Learning in Virtual Environments

Optimizing Simulation Instruction with Flow, Immersion, and Suspension of Disbelief

This document is based on my graduate research at Montana Tech in 2016 on how to leverage human psychology to optimize virtual reality interactions.

Technology changes fast. I would love to hear from you if you are interested in these ideas or have new insights in the topic.

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In 2014, I began researching the applicability of 360° imagery and Virtual Reality (VR) as a tool for training. With the support of the premiere engineering school in Montana, I conducted in-depth research to identify methods to optimize virtual reality learning experiences. Now, years later, virtual reality technology has developed in leaps and bounds, and the dream to create affordable VR learning experiences is coming to fruition.

My research investigated overlapping topics in e-learning, psychology, and VR technology that provide meaningful and timely knowledge about how to best use VR to communicate and learn.

Three key factors leading to improved memory and skill retention of instructional content in VR were identified.

Psychological State of Flow is a condition characterized by a heightened state of focus, a decrease in distraction, and an increase in the short and long term retention of information experienced during that state. Being “in flow” is the subjective experience of engaging just-manageable challenges by tackling a series of goals, continuously processing feedback about progress, and adjusting action based on this feedback (Csikszentmihalyi, 2014a).

Suspension of Disbelief allows users to believe the unbelievable and resist judgement of authenticity; it’s the cognitive act of accepting information as fact. Suspension of disbelief allows the user to accept the virtual experience as real, even with its constraints of movement or lack of visual or audio realism (Muckler, 2016).

Sense of Immersion is a satisfying psychological state of perceiving to be in an environment that meets expectations. A sense of immersion is achieved when the user’s experience feels like the real world with scenarios and interactions they would expect in the real world, allowing them to relax their focus on what is different than reality (Douglas, 2000).

VR enhances learning and training experiences because users achieve primary goals of effective learning. Users are motivated to learn, and retain more of what they learn, due to the psychological enhancement that VR provides over the traditional methods of training.

Virtual Reality as a Medium

We shape our tools and thereafter our tools shape us. This phrase is used by many to describe how the communication tools we create provide a framework of thought, thus developing new meanings for the messages we present through the tools we use. Just as the development of radio, video, and the internet created new collective consciousness, another transformation has begun in digital media that promises to shape how people communicate, learn, and play.

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) devices are now readily available at affordable pricing for consumers.
Currently, VR, AR, and MR are presented through computer-generated simulations allowing users to experience virtual environments with user interfaces that provide visual, auditory, and sensory experiences, transporting users into a different reality. Head Mounted Displays (HMDs) are worn over a user’s eyes, and as they move their head the perspective changes with their movements. Hand controllers with haptic feedback are used to interact with the environment further. These user interfaces create a remarkably realistic sense of immersion in a virtual environment.

Using virtual environments to communicate is an ancient concept that has fascinated people throughout history. Ancient temples and cathedrals were versions of some of the first virtual environments, as they were created to evoke emotions and present narratives that allowed the audience to experience a different reality. Staged plays with elaborate sets, actors in costumes, and special effects such as smoke and lights have been used for centuries to immerse the audience into a virtual environment. In modern history, Walt Disney created narrative environments with extensive spatial interfaces and virtual realities when he built Disneyland’s “Pirates of the Caribbean” and other theatrical experiences that created fully immersive and seemingly real environments (Pearce, 1997).

In recent years, massive strides in technology lead to increased computing power, improvement in screen resolutions, and enhanced graphics, allowing immersive VR, AR, and MR to the forefront as a practical method for capturing and presenting photorealistic virtual environments. Photorealism provides users with actual photo images displaying real environments and actors, whereas, CGI looks computerized, lacks visual depth, and requires a lengthy production process due to extensive graphic design and animation.

Like all evolutions in technology, the emergence
of VR provides new opportunities to create and deliver more sensory-rich information. Creating effective learning content in VR requires a next-level approach compared to other educational mediums. Content creation for VR takes a nontraditional approach, unlike print and video where the user’s attention is intuitively focused on the text on the page, the framing of the video, or the duration and pace of the audio lecture, with VR the user can look away from the intended subject and disregard the pace and timeline of the content, but still be immersed in the experience. This dynamic makes the creation of VR content more complex than the creation of other media content, but it also produces a more realistic experience.

How to Optimize VR Learning Environments

Mihaly Csikszentmihalyi’s (2014) research makes the case that an optimal experience is a measurable event and that is influenced by internal and external factors. Optimal experiences are an ordered state of consciousness, depending on factors of information flow, too much or little, predictability, and usability of the information all affect the experience. Optimal learning experiences in virtual environments are subjective goals depending on the user, the topic, and the available technology, effective learning can be something different to each person.

Previous research identifies measurable factors in effective e-learning and simulation based instruction (Liaw, Huang, & Chen, 2005; Liaw, 2007). These factors strongly relate to the effectiveness of learning content in virtual environments. While there may be variability in how much or how broadly those factors apply to diverse audiences, this research identifies a core set of factors likely to contribute to effective instructional content in VR. Sensations provided
by virtual simulations in interactive 360° environments (in other words, VR) enhance memory retention and learning experiences.

Three key factors leading to improved memory and skill retention of instructional content in VR were identified through my research. The first factor identified for effective VR training content is to create a psychological state of flow during the training experience. The second factor is to produce training content that encourages the suspension of disbelief. The third factor is to develop a sense of immersion in the training content, which is essential to create flow and the suspension of disbelief in VR.

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**Flow**

Within an optimal learning experience, the person is challenged to the edge of their skills, while the challenges do not exceed what the person can accomplish. The optimal experience is the state in which a person does not feel anxiety because they cannot accomplish the task, but they are not bored from lack of tasks or tasks below their skill level. An optimal experience is a state in which thought is ordered in response to continual challenge, without internal conflicts of worry or other distractions. The person is focused on the challenge at hand without thinking about other things. The person is in a state of flow within a stream of information with complete concen-

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**2 WEEKS AFTER A LEARNING EXPERIENCE**

**WE REMEMBER:**

- **20% OF WHAT WE HEAR**
- **40% OF WHAT WE SEE**
- **90% OF WHAT WE EXPERIENCE**

We tend to only remember 10% of what we read, 20% of what we hear, and 40% of what we see. Mixing audio and visual together in a passive video can improve retention up to 50 percent. But that isn’t effective learning. Training should be an immersive experience that delivers information employees can remember and apply to their daily work.
tration on achieving successful reactions to the challenges (Csikszentmihalyi, 2014a).

Characteristics of flow

Flow is the psychological state of the optimal experience, one in which, “experience seamlessly unfolds from moment to moment.” As flow is achieved, the individual thinks less about the past and the future, focusing on the moment with few internal distractions. When in a state of flow, memories, future plans, anxieties, and self-consciousness are put out of the mind.

- Intense focus on tasks in the present moment
- Action and awareness are closely connected
- Loss of self-consciousness
- A sense of control and self-efficacy
- Distortion of temporal experience, time passes faster
- Sense that the activity is intrinsically rewarding

Conditions for flow

Csikszentmihalyi’s experiments (2014) measured the state of flow compared to motivational aspects of a game-based learning experience. The game Csikszentmihalyi used was a location-based history game with mobile devices where learners were asked to play the game while observers watched for excitement and engagement, key indicators of flow. The learners were then given questionnaires to measure self-efficacy and flow, then given an exam to test learning outcomes.

A chief conclusion of Csikszentmihalyi’s research was that technology disrupting game play also interrupted the state of flow and negatively impacted learning outcomes. Sense of learner’s self-efficacy within the game also impacted flow and learning outcomes. Csikszentmihalyi, 2014b).

Presence

The late 90s was a hot time to study presence, immersion, and flow in virtual environments. There is substantial research measuring factors that lead to a sense of presence in virtual environments. Presence is the feeling a user experiences when they are deeply sensing an environment. The factors of presence relate closely to flow. A series of factors can be measured in experiments to understand how flow and presence influence the effectiveness of learning content in virtual environments. It is proven in several

Witmer (1998) wrote a seminal paper laying out a method to measure the extent a person feels presence while in a virtual environment. The author’s research is based on the belief that presence is a normal awareness phenomenon, requiring directed attention and is based on sensory stimulation, involvement leading to immersion, and internal tendencies to become involved. Degrees of presence depend partly on the allocation of the attention resources of the audience, and the individual factors of sensory stimulation and immersion.

Witmer grouped the factors of presence into four categories affecting involvement and immersion: control factors, sensory factors, distraction factors, and realism factors. Witmer constructed a Likert style survey that tested each factor. After experiments on 152 subjects, the score of eleven of the twelve control factors, five of the seven realism factors, eight of the nine sensory factors and four of the six distraction factors correlate significantly with the total score of a presence questionnaire (Witmer, 1998).

Another group of researchers (Dinh, et al, 1999) experimented with 322 participants to investigate effects of multisensory layers on the audience’s sense of presence and their memory recall after a virtual environment. The reported results suggest that increasing the sensory modalities directly increases the sense of presence and memory retention of experiences within the virtual environment. The research used a very simple 3D rendered space with an office layout. The experiments required users to familiarize themselves with the virtual environment software under a cover story about real estate sales. After the experience, the audience was given questionnaires to test their memory of key landmarks within the virtual environment. The sensory modes were adjusted and the resulting changes in memory retention and sense of presence were recorded.

The researchers found a strong connection with tactile, olfactory and auditory cues, and the increase in the sense of presence and memory of the virtual environment. Dinh’s research supports the idea that the more immersive the virtual environment is in each of the sensory modalities the more intense the sense of presence will be for the audience (Dinh, et al, 1999).

Pleasure Principle

Douglas and Hargadon (2000) identify the pleasure principle as a concept that affects engagement and the perception of favorable experiences. The idea comes from an analysis of the dimensions an audience experiences within a story, and the factors that make it a pleasurable experience, including: the audience’s assumptions about the continuity of the characters, narrative twists, timeline, plot resolutions, and the setting. All these factors influence the mood, feelings, and attitudes of the audience.

Designers of interactive experiences are faced with the challenge of creating stories and interfaces that lead the audience through an experience while carefully managing the elements that affect emotions. The research analyzed interactive narratives with schema theory. Schema theory charts how information shapes the audience’s perception and the choices the audience
makes by breaking the experience down to its fundamental blocks of comprehension. Schemas are connected groups of content that represent concepts and knowledge moving audiences to perceive, understand, and act.

The pleasure principle traces the pleasures we enjoy during an experience directly from how well the schemas interact with the audience. Comfort and pleasure is greatly influenced by how the schemas fit within the audience’s expectations. Immersion is a result of being swept away by the expected flow of schemas.

“The pleasures of immersion stem from our being completely absorbed within the ebb and flow of familiar narrative schema. The pleasures of engagement tend to come from our ability to recognize a work’s overturning of conjoining conflicting schemas from a perspective outside the text, our perspective removed from any single schema (Douglas & Hargadon, 2000).”

Shifting expected schemas in the narrative creates engagement through suspense and tension because the changing schema keeps the audience focused. Meeting expectations creates immersion in the experience by relaxing the audiences focus on the schemas because they are delivering what is expected. The pleasure in an interactive narrative comes from the way the audience’s meaningful choices navigate the story.

“Just as immersion is satisfying as long as local details infuse the schema with unique or unpredictable elements, so engagement remains pleasurable only when it displaces or subverts one schema while offering readers suitable alternatives (Douglas & Hargadon, 2000).”

Suspension of Disbelief

Muckler (2017) researched how the suspension of disbelief during simulation based learning facilitated the retention of information. Her research determined that learners in a simulated environment must accept the unrealistic aspects of the experience to fully engage in the experience.

She found that there are several factors necessary for suspension of disbelief:

- Fidelity
- The fictional contract
- Psychological safety
- Emotional buy-in
- Assigned meaning

Fidelity is the based on the degree of realism and believability of the simulation. This is a result of the learner’s familiarity with the simulated environment, the degree to which they can interact with the simulated environment, and the realistic nature of the scenario. Emotional buy-in is based on how relevant and applicable the simulation is to the learner’s understanding of the tasks and the learner’s goals for experience. The simulation must invoke the emotions of the real-life event.
and the learner must experience an emotional attachment to the experience. The fictional contract is based on the learner’s ability to feel immersed in the simulation, how easily they get into character as the star of the simulation, and their ability to play along with the simulation. (Muckler, 2017)

Psychological safety is built by creating a simulation that is conducive to learning. The learner must feel confident enough to take risks and feel like consequences of failure are not overly harmful. The learner must feel free from humiliation or serious penalties if they make poor decisions or fail the training. Assigned meaning depends on how the learner assigns meaning to the experience. The assigned meaning incorporates elements of fidelity, emotional buy-in, and psychological safety. (Muckler, 2017)

**Conclusion**

This investigation has value for a wide variety of applications, the obvious being for instruction in academic, industrial, medical, and business training scenarios. Simulations in virtual environments that optimize flow, presence, and immersion benefit from increased skill retention and quicker knowledge delivery.

The optimal learning experience, challenges the person to the edge of their skills, while not exceeding what the person can accomplish. Optimal learning experiences create ordered thought with continual challenge, while reducing worry or other distractions. The learner is focused on the challenge at hand without thinking about other things.
A deep sense of presence is a key factor in building the psychological state of flow in a virtual environment. Research has proven that memory retention increases with a heightened sense of flow and presence. A thoughtful and informed approach during the production of VR instruction experiences to increase a sense of presence and flow is essential for effective learning outcomes.

Further research in the suspension of disbelief during simulation based learning has shown that it facilitated the retention of information. Learners in a simulation environment must accept the unrealistic aspects of the experience to fully engage in the experience. Establishing fidelity, the fictional contract, psychological safety, and emotional buy in are proven to increase focus and learning retention.

While our research continues to transform along with the technology available to us, great benefits are drawn from studying the science behind what makes VR so enthralling.

**Bibliography**


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