Interactive Storytelling through Immersive Design

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Abstract: Linking strong narratives and play, this chapter helps educators and designers take their first steps into immersive education using the DEW Concept Model. The focus is on designing and selecting virtual worlds that break through rigid classroom structures and offer immersive experiences that enhance learning through discovery, exploration, and wonder.

Keywords: AltspaceVR, DEW Model, Discovery, Exploration, Play, Story, Wonder, World building

Introduction

From early drawings in the deepest caves to tales told around campfires, storytelling has preserved human history. Stories are powerful tools in education—transcending generations, cultures, and languages. Essential to making social connections and creating communality, stories generate healing and overcome differences as well as defenses (Gargiulo, 2006). Integral to storytelling is the concept of play, offering students interesting and entertaining experiences for learning in an exciting, stress-free environment (Acar & Cavas, 2020; Yamada-Rice, 2021). Sun and Cheng (2009) found that interactivity and "perceived playfulness could serve as a motivator to raise learner intention to engage with 3D VR systems" (p. 1). The power of the user to influence the story and thus their learning experience, especially through play and role-playing in virtual reality (VR), provides an intense learning experience that manifests the adventures of the Star Trek holodeck with the freedom to travel through space and time, whether visiting ancient Egyptian pyramids or floating untethered around the International Space Station.

Nature photographer, author, and educator George Lepp (1995) explained in his photography workshops that to get someone's attention, you must either show them

something they have never seen before or show it in a way they have never seen. Educational virtual worlds tap into the familiar by changing the perspective in a way the student has not experienced. Drawing a three-dimensional (3D) cube in art class is a classic lesson to help students understand perspectives. Drawing the same cube in a 3D environment causes dissonance when students move around the cube, and realize their 3D cube was drawn using 2D methods. When students step into a virtual world for learning, perspectives are challenged, and imagination is unleashed. Learning is now an adventure.

From our first-hand experiences, when VR worlds integrate interactive storytelling and a sense of wonder, the experience evokes the body's natural responses and widens the mind's perspective on a subject. These experiences tap into Oppenheimer's (1982) "discovery of unexpected novelty" and Bruner's (1983) theories on play and scaffolding. The struggles teachers face with students with attention difficulties, behaviour issues, and resistance to learning tend to fade into the background; indeed, studies have shown increased motivation and improved focus when learning in VR environments, especially when storytelling and play are integrated into the experience (Cho et al., 2002; Huang & Liaw, 2018; Yamada-Rice, 2021). Creating spaces and places for play in the learning process is theorized to increase memory retention, and researchers are finding that VR has an even greater significant effect on long-term memory recall and retention (Yamada-Rice, 2021; Yildirim et al., 2019; Yip & Man, 2013).

This chapter introduces the DEW (Discovery, Exploration, Wonder) Concept Model, a framework designed to help educators and students understand key concepts in virtual worlds that combine storytelling narratives to achieve academic goals. A variety of existing virtual world experiences in VR apps and metaverse platforms support easy-to-use world building techniques such as the drag-and-drop technology of the free immersive VR platform AltspaceVR, which enables the creation of simple virtual worlds that are no more complicated to build than learning how to create a Microsoft PowerPoint presentation. Even with these easy tools, teachers often don't know where to begin integrating immersive education into the classroom. The DEW Concept Model is designed to help with the selection and development of VR-based educational worlds.

We begin with defining and outlining the DEW Concept Model, then the second section explores important characteristics of educational worlds to help designers and educators in selecting or creating an immersive experience. The third section introduces eight virtual-world model layouts that represent the building blocks of educational worlds ready for applying the DEW model. The fourth section applies DEW model characteristics to the world models, demonstrating their use in education across diverse pedagogies. The last section explores world building for individual and collaborative student homework projects to expand the educational experience and implement the DEW Concept Model as a learning tool.

Vignette

In 2019, Gibson-Hylands and VanFossen collaborated on Earth Day projects to represent marine pollution as an educational experience free of traditional educational tools. VR was the perfect medium to convey our message, enabling the experience to 1) be interactive, immersive, and experiential; 2) overcome the dullness of facts and statistics to inspire curiosity and change attitudes; and 3) tap into the wonder and awe effect to stimulate conversation and engagement.

"The Ocean" (Fig. 1) *is a visually interactive world that conveys the impact of society's garbage on marine creatures. Students swim among marine animals that mistake pieces of floating plastic for food and become entangled in debris, causing distress, injury, and eventually death. The experience often evokes an emotional response that leads to interactive discussions that meet the goal of inspiring curiosity and motivate action in day-to-day lives. The response to this experimental world inspired the authors to explore the DEW Concept Model for use in many of their VR teaching classes and workshops, test the model, and develop it as a case study for educational world building techniques.*

Fig.1 *Students swimming in "The Ocean" to learn about water pollution (Gibson-Hylands, 2019)*

Introducing the DEW Concept Model

The desire to explore is natural for humans from birth. Each new discovery generates wonder, encouraging humans to continue the experimental exercise called *play* (Bruner, 1983). The continuous interactive progression of exploration and discovery, accompanied by wonder, leads to enhanced learning, understanding, and retention.

The DEW Concept Model (Fig. 2) is a philosophical framework that encourages educators to integrate immersive virtual worlds (Immersive, 2008) and experiences into curricula for learning, understanding, and increased knowledge retention. The DEW model is designed to help the educator make informed choices on selecting or designing a VR experience or world, as well as encourage students to create project-based virtual worlds. The key principles of the DEW model balance the amount of scaffolding needed to facilitate navigation through an educational virtual world with the amount of freedom to encourage exploration, leading to the discovery of unexpected novelty (Oppenheimer, 1982).

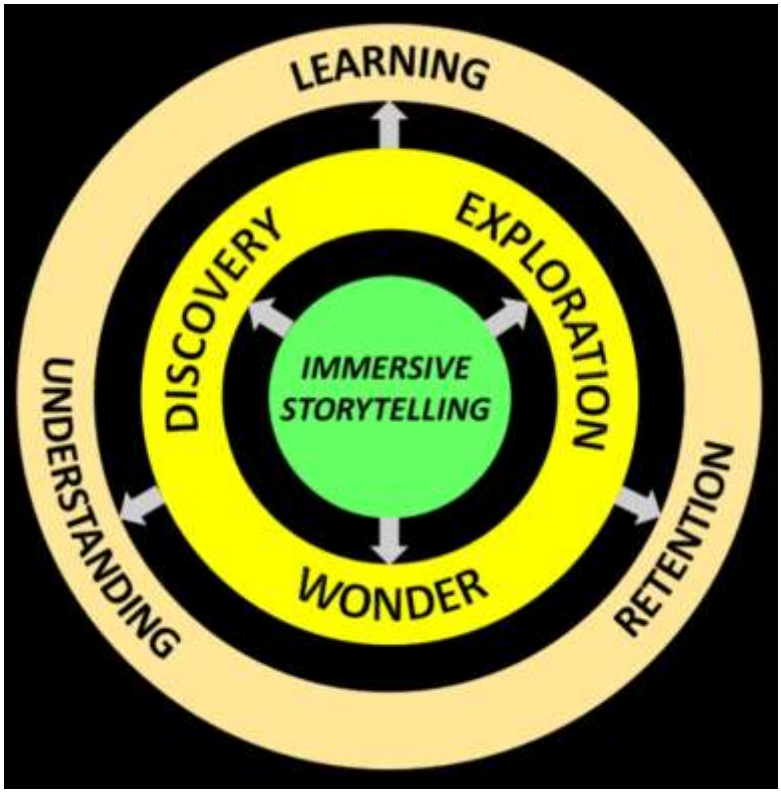

Fig. 2 *DEW Concept Model*

Worlds with a clear narrative immerse the student into the story and the learning experience. Such worlds have a clear sense of purpose, focus, and a path to follow. If students land in a virtual underwater world, the story begins with life underwater, and instinctively they start swimming, becoming part of the narrative. Through exploring the world as a guided or self-guided experience, learning becomes an adventure through discovery and wonder that amplifies learning, understanding, and retention.

Combined with the power of immersive reality to fool the mind with embodiment and presence, wonder is often easier to inspire. In *The Last Glacier* (VanFossen, 2019a; Fig. 3), students arrive in a glacier-covered mountainous world alongside an iceberg-filled ocean. Students report feeling cold, even to the point of shivering, in contrast to their ambient temperature (Yeom et al., 2019). Signs guide them to climb over the mountain to an ice cave maze, learning about the science of glaciers and their impact on our climate and water sources and the risk to civilization due to glacial loss over the past 20 years (Watts & Kommenda, 2021). Responses to the learning experience show students have increased curiosity and

interest in learning more about glaciers and their impact on the climate. Many students surveyed over time reported fond memories of the experience even a year or two later, with some stating they started researching glaciers and seeking out ice caves near them with the hope of visiting them before the caves disappear.

Fig. 3 *Learning about the impact of glacial warming in "The Last Glacier" (VanFossen, 2019a)*

Exploring how the experience inspires deeper curiosity and wonder responses, we researched the concept of wonder's impact on the body, mind and memory retention through informal participant questions and surveys. Users are often changed by the immersive experience's visual, auditory, and emotional sensations, much like real world transformative experiences (Krause, 2020). The sense of presence and embodiment in VR taps into the autonomic parasympathetic nervous system associated with fight or flight responses. Some scientists believe the small boost of adrenaline—shown in increased respiration, heart rate, and dilated pupils—enables the mind to absorb and process information faster, thus improving memory retention (Allen, 2018; Fleming, 2013). The concept of play as Bruner (1983) has described is also essential to the learning process because "play provides a courage all its own" (p. 61), followed by the natural desire to share experiences with others. Indeed, students often want to share the experience, exclaiming, "Guess what I did today?" The retelling reinforces the process of scaffolding learning as students translate the experience into their version of the story, leading to learning, understanding, and increased retention (Hung et al., 2012).

We continue to investigate how these VR experiences influence the learning process to improve understanding and retention by identifying the elements of discovery, exploration, and wonder as essential in immersive educational world building. This chapter represents examples of that initial research to help educators select or create educational VR worlds with clear criteria.

Key Characteristics of Educational Worlds

Our continuing research into the DEW Concept Model shows that an educational virtual world experience has a higher success rate in meeting learning outcomes when it contains the following characteristics as part of the model's multimodal framework.

Story

"Data doesn't speak for itself; it needs a good storyteller. … Some have said data is the new oil. The findings, though, will stay buried without the help of a communicator," explained Nancy Duarte, CEO of the Durate, Inc. communications company (Wood, 2022). Storytelling structures the information in a logical or chronological order, increasing retention as the story is easier to access and play back in the student's memory (Boris, 2017). To put this another way, Katherine Cather explains:

> Further, socially minded are we, and so dependent upon social guidance, that curiosity is nowhere so keen, nor the imagination so active, as in the communication of a life situation. Any incident or accumulation of incidents that we call a plot in the experience of an individual or group of individuals, grips the mind. (Cather, 1918, p. ix)

Our experiment in developing the DEW model found that VR experiences using the *show not tell* writing principle to convey information result in increased engagement and memory retention. The more emotionally relatable the story, the greater the wonder generated. An example is the *D-Day* world (Fig. 4), which takes participants back through time to World War II on an unnamed beach in Normandy to *feel* the moment soldiers landed on the shores to face the enemy army. The memorial world offers no facts, no signs, only the sensory experience as students step off the small transport ship onto the barbed wire-lined beach

accompanied by the mournful sound of the military bugle call *Taps*. With little initial discussion, students become part of the story as they explore the scene, imagining themselves as soldiers struggling past the enemy guns. Students report sadness, respect, and an increased curiosity about the history of D-Day. Psychological research found that in response to news stories about mass violence, readers need empathetic connections to deal with large-scale suffering (Maier et al., 2017). VR experiences designed with thought-provoking empathetic narratives often create a deeper connection with the student.

Fig. 4 *"D-Day World Memorial" in AltspaceVR (Tim, 2020)*

Embodiment and Presence

When the virtual environment matches the lesson's goals, students report a feeling of presence, as if they are *really there*. We have found that the environment does not need to represent the real world, just allude to it. Participant surveys for the DEW Concept Model report that VR users feel as if they left their home or the classroom, experiencing sensations of heat, cold, apprehension, fear, joy, etc. in direct relationship to the immersive environment. During recent extreme heat waves, VR users in DEW research worlds reported feeling cooler when visiting snow and ice worlds and body temperatures rising when sitting in a hot jacuzzi (Yeom et al., 2019) (see Fig. 5). The greater the engagement with the virtual environment—especially the ability to move oneself, move objects, and to investigate—the more immersed and real students tend to find the experience: making it an adventure (Yamada-Rice, 2021).

Fig. 5 *"Winter Jacuzzi" in AltspaceVR (VanFossen, 2019b)*

Role-Playing

Instead of remaining spectators, students may become the actors and sometimes the directors in the story, leading the learning experience through role-playing (Cather, 1926). In *Designing Wonder*, Krause (2020) found that VR allows users to become the heroes, to feel both immensity and insignificance at once, essential characteristics of wonder in the DEW model. Often aided by avatar enhancements such as wings, hats, and costumes, students transform themselves into an integral part of the virtual narrative. In a coffee house in AltspaceVR, someone will naturally step behind the counter to sell coffee and cakes (Fig. 6). In a world of spies and mystery, a retina scanner had instructions to scan people's eyes before entering the security door, causing people to pause to scan their eyes before entering the room, becoming immediately immersed into the West World adventure worlds (Gust, 2021).

Fig. 6 *Role-playing in the "Naboombu Sport Café" (SmartieMartie83, 2019)*

Inspired Curiosity

The elements of discovery and exploration inspire curiosity, creating a call-to-action response and eagerness to learn more. The information in the world does not have to answer everything about the subject; however, it should help the student feel a compelling need to know more. Students exploring the International Space Station (ISS) in AltspaceVR report a greater interest in the station. With news of the ISS disintegrating in the atmosphere after 2028 (Heilweil, 2021), students and teachers are using the ISS virtual experiences as a memorial to study the history of space exploration and research. Students visiting the *Food Waste* world by Gibson-Hylands (2020a) report that they researched and changed their food consumption and handling habits after visiting the world, realizing that small personal steps in food waste management contribute to the whole.

Emotional Response

Expressions of wonder and awe are often heard as students surge into a world eager to learn and explore more. Students' emotional responses may improve their sense of connectedness to the experience, allowing them to become deeply immersed, sometimes achieving a state of

self- transcendence (Chirico et al., 2016; Chirico & Yaden, 2018; Yamada-Rice, 2021). Through our research on the DEW model, we observed participants exploring the COVID-19/ACE2 recreation of the virus, complete with interactive elements and up-to-date statistics and information (Fig. 7). Participants reported feeling calmer and less anxious about the pandemic as the experience put the phenomenon into a playful and adventurous context (Laurenanti, 2020). Not every virtual educational experience is this intense; however, the eagerness to return and repeat the experience is a positive sign. Research into creativity and happiness finds that our instinct for entropy, relaxing and conserving energy, competes with our brain's programming for creativity, which Csikszentmihalyi (1997) describes as "an ability to enjoy almost anything we do, provided we can discover or design something new into the doing of it" (p. 9).

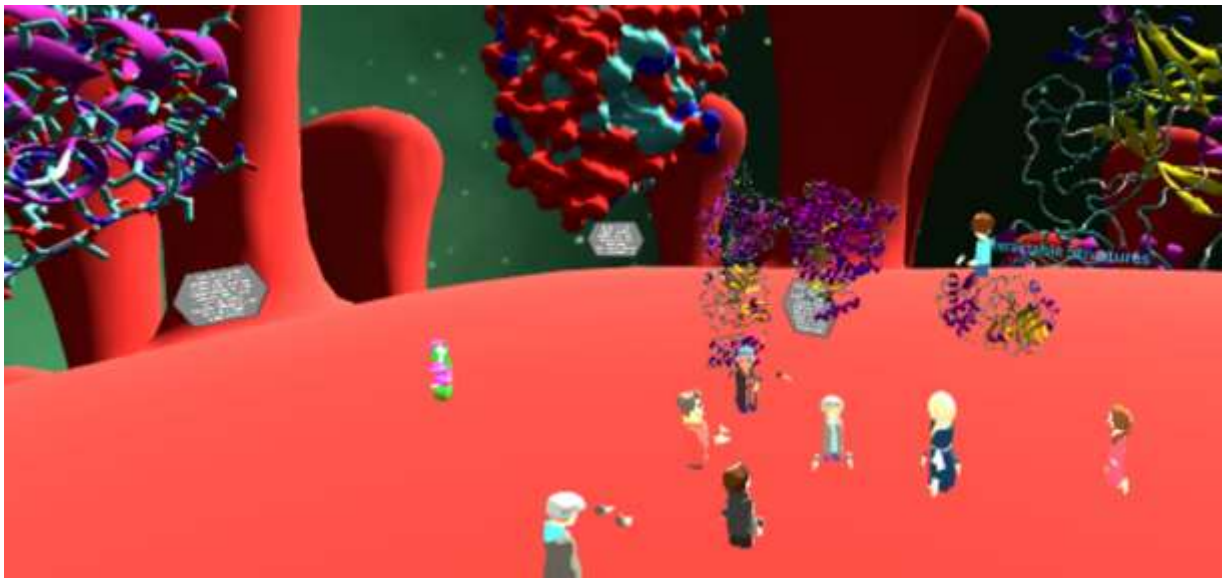

Fig. 7 *Interactive "COVID-19/ACE2" models in AltspaceVR (Laurenanti, 2019)*

Shared Experiences

The DEW Concept Model relies heavily on the idea that virtual experience is shared, with student and teacher discussions increasing the student's understanding and improving their retention through repetition (Chirico & Yaden, 2018). We found that multi-player educational experiences allowing the students to help each other learn how to navigate and interact with the environment, also improved prosocial skills and altruism (Allen, 2018). Students reported they had more fun when they stepped into the teaching role, such as

helping fellow students put roller skates and hula-hoops on their avatars for a fun roller-skating party (Fig.8). Through the process of aiding others and telling stories of their adventures in VR, the students translate their experience, reinforcing the scaffolding process.

Fig. 8 "Roller-Skating Party" with colourful hula hoops in AltspaceVR

Familiarity

DEW research has found that when the narrative taps into the known or familiar, primarily through empathy, and builds from there, students engage faster and adapt more quickly to different viewpoints on a subject (Firth, 2015; Maier et al., 2017). Presenting a familiar story in an unfamiliar way often promotes greater interest in the story, such as found in the numerous derivations of fairy tales in modern novels and movies.

By better understanding the functionality behind wonder-responses in the discovery and exploration process of teaching in VR, we hope to clarify these characteristics for educational worlds to help teachers, students, and world builders make wiser choices about design and layout. In our early studies, we found that the use of virtual worlds aligning with the DEW Concept Model resulted in students making strong connections to the subject matter and led to

understanding a diverse range of perspectives on a subject, with improved knowledge recall. The following section covers educational virtual world scenarios that represent implementing the DEW Concept Model for the process of selecting educational world models.

DEW World Models

The DEW Concept Model process begins with the educator selecting the virtual world's base layout and structure, called the *world model*, that reflects their teaching style or need. Next, they apply the above characteristics to help them select or build their teaching world. Since 2018, we have explored a wide variety of educational virtual world layouts supported by different pedagogies to support the DEW Concept Model. We have narrowed the list to eight core virtual world models that are the building blocks for educators and students to apply the DEW model characteristics of embodiment, role-playing, curiosity, emotional response, shared experience, and familiarity. These characteristics expand an ordinary educational experience into one based on discovery, exploration, and wonder. We tested each of these world formats extensively, teaching various classes and workshops as part of the research. Each world format offers a distinctive method of presenting educational information and may be used in combination with each other, offering educators various options.

- **Static presentation worlds**, often referred to as *event or lecture worlds*, present content in a traditional form with slides, videos, or lectures delivered in familiar teaching spaces such as classrooms, theatres, or auditoriums, with a clearly defined audience and presentation areas.

- **Progressive learning worlds** offer a step-by-step learning process, taking students through a chronological or logical sequence to aid in understanding complex topics such as sentence structure or mathematical equations.

- **Demonstration worlds** present a framework that allows the student access to the demonstration of a machine, simulation, or model to study, observe how it works, and understand its operation. In VR, the student can walk into a machine engine while it is running or travel through an assembly line.

- **Discussion or meetup worlds** are usually designed for small group discussion and often feature one or more *storytelling circles* such as campfires, rock circles, or tables.

- **Walking tours** are guided or self-guided tours through worlds of galleries, museums, theatres, and buildings or nature areas. These tours feature educational materials like posters or pictures that allow the user to physically move through a visual learning process (Fig. 9).

- **Complementary worlds** augment the subject matter visually and contextually to enhance the immersive experience. Examples are discussions on astronomy held in outer space and mythology's impact on culture surrounded by recognizable mythological creatures.

- **Simulation worlds** offer experiential lessons or training simulations often used in emergency services, medical training, job training, and flight simulators. In VR, simulations can be used to walk through history, science labs, math problems, and more. Students can fly an airplane or walk through a historical landmark in its heyday.

- **Hub worlds** act as a directory, a centralized location that transports students to related worlds, allowing the class to explore individually or in sequence. Hub worlds can act as a storyline, expanding the lessons into something resembling book chapters or sequels. Students collaborating through world building may create a hub to highlight topical worlds or link them to their virtual worlds as homework. An example is the *World Building Tips & Techniques Hub* (Fig. 10) with themed designs around the teleporters to tutorial worlds.

Fig. 9 *Walking tour featuring "World Building Tips and Diagnostics" (VanFossen et al., 2019c)*

Fig. 10 *Workshop in the "World Building Tips and Techniques Hub" (VanFossen et al., 2019)*

DEW World Model Scenarios

We continue to explore the DEW Concept Model affordances for world building and have found that many of these basic world models often combined formats to enhance the learning experience. Using the eight world models, we apply the characteristics of the DEW model for various educational scenarios.

Complementary World Model

An example of a simple and elegant complementary world model, *Messages in the Mist*, was created by Kawaii Sammich (2019) (Fig. 11). The AltspaceVR world is filled with quotes in text form in an all-black skybox saturated with rain and fog that complements the thoughtful intention of the messages. This simple and easy-to-build world hosts frequently changing narratives. In 2021, the world presented quotations and comments from the AltspaceVR community about their feelings of loneliness and need for social connections during the pandemic. Change the quotes to those associated with happiness, switch the weather to sunshine and blue skies, and the lesson would be instantly different.

Fig. 11 *"Messages in the Mist" (Sammich, 2019)*

Complementary worlds situate students deeply into the experience, which is essential to the characteristics of the DEW model. The environment feels embodied, so participants feel they are wandering through the fog searching for words of insight. If the words are theirs, students report a sense of ownership in the experience. Even if the words are not theirs, they still report an emotional connection with the words and their unknown author. A student highlighted one phrase and said, "I feel like they know me, the real me, and how I feel. I feel like I've found a friend I haven't met yet."

Simulation and Demonstration World Models

A science curriculum exploring astronomy is enhanced by virtual walks through space exploring planets, the sun, and star systems across the universe. For example, *Andy's ISS Space Walk* (Fig. 12) is a mix of simulation and demonstration world models that allow students to float untethered around the International Space Station, replicated in extraordinary detail. Students experience a realistic experience spacewalking in bulky spacesuits, complete with the impaired view through the helmet. A teleporter relocates the students inside the Space Station, allowing them to crawl around, explore the various compartments, and float without gravity.

The wonder begins the moment when students enter the world and realize they are dressed in the bulky spacesuit and floating over the earth. Their attention is then drawn to the planet below, where many report experiencing the *overview effect* experienced by astronauts (Overview, 2022). Slowly, a few students look up and exclaim at seeing the space station overhead. Encouraging others to join them, the students fly around the station. Younger students quickly slip into role- playing as astronauts, manoeuvring in space, repairing the station, or climbing around inside, often collaborating on a space adventure story. Our surveys find participants expressing their wonder and delight with the experience, and their eagerness to share the story of their adventures months after experiencing them. Additionally, they revisited it often and brought friends and family to enjoy the experience.

Fig. 12 *"International Space Station" (Andy, 2021)*

Demonstration and Complementary World Models

Instead of teaching through cultural and historical stories, an option is to encourage students to research and share their own stories from their current or indigenous culture and family history, expanding the potential for inclusive learning and empathy. The *First Nations Tepee Camp* (Stands with Trees, 2021) is used for teaching diversity and inclusion workshops as well as for storytelling focused on heritage (Fig. 13). The tepees and the campfire among snowy mountains demonstrate an ancient Indigenous village in North America and also complement the storytelling experience. Virtual worlds providing demonstrations and designs that complement the stories enhance the experience more dramatically than traditional show-and-tell experiences. When students design their storytelling backdrop, the process reinforces their learning experiences due to the research, problem-solving, and collaborative nature of world building.

Fig.13 *"First Nations Tepee Camp" (Stands with Trees, 2021)*

Complementary, Simulation, and Demonstration World Model

In April 2021, Chinese researchers identified a space hurricane over Earth's polar ionosphere (Zhang et al., 2021). This inspired Professor Mark Gill of St. Cloud State University, Minnesota, to create in AltspaceVR an orbital platform hovering over Earth above the space hurricane, thereby representing the invisible space weather phenomenon (Fig.14). Students were filled with wonder and curiosity as they explored the central exhibit area featuring a 3D visual spatial recording explaining a space hurricane and how it is formed, then moved to a platform overlooking the spinning planet below the graphic simulation of the space hurricane above. The world does not explain all the science. Still, it creates wonder and intrigue and encourages deeper discussions. Mixing complementary, simulation, and demonstration world models in line with the DEW Concept Model builds multiple scaffolds of learning through the experience, and enhances learning modalities.

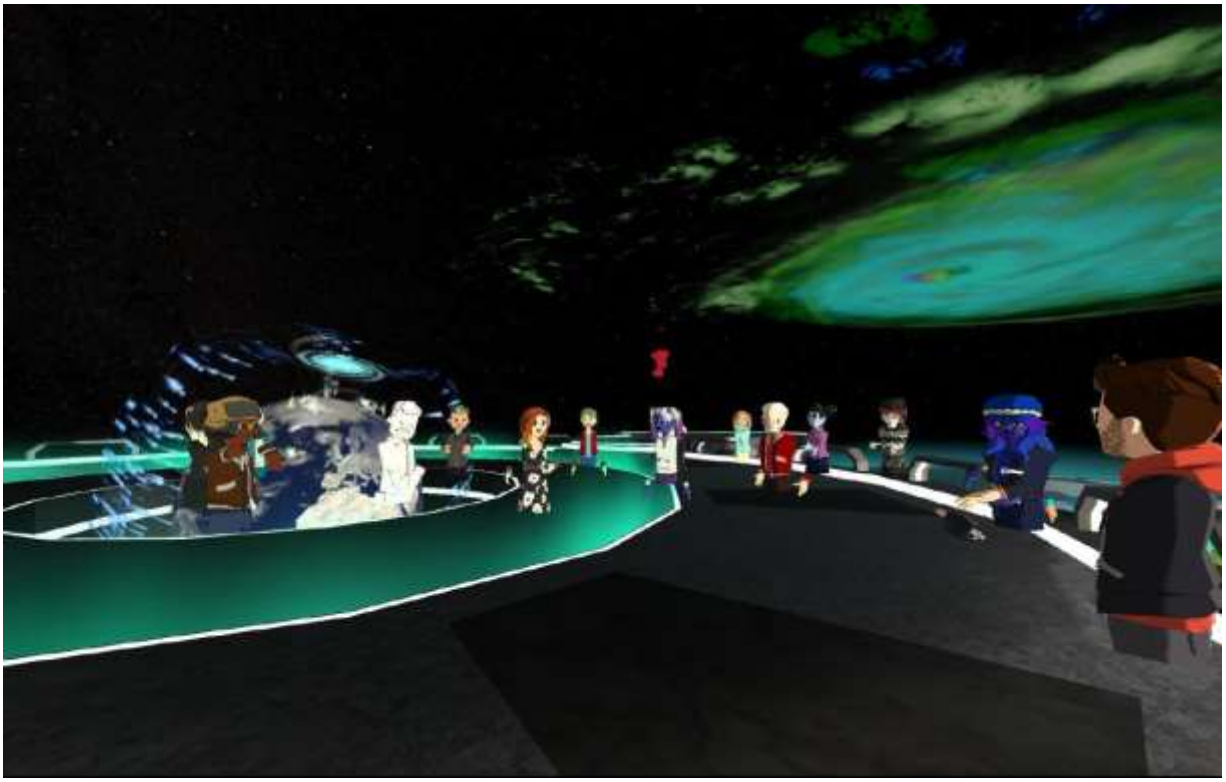

Fig. 14 *Students study the "Space Hurricane" over the ionosphere of Earth (Gill, 2021)*

Simulation, Demonstration, and Progressive Learning World Models

Traditionally, aerodynamics is demonstrated in a classroom with textbooks and videos animated with arrows indicating wind patterns. In *Forces of Aerodynamics*, Richard Korff (2021) demonstrates lift and thrust to teach piloting and aerospace engineering classes by providing wand-shaped objects students can hold to direct the red arrows flowing from each wand, indicating the flow of the wind moving across the body of the plane (Fig. 15). The interactivity is a form of role-playing as the students *become the wind*, fascinated with its reactions as they move the wind over the airplane's surface. Korff (2021) found that students improved their understanding of aerodynamic mechanics. Inspired by their own curiosity, they also tested collaborative experiments with the interactive wind wands, exploring aerodynamics in ways rarely taught in traditional contexts. The teacher reported that his students showed greater interest and began to develop a variety of narratives to test their newly developed hypotheses on aerodynamics.

Fig. 15 *"Forces of Aerodynamics" (Korff, 2021)*

Progressive Learning and Discussion World Models

The *Food Waste* world by Gibson-Hylands (2020a) uses a compelling educational narrative to tap into students' lifestyles and change their hearts and minds in the process. Students begin their journey exploring the wastefulness of Western world culture caused by over-buying and poor food management taking a different perspective, from farm to table to trash. The educational world ends with a discussion area with information on potential solutions and lifestyle changes. Throughout the educational world are powerful tableaus, scenes set against a backdrop that reinforces the lesson. For example, in a kitchen scene for a typical American meal of fast food, the fridge and food cupboards in the background frame the next part of the lesson, and the destination of the displayed food items in the landfill site is visible in the distance (Fig. 16). Each design element conveys a powerful message about the consequences of food waste and excess in the Western diet.

Carefully crafted by Gibson-Hylands (2020a), the *Food Waste* world serves as a training world for the authors as they research the DEW model. Each step inspires discussions by combining step-by-step progression, beginning with where food comes from, through the dining table and kitchen, to the landfill, to a home demonstrating composting. Those with gardening experience at home will jump in to share their experiences, personalizing the lesson, often evoking reactions of wonder from other students: "You grow your own food?" At the familiar dining

table scene, many students role-play eating pizza and making slurping sounds as they pretend to drink from the sodas and milkshakes. Passing through the landfill, students begin to question the choices they and their families make, leading to discussions on problem-solving the ever-growing crisis of waste and pollution facing global communities. Recycling and composting are part of the solution, but the virtual world teaches that the process starts with the choices we make before making our food purchase decisions—telling the story in a new way.

Fig. 16 The "Food Waste" world offers powerful conversation visuals (Gibson-Hylands, 2020a)

Static Presentation, Simulation, and Discussion World Models

As part of an ongoing series on global waste, Gibson-Hylands created *Plastic Mountain* (2020b)—an example of a static presentation, simulation, and discussion world model—to convey the impact of global waste on worlds far from where the rubbish was generated. As students enter the simulation, they arrive in a small building representing a static presentation, with wall posters providing key facts on the practice of Western countries shipping their garbage to other countries and the harm these landfills cause to the people and their land. The

information prepares them for the experience outside the doors of the building, the simulation model for the lesson. As students exit the building, they find a beautiful Malaysian village slowly being destroyed by plastic waste from other countries (Fig. 17). Each element within the world's design plays a key role in the narrative to enhance the student learning experience with thought- provoking discussion points. The focal point of the world is a mountain of burning plastic draining chemicals and toxins into a river and killing the ecosystem on its deadly journey to the ocean, allowing students to see a direct connection and consequences of the pollution. The skybox adds a polluted yellow atmospheric haze representing the pungent toxic fumes from the burning plastic waste.

Fig. 17 *"Plastic Mountain" reveals a burning mountain of garbage (Gibson-Hylands, 2020b)*

Experiencing the impact of global waste in VR emphasizes the imperatives of the situation and the desperate need for solutions, stimulating conversation very different from the classroom experience. Discussions covering pollution, excess lifestyles, recycling, culture, climate change, economies, and international politics reflect the student's emotional response combined with a natural curiosity inspired by the scene. As another test world for the DEW model, our surveys have found that the experience stays with the students for a long time. Students report that their interactions with the world increased their awareness of recycling options and making purchasing decisions with recycling in mind, for themselves and others.

Combination of World Models

The Flooded House (Vodloc, 2019) is an example of a world that hosts diverse story lessons through powerful narrative and mixed world models. The virtual world offers a learning experience challenging to reproduce in the real world. Students arrive in a typical two-story modern home in a suburban cul-de-sac to find themselves in water up to the chest of the avatar (Fig. 18). Outside, there are cars, toys, furniture, and garbage floating around them while overhead, a helicopter hovers with a rescue crew. The role-playing response is immediate as some students instinctively make their way to the roof of the house and some climb on the floating cars. Others begin playing the victims or rescue teams, while some gather to begin problem-solving, each role adding to the narrative and experience of the students. This world has been used in many lesson plans, users being inspired by the opportunity to host diverse discussion topics such as community water and sewer management, community infrastructure and prevention planning, emergency management and responses, climate change, crisis management, and problem-solving scenarios.

Fig. 18 *"Flooded House" features a community in the middle of a flood (Vodloc, 2019)*

As authors of the DEW Concept Model, we continue to explore virtual world models and how their characteristics may be applied to educational VR worlds. Our goal is to better understand how to break through the rigid structure of traditional classroom experiences and develop virtual educational spaces for discovery, exploration, and wonder.

World Building for Homework and School Projects

We developed the DEW Concept Model to encourage teachers to select educational worlds in VR wisely or to build their own. We found that encouraging students to design worlds in collaboration with the teacher or as homework expanded the DEW framework even further, turning discovery, exploration, and wonder into teaching-by-doing collaborative experiences.

Homeschooling programs traditionally include visits to local museums, parks, and historical sites. During the pandemic, we worked with a private homeschool program to help students create historical virtual worlds as history lessons in VR. Inspired by Liberopoulou's (2020) *Ancient Athens* collection of worlds in AltspaceVR (Fig.19), the student project worlds had to use discovery, exploration, and wonder to encourage embodiment, role-playing, curiosity, emotional response, shared experience, and familiarity. The high school students created a hub world in AltspaceVR representing a room in a museum related to their history assignment. They wrote up a research plan that included a sketch of their proposed world and checklist of the DEW model characteristics, and a set of guidelines limiting their choices on what they could use to build their worlds. Students were to collaborate and help each other and create the hub world. Their final project was a tour and presentation of each world representing their history museum.

Fig. 19 *"Ancient Athens Agora" marketplace, social hub of the Greek Empire (Liberopoulou, 2020)*

This type of homework project in VR is in line with the ISTE guidelines (ISTE, n.d.) and Bloom's revised taxonomy emphasizing digital citizenship (2001). Virtual world building shows that it improves math and spatial geometry skills and develops broader competencies such as planning, research, and project management (Roman & Racek, 2019). When world building is collaborative, it teaches students to work together to create situations with a blueprint plan in hand (Fig. 20), then stretch their imagination to problem-solve the development challenges. Students learn how to follow instructions, ask for guidance when needed, and critically question concepts, thereby learning the adaptive project management principles of Agile and SCRUM instinctively as they embrace the criteria characteristics of the DEW model (Galloway, 2012; Maruping et al., 2009; Van Petegem et al., 2021).

Students thrive in an environment where curiosity encourages imagination, creativity, and risk-taking. The Creative, Cognitive, Qualitative model for creativity (CCQ Tool) is an example of learning with a focus on the internal mechanisms of creativity naturally arising from virtual world building (Smyrnaiou et al., 2020). In our continuing research, we find that when students take charge of the world building experience by including the DEW model characteristics supported by the CCQ Tool to create their homework worlds with a sense of immersive presence, role-playing, and curiosity, their emotional response creates a sense of shared experience and familiarity through discovery, exploration, and wonder. Overall, the students feel empowered, with a greater connection to and ownership of the lesson. They are better able to add their storytelling narrative, transforming homework projects into "personal values into stories ... and influenced by social, cultural, and ethnographic characteristics" (Smyrnaiou et al., 2020, p. 19).

Fig. 20 *Example of a virtual world plan on a whiteboard*

Strategies for Implementation of Design using the DEW Concept Model

We recommend the following strategies for integrating world building assignments across the curriculum, aligned with the DEW Concept Model:

- **Create a data-driven storyline**. Creating a data-driven storyline in virtual worlds naturally incorporates collaboration, teamwork, project management, leadership, and creative problem- solving.
- **Collaborate on the narrative.** Collaborating in highly visual virtual environments and focusing on the narrative to convey ideas through experiential storytelling promotes improved understanding of the topic and increased retention.
- **Facilitate critical feedback.** Generating ideas and perspectives with immersive environments increases critical feedback, especially when including emotional and experiential activities.
- **Cultivate curiosity.** World building cultivates curiosity through discovery complemented with the physical response rewards associated with exploration and wonder. To create the virtual worlds, students need to know more. As they know more about the subject, they want to learn more.
- **Foster accomplishment and achievement**. Tapping into a vast range of skill-building techniques improves students' sense of accomplishment, self-confidence, and self-efficacy, especially combined with the pride students feel when they are eager to show off their worlds to others and share their experiences.

Conclusion

As teachers and authors of this chapter, we strive to find better ways to translate material into tangible, relevant, and engaging learning experiences by mixing and matching the characteristic ingredients to apply to the eight world models. We help educators and students select or create educational worlds that are interactive, immersive, and experiential, that tap into wonder and awe to increase engagement, and that challenge traditional teaching methods often filled with dull facts and statistics. Our goal is to go further in our research to identify how to develop

virtual educational experiences that change hearts and minds to truly define a quality educational virtual world.

VR offers a transcendental teaching experience that involves storytelling and play to deliver facts and data through story, taking the student on a learning adventure. In this chapter, we explored the world models that serve as the building blocks, to which educators and world builders may add embodiment, role-playing, curiosity, emotional responses, collaboration, and familiarity grown naturally out of discovery, exploration, and wonder, ingredients that bring educational virtual worlds to life. We are continuing our experiments aimed at developing a teaching toolkit to help educators select and build educational worlds and encourage students to use virtual world building as homework, especially as collaborative experiences.

We invite educators and students to integrate virtual worlds into their pedagogy using free immersive platforms such as *AltspaceVR, Mozilla Hubs*, and *Frame VR.* Our DEW (Discovery, Exploration, Wonder) Concept Model is a starting foundation for learning how to facilitate teaching in VR, filling virtual worlds with storytelling techniques and the right ingredients to take learners on an adventure of change and influence. VR can educate on diverse topics, from simple grammar lessons to computer science, history, and beyond. It can positively affect our world by immersing participants in the consequences of human history, greed, pollution, and war. By showing students a topic in a way they have never seen before, complemented by the adventures made possible by discovery, exploration, and wonder, VR is disrupting education with innovative immersive learning experiences and environments.

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