to learning, a reasonable conclusion can be drawn. Presence is the capacity of an individual to accept the virtual environment as a reasonable facsimile of what they perceive as authentic, creating opportunities for contextual engagement in the environment that directly expose the individual to the material and allow for the construction of meaning. However, meaning constructed through this means is primarily non-symbolic, creating tensions when attempting to convey what was learned.

Articulation of First-Person Learning

Despite evidence of engagement with the virtual environment, participants struggled to express their first-person, non-symbolic knowledge. This struggle became evident when asked to describe specific proofs of what they learned, as participants would often stumble in assembling the language to articulate their experience, leading to overly generalized statements or shutting down during interviews.

Zara remarked she learned about *“...different moons and stuff like that... that there is a thick atmosphere on some of them... and... that it takes a long time to go from planet to planet... I don’t know... there’s lots...”* (150). After more thought, she explained, *“...I feel like there is more, but I can’t honestly remember”* (Zara, 165). It was clear that Zara was unsure how to express her knowledge, often resulting in her disengaging in the interview with statements like, *I don’t know*, or *I can’t remember*. A cursory glance at these results could mean that Zara learned very little from this experience despite feeling she *“...learned new things”* (Zara, 293). However, by utilizing the *Experiential Learning Cycle* (Kolb & Kolb, 2009), it became clear that Zara was struggling to reflect on her observations which hampered her ability to assemble new abstract conceptualizations based on this experience.

Adam also struggled to express his first-person learning. *“I think it helped in... terms of learning, what each planet is about ...how many satellites, learning how big it is, learning the* *different parts, and... overall, like I said, being more informed about the solar system"* (Adam, 360). The concept of being informed was an ongoing theme for Adam, yet he struggled to express this feeling. *"[T]here [are] things that I didn't know about the solar system and a lot of things like, like the shape of, like... um..."* (Adam, 115). He often broke down into thought as he attempted to express this sensation, resulting in fragmented explanations. *"Um, and there is also things like the shapes the... um... moon and stuff, like it makes it look more... um.. zoomed in so you see more of it..."* (Adam, 120). I believe Adam was trying to express that the virtual experience allowed him to explore from nearly infinite perspectives, which gave the impression of the experience being *more than the sum of its parts* because it mimicked what he believed reality would be. However, as he attempted to filter his experience through symbolic language, he stopped as he was aware that it did not convey the breadth of his experience, resulting in pauses, stutters, and false starts.

Similar to Zara and Adam, when Sonia discussed what she had learned, she focused on the generalizable at first, stating she learned about *"...the size of the planets, how far they are apart, [and] how bright the sun actually is"* (Sonia, 1010). However, when Sonia explained her interactions with the Sun, her tone shifted to a first-person perspective, comparing her already embedded real-life exchanges with the Sun to her new virtually created view. *"[Y]ou could see [the Sun] from each of the planets that I visited and... we think it is bright, you have to wear sunglasses and you shouldn't look at it, but.. I didn't realize it was that bright…"* (Sonia, 1013). Likewise, when describing the distance between planets in more detail, she stated, *"...if you were to stand on the beach and look at the ocean you can't see the end of it, but that was all around you in space, it went on forever"* (Sonia, 1098). As Sonia continued to reflect on her experience, looking for ways to express herself, her explanations changed from generalizable statements to relatable personal experiences and finally ended with group analogies that she hoped would convey the scope of her experience.

Frank used previous learning when discussing his non-symbolic knowledge, comparing and contrasting the different views. Initially, he was dubious of what he could learn from the experience citing his firm grasp of the concept. *"I'm going into grade nine science, I know pretty much everything about space, I mean, what is there much to know?"* (Frank, 835). He quickly added, *"...actually, way more than I thought"* (Frank, 838). Formerly, Frank viewed planets other than Earth as muddled spheres that had no meaning or connection to his life. *"[T]he... planets that I was visiting are.. probably... I am pretty sure as detailed as Earth, each planet and not just one... uh... gigantic ball of one element like, or... like two elements, like I thought it would be…"* (Frank, 839). Further elaborating, *"...each planet is so different from... Earth or the last planet that is kinda crazy"* (Frank, 856). Despite having a plethora of different anecdotal events that created meaningful learning for Frank, he struggled to express his non-symbolic knowledge.

Much like the other participants, Netta struggled to express her first-person knowledge. However, she embraced and discussed this conflict. *"I feel like I just learned so much that I can't figure out what I actually learned in total*" (Netta, 623). Netta attempted to convey the struggles of distilling all her learning into a few words that accurately depicted the magnitude of her experience. *"I feel like I learned a lot, but I can't like... think of all the things I have learned specifically, or like, non-specifically, I can't just like, put it into words, I don't know how"* (Netta, 604). As she further explored this topic, it became evident that she was focused on specific facts rather than explaining her experience. *"I just feel like.. overwhelmed when I need to say what I have learned... it wasn't overwhelming in the actual VR, like that was totally fine... I just don't know how to explain... what I actually learned"* (Netta, 632). Ultimately, she added, *"... you* *didn't learn any facts, right? ...No, you figured them out... [a]nd, like you — you just saw everything"* (Netta, 638).

As discussed throughout this section, each participant was generally unable to illustrate their non-symbolic, first-person learning. However, I do not believe this is an issue with maturation or a lack of expertise in the English language. It seems more likely that the limiting factor in their struggles is the language itself. One way to understand this struggle is to explore the domain of the mind-philosophy.

In this view, possible experiences can be divided into three perspective realities: subjective, objective, and propositional (Goertzel, 2006). Objective reality is embedded in the physical reality and is defined by science and society; likewise, subjective reality is based on an individual's experience and the meaning they make through this experience; and propositional reality uses logical statements that the speaker and listener can understand through linguistic interactions (Goertzel, 2006). In many cases, language can be viewed as an expression of propositional reality. Two participating groups need to reach a mutual agreement to convey the subjective; however, a long chain of derivations must be navigated to reach this agreement (Goertzel, 2006). As participants attempted to articulate their subjective realities, they had to derive generalizable linguistic interactions that obfuscated their original intent. Complexity was lost with each translation from the subjective of the speaker to the propositional back to the subjective of the listener, leading participants to question how best to articulate their experience resulting in broken statements and limited objective representations.

A Sense of Autonomy

An unexpected result of this research was the sense of autonomy experienced by all participants. As participants revisited their learning experience, each discussed the freedom they felt. Three sub-themes help inform this sense:

- Comparisons to contemporary instruction,
- Feeling of exploration, and
- Pedagogical autonomy.

Initially, the sense of freedom was attributed to spatial liberty, as there was freedom to explore within the environment; however, as different accounts became clear, spatial freedom could only account for a tiny facet of this sense.

Comparisons to Contemporary Instruction

Many participants compared their virtual experience to contemporary instructional methods. This comparison makes sense as the virtual experience was framed to each participant as a learning experience. Even though each participant had self-identified vastly different learning preferences, all participants felt the virtual experience added something that surpassed other instructional strategies.

Sonia and Zara discussed how this experience allowed them to view things from a different perspective that helped solidify their knowledge despite initially stating they comprehended new knowledge best through traditional rote methods. Sonia preferred learning through textbooks and Zara through cue cards. Zara focused on creating a different perspective: *"I ... see it in different ways... [r]ather than just seeing it on the board, or in a textbook... it's just something different"* (688). Sonia examined her previous experience learning about the topic. *"[Y]ou would learn about it, and you just try to apply that knowledge to what you think is* *actually true, but you never got that confirmation within space because you can't actually go there"* (Sonia, 789).

Frank and Adam gave the impression that they felt trapped in the classroom, discussing how everyday school life has become monotonous. Both viewed school as a place where *"...you have to answer this question... [y]ou have to do this..."* (Adam, 185) as the teacher is at the front *"...telling everyone what to do, telling you, this is what you are doing..."* (Frank, 887). Frank elaborated on his school experience: *"I did this objective now I need to do this objective and then I need to do this objective, like, a linear path to the goal that you are trying to learn"* (682). Instead, both enjoyed VR because *"...it provided something different to do than regular school work..."* (Adam, 520) because you *"...catch on to what's going on while you are doing [it] and not even knowing it and that is more fun"* (Frank, 688).

Netta agreed with the others, stating, *"[i]t was a different way to learn..."* (654), further commenting on how VR gave her more control over her learning. *"Like, you come to school and.. you go to classes, and you listen to your teacher, but with VR you could do all that on your own, and you could figure it out for yourself"* (Netta, 655). Netta was able to compare her classroom experience to her previous experiential learning. *"I always find that when you are trying to teach yourself something, I find you learn it better... you didn't have someone tell it to you or make you learn it, you wanted to learn it"* (Netta, 661).

Feeling of Exploration

All participants depicted a feeling of exploration. This experience was intentionally crafted to understand the scale of local space through an experiential process rather than a symbolic one. Participant exploration was designed at the software development and pedagogical implication levels; as such, a sense of exploration was expected.

The sense of exploration came from the autonomy of controlling their spacecraft while searching virtual space. *"I think it was fun because you get to explore around on your own…"* (Adam, 271). *"I think it was just being able to go.. anywhere... I was in my own spacecraft, which I could control"* (Sonia, 480). Participants became drivers of their learning which motivated them to continue. *"[I]t was a really cool experience,* obviously*, to be in a spaceship... to fly around space and stuff…"* (Frank, 137). This motivation further developed a sense of awe, which was hard to express. *"[I]t was just so cool to be able to fly around space.. and.. look at all the planets and stars…"* (Netta, 323).

It was clear that the virtual environment contributed to a sense of exploration; however, highlighting this exploration was a sense of autonomy. While participants could explore a to-scale virtual solar system, most commented on their ability to control this exploration. The exploration was enabled through the capacities and design of the virtual environment, while autonomy was encouraged through a non-symbolic approach to pedagogy through an experiential learning methodology.

Pedagogical Autonomy

Pedagogical autonomy is the notion of being in control of one's learning. Each participant reported a profound sense of control or freedom. As stated earlier, this freedom was initially associated with spatial-kinetic freedom. Yet, as data were analyzed, it became evident that the virtual environment's spatial freedom acted more as an enabler. It created a virtual space that facilitated exploration allowing for the pedagogical liberation of participants.

Participants view their pedagogical autonomy as learning that is self-directed. *"I kinda got to explore on my own a little bit and that was honestly pretty cool and fun I'd say*" (Adam, 436). This autonomy fostered ownership of their learning. *"It was more me learning myself and* *like, figuring it out as I went…*" (Zara, 563). Sonia specifically spoke of an emancipating feeling as she engaged in the activity compared to the strict boundaries of her school life, *"...it felt really good to just be in control and just.. be free…"* (722). Others focused on the instructional autonomy they felt compared to traditional classroom activities. "[I]*t felt like it was.. a lot more focused on... what I want to do, instead of what the teacher wanted me to do…" (Frank, 987). "[Y]ou come to school and... you go to classes, and you listen to your teacher, but with VR you could do all that on your own, and you could figure it out for yourself"* (Netta, 655).

Despite the presumption that participants felt they were learning independently, a great deal of care and planning went into the activity to foster an environment that enabled first-person non-symbolic learning. This carefully constructed environment allowed learning through interactions within it rather than through abstract symbolism often employed in the classroom. Interestingly, as the virtual environment was the primary means of learning, the pedagogical implementation of the activity required minimal classroom management and scoping strategies, changing the role of the teacher to a guide. Minimal instructions were given to participants outside the intent of exploring the local solar system and visiting all the planets, as the activity's primary purpose was to experience local space and not the accumulation of symbolic knowledge. Adam discussed this suspension of expectations:

> *Well, what I thought we would do, was I thought it would be something like you would be in control a bit and take me around and stuff and then, maybe at the very end, I would get to play around with the controls myself. But, when I did the program, obviously, I pretty much had most of the free range of motion, so... um... I kinda got to explore on my own a little bit, and that was honestly pretty cool and fun, I'd say.* (436)

Active Engagement

The final group theme to be discussed will be the participants' active engagement in their learning throughout the study. As the research was deeply embedded in experiential and constructivist theoretical frameworks, it was expected that a significant level of engagement would be reached. In many ways, immersive virtual learning follows the *learning by doing* conceptual underpinnings in which participants were placed in authentic situations, which were viewed as plausible through a sense of presence, where they had to apply their knowledge and develop a conceptual understanding (Munge et al., 2017). Ultimately, participants were drivers of their own learning, while design factors and presence acted as facilitators. Therefore, a careful examination of engagement could help illuminate how virtual learning experiences enable participants' learning by doing. This theme is divided into three subcategories:

- Fun and motivation,
- Dilation of time, and
- Curiosity.

Fun and Motivation

Each participant expressed excitement and willingness to continue with the activity, with some searching out similar experiences. *"I haven't actually been able to do this on my own VR headset, I don't know if there is any way you can..."* (Frank, 378). *"[I]t's probably something that I will only do once... [because] it's yours..."* (Netta, 76).

The purpose of the activity was to create an experience comparable to real space to allow participants to understand the scale of the local solar system. An unintended, though not an unexpected byproduct of this creation, was the degree of fun and engagement that participants reported. *"I think I was just having a blast with it, honestly"* (Frank, 667). Adam mentioned, "*[I]t was fun because... you get to explore around on your own and it makes it sorta of like a game…*"

(271). Freedom was a common theme cited among participants as a rationale for their engagement. *"[W]ould it make sense if I said it was an engaging experience?"* (Zara, 112). Sonia agreed, *"...it was really cool, and I wanted to.. like I wanted to explore…"* (270). *"It was just so cool to be able to fly around space... and... look at all the planets and star... er, and the stars all around you and moons and... everything, it was just really cool to see"* (Netta, 323).

Undoubtedly, an extensive array of individual factors resulted in the level of engagement demonstrated in this sample size. However, all participants affirmed that a sense of freedom encouraged them to explore the environment. Thus one of the critical drivers of fun and motivation in this experience was freedom.

Dilation of Time

The virtual learning activity was completed in approximately eighty minutes over one session near the school day's end. All participants used the total session length, with some choosing to stay after the session to finish their current activity. Despite the relatively long session time, all participants apprised their time in the virtual experience was shorter than their allotted eighty minutes.

The degree of time dilation varied between participants, yet all reported that time seemed to pass at an increased rate. *"[T]o me it felt... half-an-hour?"* (Netta, 447). Likewise, most participants attributed this dilation of time to the fun they were having. *"[I]t did feel, obviously, shorter than what a regular class would be cuz I was actually having quite a bit of fun..."* (Frank, 634). Adam and Zara spoke, *"...time [flew] by"* (Adam, 264) because *"...I just had fun like, exploring around..."* (Zara, 512). Sonia commented on her perspective of time dilation and the willingness to engage in the activity longer: *"I don't know, the hour and a half I was on there felt* *really fast... I guess if you were to do it all day, you could explore more of each of the planets, but I only got to explore so much"* (754).

The *flow experience* phenomenon could be responsible for the time dilation conveyed across participants. Flow is the feeling of doing something that is "...so enjoyable that you want to pursue them for their own sake" (Csikszentmihalyi, 2014, p. 132). In a flow state, "...time seems to fly, that hours pass by in what seems like minutes" (Csikszentmihalyi, 2014, p. 137). A vague overarching purpose, exploring the local solar system, was given to all participants to achieve this flow state. Each participant had to navigate a self-defined series of small steps they needed to take to achieve their original goal.

Furthermore, each step they defined and acted upon gave immediate feedback based on their actions. For example, if a participant chose to fly to a moon, the moon would become larger and more detailed as they approached it. As Csikszentmihalyi (2014) states, flow is achieved through the uninterrupted balance of challenge and skill where the goals are clear. The virtual experience seemed to be naturally conducive to a state of flow in participants as the challenge was to experience the local space, something that is near impossible to undergo in current life.

Curiosity

Curiosity is essential for education, inquiry, and knowledge (Schmitt & Lahroodi, 2008). Today, many pedagogical approaches, such as project-based learning and inquiry-based learning, acknowledge the value of curiosity in education. These approaches are rooted in constructivism and experiential learning philosophies, emphasizing learners defining their inquiries and instructional strategies (Pluck & Johnson, 2011). The virtual experience is innately focused on inducing curiosity because it is theoretically underpinned by constructivism and experiential perspectives.

"I never imagined that we would be beyond our wildest dreams, and it continues to grow as we find... new... celestial objects" (Adam, 313). Specific interactions with the virtual environment expanded individual perspectives and incited curiosity. *"I was really surprised at the amount of stars because some of those stars are as big as our planet, so... just seeing how many of, maybe our planet that's out there just was really intriguing"* (Frank, 322). Sonia's curiosity was provoked as she explored the interactions she had with Saturn's rings and dense atmosphere: *"I liked to... learn more about how to go into the atmosphere... [a]nd, especially about the... ice and learn, and the refraction ice and how that actually works"* (380). Furthermore, others express a general curiosity regarding space, with Zara stating, *"[I am] more intrigued with like, what goes on... in space"* (330). *"[I]t be cool to check out some of the stars and find more constellations and moons and things like that"* (Sonia, 763). Netta focused on pushing the boundaries of the virtual experience, wanting to visit the local star, Sol, even knowing it would take days of travel time; which was expressed when asked what else she would like to do in the virtual experience: "*I mean other than try to fly towards the Sun and take forever"* (771).

To encourage curiosity, each interaction within the virtual space needed to be designed to be plausible to the participant. What made specific interactions meaningful depended on the individual experiencing them. If an interaction is plausible, it is accepted as possible, encouraging the participant to discover and develop new *abstract conceptualizations* (Kolb, 2015), inciting curiosity.

Chapter 5: Discussion

Many different phenomena appeared during the analysis of the data. To keep this thesis concise and focused, only three topics will be explored in-depth: (1) virtual presence and learning, (2) autonomy illusion, and (3) symbolic and non-symbolic tensions. However, this does not mean other topics do not represent value to learning and presence or are not worthy of future research.

One specific matter that should be explored in the future is the phenomenon of sensory input outside the scope of the experience. In particular, the feeling of heat when looking at the Sun (Sonia, 585) or the notion of physically moving when manipulating the spacecraft (Zara, 188). Both these participants reported feeling sensations in coherence with their virtual experience, yet outside the scope of sensory manipulation. Psychologically, sensory events are highly subjective, varying from one individual to another, most likely resulting from past experience and future predictions about the stimulus (Koyama et al., 2005). In Sonia's case, she expected the Sun to be warm, and thus her brain created the sensory input to align with this expectation. However, given the scope of this paper, a further dive into the psychological rationales and neurological meanings of this phenomenon will not be possible; still, it incites many questions about how these phantom sensations could be utilized in education and beyond.

Virtual Presence and Learning

Before discussing how virtual reality and presence may impact learning, an understanding of learning needs to be addressed. At a glance, such inquiries seem unwarranted. However, it is essential to remember that "there is no one definition of learning that is universally accepted by theorists, researchers, and practitioners" (Schunk, 2011, p. 3). Schunk (2011) further proposes that learning requires three criteria: it involves change, endures over time, and occurs through experience. As this thesis is primarily viewed through a constructivist lens, I would further postulate that not all changes incited from learning experiences can be objectively observed. This perspective is informed by the belief that learning occurs in the mind of the observer or from the view of a constructivist, the active participant (Bada & Olusegun, 2015; Cooper, 1993; Rannikmäe et al., 2020). In this view, learning is subjective to the individual; therefore, their conceptualizations of what was learned cannot easily be observed outside the context of their mind. This phenomenon was observed in chapter four, where participants struggled to articulate their first-person experiences. In summary, learning involves change based on experience that endures over time; however, it cannot always be observed from an outside party.

The next lingering issue that must be further explored is presence. As investigated in chapter two, presence is the sense of being there (Slater, 2018). Slater's (2009) paper describes presence as two forms of illusion: place and plausibility illusion. Place illusion is the strong illusion of being in a place brought on by manipulating various senses, while plausibility illusion is the illusion of the events in the virtual environment as real (Slater, 2009). Furthermore, Slater (2009) has "...considered [plausibility illusion] as an automatic and rapid response of the human participant to the important issue" (p. 3555). This view is particularly concerning in a constructivist educational context where learning is the active construction of knowledge (Rannikmäe et al., 2020) and not an involuntary action or data transmission.

Using the learning criteria above, it is evident that learning occurred that went beyond knowledge to a greater understanding of complex concepts. Evidence of this can be viewed in Sonia's statement about the vastness of space: *"...if you were to stand on the beach and look at the ocean you can't see the end of it, but that was all around you in space, it went on forever..."* (1098). Sonia's statement exemplifies virtual learning as her view of space has permanently changed through experience, and, in this case, she was able to articulate this learning. Furthermore, Sonia's statement came after deep reflection during the interview process, in which she had ample time to disregard the virtual experience as solely an illusion. This learning experience is not limited to Sonia and was expressed by all participants to varying degrees of articulation, as demonstrated in chapter four.

It could be that presence is an involuntary reaction to a given stimulus. "The whole point of presence is that it is the *illusion* of being there" (Slater, 2018, p. 432), further elaborating that presence is a "...perceptual but not cognitive illusion... [where] the brain-body system automatically and rapidly react... while the cognitive system relatively slowly catches up and concludes *but I know that this isn't real*" (Slater, 2018, p. 432). Here is where the issues arise, and we must ponder if presence ends once the cognitive mind takes over the initial reaction to the stimulus. Place illusion seems particularly aligned with these involuntary responses to sensory stimuli. However, through an educational constructivist lens, plausibility illusion does not.

I acknowledge that there are involuntary responses to specific interactions. For example, if I were to push a cup off a table accidentally, my body would respond before my cognitive mind could comprehend the situation. If I catch the cup or it shatters on the ground, my cognitive mind does not question the validity of the events as it aligns with my expectations of what should be. However, if I reacted quickly enough that I *should have* caught the cup and it fell *through* my hand, my cognitive mind would become confused and question if the event had occurred. My cognitive response would be the same whether this occurred in a virtual environment or reality because the event did not align with my expectations. This thought experiment demonstrates that plausibility occurs after an event in an ad hoc reflection.

If presence is the sense of *being there* and solely an involuntary response, my cognitive reflection, when the cup fell, would have no bearing on this sense and most likely always result in the dismissal of a state of presence. However, I argue that it is at this time that plausibility is determined. I am informed of this view based on the analysis of this study, where participants knew the virtual experience was not real but believed it could be plausible. This plausibility becomes evident when looking back on how Sonia articulated her understanding of the vastness of space, in which she interjected that *"...VR... obviously wasn't... the real thing, but it felt easier almost"* (581). Sonia's interpretation of the vastness of space was not indicative of her believing the event as real but *plausible*.

The critical difference between this view of presence and Slater's (2009) is embedded in plausibility illusion where the constructivist is informed by the construction of knowledge, and Slater is informed by observable responses that align with reality. The constructivist point of view acknowledges the potential of invented realities that are firmly influenced by the participant's perceptions and actions (Aiello et al., 2012). Thus there is less emphasis on what is objectively real and more on what is subjectively perceived. To the constructivist, when involuntary responses end and the cognitive mind takes over, concluding "...but I know that this isn't real" (Slater, 2018, p. 432), it adds, *but it could be*.

It is through this understanding of presence that learning occurs in virtual environments. In this thesis, learning primarily was achieved through first-person non-symbolic interactions (Winn, 1993), where participants actively engaged in the virtual space developing their conceptualizations through experience rather than symbolic knowledge. This approach to learning allowed participants to *"...see [learning] in different ways and different perspectives... rather than just seeing it on the board or in a textbook"* (Zara, 688). It is an experiential, not a didactic, approach to education. However, each experience is conditional on the participant accepting the interaction as possible. If the interaction falls outside the scope of believability, a state of presence is lost, and the interaction is no longer acceptable for learning.

An example of this phenomenon was demonstrated in some participants as they explored virtual space. During the design process of the experience, an issue arose that had to bend the realm of plausibility. Since the goal of the experience was to recreate a one-to-one replica of the local solar system that participants could explore, astronomically vast scales were introduced that accurately mimic the distance between different celestial objects. Realistic travel to these objects would range from hours to days or even months. The concept of faster-than-light travel through a warp tunnel was introduced that fell into the theoretical but was still plausible. This approach allowed participants to navigate inter-planetary objects realistically while dramatically decreasing the travel time between different celestial objects. There was an overwhelming worry that this inclusion would have detrimental effects on presence as warp was theoretical and not part of our current objective reality, yet it was needed to keep it concise and within a reasonable timeframe. Surprisingly, the inclusion of warp was of little consequence to most participants, with Frank stating, "...the straight path that you took from where you wanted to warp to where you would warp, I think... in real life it would [be] ...a little more wind[ing]" (563).

In Frank's case, it was not the inclusion of a concept that did not align with his reality that broke a sense of presence, but the unrealistic path it took. Undoubtingly, in Frank’s and others' minds, warp travel is possible even though it does not currently exist; thus, they did not question its inclusion. However, upon reflection, Frank felt that a straight line between two points in space would not be realistic because the spacecraft would need to avoid debris. This specific event did not result in the cognitive disbelief of the illusion as a whole but the rejection of that singular event. Nevertheless, It would be safe to assume that if the goal of the experience were to teach how warp travel functioned, Frank would not accept it as he disagreed with its representation.

If we accept Slater's (2009) definition of presence, particularly plausibility illusion, as solely reactionary, we need to consider how best to address the cognitive acceptance of an event in virtual spaces. One possible solution is to look at presence as a subjective degree of acceptance. A model of this view could be broken down into stages. Stage one could align with Slater's (2009) view of presence, where it is an involuntary reaction to a given stimulus. Stage two aligns with the findings of this thesis, where presence is the cognitive acceptance of the virtual event, not as real but a reasonable facsimile of it. Finally, stage three would hypothetically be complete virtual envelopment, where the observer could no longer distinguish the virtual from reality. Such a view would expand our conceptualization of presence, allowing it to become a functional aspect of learning in virtual environments, a belief held by many education-focused scholars (Dalgarno & Lee, 2010; Fowler, 2015; Maskransky & Gustav, 2021; Mikropoulos & Natsis, 2011). However, more research will be needed to justify such a model at this novel stage.

The approach to virtual learning discussed in this section will be addressed as *experiential virtual learning* for the remainder of this thesis. Experiential virtual learning focuses on provoking learning through the transformation of virtual experiences, aligning with Kolb's (2015) proclamation that "learning is the process whereby knowledge is created through the transformation of experience" (p. 49). These transformations can occur through interactions within the virtual environment, contingent on the observer's acceptance of the virtual space enabled through presence. The role of the virtual environment is paramount, as it is the means to empower learning through the inclusion or disclusion of meaningful interactions. It scopes the experience and contains learning from these interactions yet does not restrain the individual, allowing them to come to their own conceptualization as they interpret each interaction.

Autonomy Illusion

Many participants expressed a feeling of pedagogical freedom as they explored the virtual space. This sense of autonomy was developed by removing traditional classroom structures and management strategies, allowing participants to direct their learning.

Let us examine a traditional classroom in the K-12 system in Canada to understand the value and difference of virtually influenced autonomy illusion. While I will acknowledge that the roles of the teacher differ from classroom to classroom, typically, teachers exercise their part as distributors and managers of knowledge. The purpose of the teacher, in its purest form, is to provoke learning. Such learning is often articulated as a learning objective, in which a well-structured lesson is presented with a clear set of steps that, when completed, result in *learning*. In this model, students are told what they need to know, memorize the information, and are assessed based on how they solve problems associated with the memorized information (Ali, 2019). To ensure students stay on task, teachers employ various artificial delimiting strategies to narrow the focus of inquiry and reach the learning objective.

These well-intended interventions force students to conform to a specific approach to learning. While they are designed to ensure that most students can succeed in the classroom, they can have detrimental effects over time. As demonstrated in the findings of this thesis, participants felt they had lost control of their school activities and that they were passive observers in their education rather than active participants. When describing their classroom experience, they expressed their disengagement, stating the classroom is *"...like a linear path to* *the goal that you are trying to learn"* (Frank, 684) and *"...when you do school work it's not very exciting"* (Adam, 203).

The virtual learning environment has an evident advantage when dealing with disengagement influenced by delimiting classroom management procedures because it is a construction. When designed with learning in mind, the inclusion or exclusion of different entities, actors, and interactions establishes the boundaries for learning. For example, if I were developing a virtual learning experience to understand ancient Greek democracy, I would need to consider what to include and exclude carefully. The setting would need to mimic an ancient Greek agora where the assembly would be gathered to discuss issues of the state. Furthermore, to highlight a direct democracy, would-be participants need to vote on each issue. In this specific case, learner inquiry would naturally be limited to the inclusion of specific elements in the virtual space; yet, at the same time, essential learning objectives could be focused on by encouraging direct interaction, demonstrated by having participants vote on each issue. How narrow or vast the scope of possible learning is relegated to the construction of the virtual environment. However, individuals within the virtual space are not restrained in their methodological approach and understanding of their learning—the scope limits *what* can be learned, not *how* it can be learned.

Through the constructivist lens, learning is believed to be formed through experience and reflection (Rannikmäe et al., 2020; Bada & Olusegun, 2015). Furthermore, to provoke learning, students need to be disclosed to learning environments that expose learners to the materials being taught; as such, learning must be embedded contextually (Bada & Olusegun, 2015). It is in this contextual understanding that classroom instruction struggles. The classroom is a clean room for learning; it removes most of the minutiae that the world imposes when learning contextually.

This sterile approach creates issues in student learning because each experience is idiosyncratic based on the observer's perception (Gentry, 1990).

Such problems are not new to education. To establish a deeper contextual connection with the curricula content, different approaches, like project-based learning (PBL), have been utilized across many institutions. PBL focuses on student inquiry, where learning is contextualized through authentic questions and real-world problems (Kokotsaki et al., 2016). Experiential virtual learning has many parallels with the principles of PBL as they both identify learning opportunities within a scenario intending to increase knowledge and understanding (Ali, 2019). However, three vital differences arise when comparing methods:

1. PBL focuses on group work; experiential virtual learning does not necessarily require it.
2. PBL utilizes teacher expertise to scaffold and frame student development, while experiential virtual learning utilizes the virtual environment and teacher expertise to create meaningful learning.
3. PBL requires an objective problem to solve; experiential virtual learning only needs an intentionally crafted environment which can become the problem in need of solving.

Both PBL and experiential virtual learning value student autonomy and authenticity. However, I would argue that an intentionally designed virtual learning experience has the capacity to become more authentic because it completely envelops the learner in the learning context. It is through this envelopment that the role of the teacher changes. Teachers are no longer required to structure student learning as the virtual environment allows learners to interact authentically, receiving instant feedback based on their actions, allowing them to learn through action and exploration more akin to real-world inquiry. Furthermore, these self-directed interactions allow learners to control how they approach their learning, giving them a sense of autonomy.

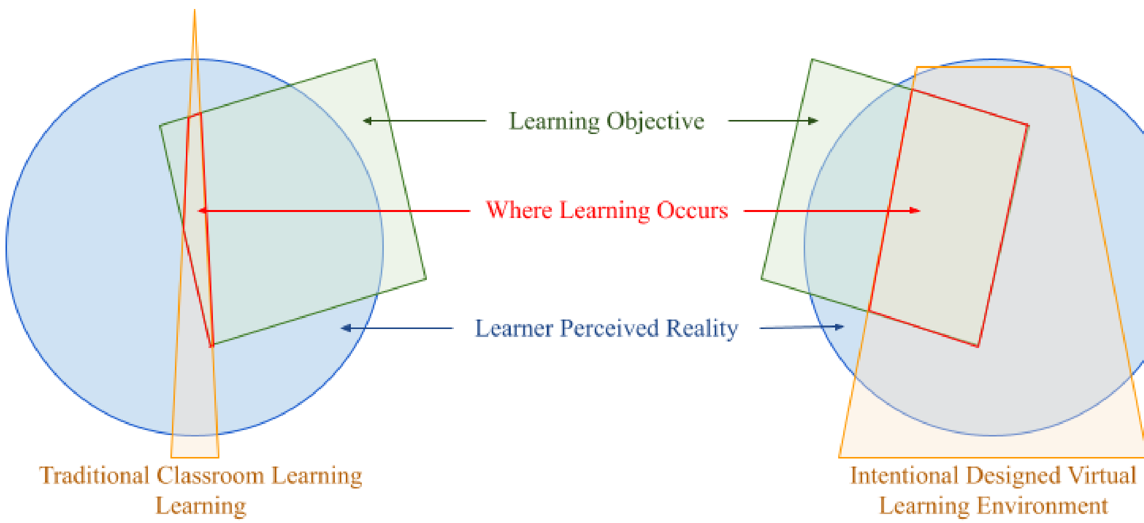
The control felt by participants in this thesis was empowering. To paraphrase Sonia, it was like having a heavy force like gravity removed, where it felt so good to be free. It is in this sense of freedom that I identify autonomy illusion. Autonomy illusion is the feeling of control in virtual learning environments induced by removing traditional classroom delimiting factors and enabling self-directed learning through meaningful interactions.

Interestingly, autonomy illusion is real and illusionary. It can be viewed as real as learners can direct their own learning. However, it is an illusion as the learning is intentionally limited through the design of the virtual space. These seemingly opposed perceptions homogenize into a symbiotic dichotomy that focuses on the individual's qualia of the virtual experience to come to a scoped sense of control that requires the learner to accept the virtual space as a reasonable facsimile of their perceived reality.

An intentionally designed virtual environment enables autonomy illusion. Compared to traditional pedagogical approaches, a virtual environment designed for learning enables more opportunities by not constricting the methods of learning to a single dialectic approach (see Figure 5), giving learners more freedom in how they understand a given topic.

Figure 5

Learning in Intentional Designed Virtual Learning Environments



Note. This figure demonstrates how an intentionally designed virtual learning environment enables learner opportunities beyond traditional pedagogical approaches. It acknowledges that intended learning occurs when the learning objective, pedagogical approach, and learner's perceived reality all align.

There is much left to discover, given the novel nature and unexpected occurrence of autonomy illusion. Connections between autonomy illusion and motivation seem apparent. A specific area that warrants more study that falls outside the scope of this thesis is how autonomy illusion can drive learning and spark curiosity, engagement, and intrinsic motivation in disengaged students.

Symbolic and Non-Symbolic Tensions

Objectively examining primary and secondary education through first-person non-symbolic and third-person symbolic experiences reveals a dichotomic tension. Symbolic learning employs a symbol system, like mathematical formulas or language, to comprehend and provoke learning, while non-symbolic learning focuses on the naturalistic interactions that predominate everyday life (Winn, 1993). In the K-12 system, there is a clear bias toward the value of symbolic interactions.

Symbolic systems ground or universalize learning. They create a series of strategies to create a vehicle for learning that can be universally understood. When it comes to human experience, symbolic knowledge focuses on generalizable themes that give the observer an understanding of the experience without needing to explore each specific case, often sterilizing the personal attributes of an experience like culture, emotions, and personal interpretation. It distills learning to bite-sized bits of knowledge by removing the qualia from the learning experience. This approach is instrumental in primary and secondary educational assessment by allowing a series of universal truths to exist that can be objectively assessed and understood by all individuals that comprehend the symbolic system. In modern literature, this policy is known as the knowledge economy.

"The *knowledge economy* alienates knowledge from its environment and renders it as an objective, efficacious and globally transactionable good" (Carson, 2019, p. 1019). It is concerned with the objectively observable, assessable, and universally understandable through the categorization of knowledge. At a glance such a system seems advantageous as it creates universal truths that *all* can understand. However, one must ponder, what if mastery of the "...symbol[ic] system is a necessary, though not sufficient, condition for learning[?]" (Winn, 1993, para. 15). It would create learning contextually tied to the sterile learning environment in which it was conceived, overemphasizing the symbolic structures and their instructional methods that disconnect learners from the contextual application through the limitation of comprehension, which denies new learning opportunities (Conley & Wise, 2011). This approach to learning is particularly concerning through the constructivist paradigm, as learning occurs in situations where the cognitive mind constructs its understanding through situated experiences (Schunk, 2011).

More recently, the connection between presence in virtual experiences and learning has come under scrutiny. Makransky et al. (2019), Ochs and Sonderegger (2022), and Ahn et al. (2022) all examined presence and knowledge retention when learning in immersive virtual environments; concluding that when compared to traditional media, like computers, immersive virtual learning had no impact or a negative correlation on knowledge retention. Such results are not surprising and align with participants struggling to articulate their first-person knowledge discussed in chapter four. However, it is essential to acknowledge that virtual learning, particularly experiential virtual learning as utilized in this thesis, is primarily a first-person, non-symbolic approach to learning. When learners attempt to convert this non-symbolic knowledge to symbolic understandings for universal consumption, they must translate it. It is highly probable that connections between a virtual learner's non-symbolic knowledge and a suitable symbolic equivalent have not been established if such a connection is even possible. It may be that, instead of not learning as much, the methods of learning have shifted so extensively that would-be learners struggle to articulate their understanding in a way that can be universally understood. However, this rationale has little backing outside the tangential struggles for first-person articulation observed in this thesis and should be explored in future research.

Therefore, it is hard not to ponder assessment methodologies in experiential virtual learning environments. It would seem that contemporary education and experiential virtual learning are currently at odds. Primary and secondary education are highly reliant on the knowledge economy, needing observable and universally understandable truths to acknowledge learning, often resulting in learning viewed as the accumulation of these truths as its sole metric for assessment. Experiential virtual learning is a highly contextualized and subjective experience resulting in truths that may not be universally understood because they are conceptualized in the learner's mind. Furthermore, I would question the authenticity of attempts to extract such conceptualizations, as they would need to articulate the near-infinite variables in such constructions accurately, something outside the means of current and foreseeable technologies. However, the influence of such experiences may not be in knowledge acquisition but in personal connections to the materials learned.

Experiential virtual learning can help desterilize and re-contextualize education. Learning experiences designed to evoke learning through meaningful, contextual environmental interactions would allow learners to construct their subjective interpretations of these experiences and represent their knowledge through naturalistic interactions (Rannikmäe et al., 2020). Rather than approach assessment in experiential virtual learning as exclusively the accumulation of knowledge, it can be viewed as a de-sterilizing event that allows learners to connect with their learning. The value of such connections is presently connected to motivation, interest, and engagement, which is already observed in virtual environments (Cheng & Tsai, 2019, Ahn et al., 2022). Virtual reality is uncannily well equipped for such an approach to learning as it can create virtual spaces that accurately mimic real-life encounters or even move beyond traditional experiences, such as viewing molecule vibration to understand heat.

To be clear, I am not championing the removal of third-person symbolic knowledge from the K-12 system; instead, I am stating that a more balanced approach could benefit students. This view is embedded in the belief that not all learning is measurable and observable because of subjectivity. Educators need to empower and provoke students to construct their understanding out of the seeming disorder rather than create sterile environments with no contextual relation to reality. Carson (2019) encapsulates this view with his statement:

> When we insulate them against the confusion that follows from ambiguity and uncertainty we deny them the opportunity to develop the most basic competency they will need – the protean capacity to create order out of chaos and knowledge out of information. (p. 1021)

Conclusion

Many different models of learning in virtual environments were explored in chapter two. Initially, during the design and development of the virtual experience, I advocated for Fowler's (2015) approach because it embedded the learning objective in the affordances of the virtual environment. However, while creating the virtual experience, I naturally diverged from the model. Reflecting on the rationale indicates it was not an intentional departure but a necessary one. Fowler's (2015) model attempts to directly connect Dalgarno and Lee's (2011) learning affordances, including presence, to a preexisting framework. However, this research uncovered that presence is not a learning affordance but a precursor for learning in virtual environments.

As discussed in chapters four and five, presence is the acceptance of the virtual environment, not as real but a reasonable facsimile of it. It is ongoing and particularly impactful. Slater's (2009) plausibility illusion describes this impact as rapid and involuntary, without the involvement of the cognitive mind. However, to view presence solely through this lens creates conflict when discussing and determining a state or degree of presence for learning through a constructivist lens.

To solve this conflict, I proposed a tiered approach to presence that allows for the cognitive acceptance of virtual space. The first tier aligns with Slater's (2009, 2018) view of presence as a reaction to a given stimulus that ends when the cognitive mind takes over. The second tier occurs after an ad hoc reflection of the reactionary state, where the observer accepts the event as possible, allowing them to construct new conceptualizations. The final tier would be complete virtual envelopment, where the virtual space and reality are indistinguishable.

Such an approach to presence creates many opportunities when developing and understanding its role in virtual learning environments. By accepting that presence and plausibility can be situated in cognition, we can craft each entity, actor, and interaction in a virtual environment to invoke a sense of presence by enabling the meaningful, non-symbolic exchange between the observer and the environment. Furthermore, such an approach enables future research to objectively identify a state of presence as the participant would be cognitively aware of their acceptance.

Like Fowler's (2015) model, each exchange must be situated in a learning objective. However, each interaction needs to be intentionally and thoughtfully considered through the lens of educational relevance. As Netta so elegantly remarks, the goal here is to *"...see all the facts that you learn..."* (309). Each interaction should enable learning through active engagement rather than dictation. This approach allows learners to construct knowledge through active participation, aligning with its constructivist underpinnings.

Furthermore, by carefully examining each interaction and connecting it to an educational outcome, the role of the virtual environment changes from solely an enabler of presence to a facilitator of learning, dubbed *experiential virtual learning*. This transformation occurs because each interaction has educational potential that has been crafted with a specific learning outcome in mind. As would-be learners explore and interact with an experiential virtual learning environment, they can subjectively conceptualize their learning.

Participants who engaged in an experiential virtual learning environment encountered an unexpected sense of autonomy, designated autonomy illusion. Autonomy illusion appears unique to experiential virtual learning because it is the sense of pedagogical freedom and control over one's learning despite being constrained by the virtual environment. This freedom directly results from the pedagogical approach used in this thesis, where each interaction was included to evoke learning through direct engagement. These pedagogically designed interactions constrained what could be learned but enabled learners to control how it was learned, creating this sense of autonomy.

Given the novel state of autonomy illusion, more research is required to determine its connection to learning. Throughout chapters four and five, autonomy illusion was shown to engage learners, encourage curiosity, and motivate participants to learn more about the material being taught. Thus, research into the connection between autonomy illusion and engagement could dramatically impact how we view learning, motivation, and engagement in the classroom.

Finally, I argue for a more balanced approach in the K-12 system, where learning is often sterilized from its context and delivered as an efficacious truth. Such an approach can help understand and alleviate participant disengagement in contemporary classrooms by recontextualizing their learning, allowing them to engage in a learning event that avoids reductionism as they attempt to understand the specific phenomena. Furthermore, by allowing learners to engage in their learning in meaningful and subjective ways, we can rekindle the spark and wonder for learning lost for too many as they are processed through the current education system.

Thus more research is needed to understand contextual learning in virtual environments and possible frameworks that help enable such experiences. While I have cited the need for a more granular approach to virtual learning, a concrete model or framework seems premature, predicated on future research and the acceptance of non-symbolic knowledge in the classroom.

Still, many questions remain regarding experiential virtual learning. Practitioners and researchers alike would cite worries or concerns over assessment. There is no clear answer for this area, and I question the validity of such assessments: how can we genuinely articulate the human experience? Perhaps these worries are too entrenched in the knowledge economy, where all learning is measurable and observable.

Nevertheless, some correlations can likely be found between the contextually induced virtual experience that could benefit objective learning. Based on the findings, I believe an experiential virtual learning approach can remove the need to objectify learning, allowing learners to actively participate in their education by constructing non-symbolic knowledge, leading to intrinsic motivation empowered by curiosity and engagement. Experiential virtual learning is *"...something different... from everyday school work"* (Adam, 500) that creates a sense of cognitive presence by engaging learners through a carefully constructed virtual environment. Much more research is needed on how best to construct such environments and discover the impacts such an approach could have on the education field. However, it seems an experiential virtual learning environment has the capacity to provoke learning out of the seeming disorder that has become so feared in the current K-12 system, allowing for the recontextualization of education through the emulation of real-world learning.

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