VIRTUAL REALITY AND HIGHER EDUCATION:
PRESENCE AND MOTIVATION TO LEARN VIA
IMMERSIVE MEDIA EXPERIENCES

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ABSTRACT

Although many studies have pointed out the limitations of applying more advanced technology in educational settings (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015; Kozma, 1994), some studies have shown media technology enhances essential educational outcomes (Gardner, 1993; Hew & Cheung, 2010; Jensen & Konradsen, 2018; McLellan, 1994; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014) and that more immersive media technology can help people to perceive events through media technology better (Bracken & Lombard, 2004; Lombard, Biocca, Freeman, IJsselsteijn, & Schaevitz, 2015; Lombard, Ditton, Grabe, & Reich, 1997; Lombard, Lee, Sun, Xu, & Yang, 2017; Lombard, Reich, Grabe, Bracken, & Ditton, 2000). These current debates lead to a question of whether providing immersive experiences can help to achieve higher goals of education and what is the psychological processes behind it.

The main purpose of this dissertation is to help people exploring these debates by providing more understanding of the psychological processes behind the motivation to learn in higher education when students have more immersive media experiences. Therefore, the role of presence and information processing in HMD VR (Head Mount Display Virtual Reality) on motivation to learn were tested and analyzed with a mixed-method study incorporating a lab experiment and in-depth interviews. Theoretic backgrounds and assumptions of Risk Information Seeking Processing (Kahlor, 2007; Stern & Fineberg, 1996) and Social Cognitive Theory (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Bandura, 1982) were deployed in the study design to see
whether and how HMD VR can help transformative learning (Dewey, 1938; Mezirow, 1997; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007).

Results revealed HMD VR increased students’ Motivation To Learn significantly. The increased level of Motivation To Learn in the HMD condition was also observed in the in-depth interviews. The results support these studies that suggested the association between interactive experiences and enhanced learning outcomes (Ang & Rao, 2008; Hew & Cheung, 2010; Kaufmann, Schmalstieg, & Wagner, 2000; Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017; Moreno, Mayer, Spires, & Lester, 2001; Steinberg, 2000). The results also support the effectiveness of creating more immersive learning environments under the Social Cognitive Theory framework (Bandura, 1977; Miltiadou & Savenye, 2003; Rotter, 1990) but with limited support under the Risk Information Seeking and Processing framework (Kahlor, 2007; Stern & Fineberg, 1996). These results demonstrated the relationships between presence and MTL identifying how cultural experiences trigger social responses when people make associations in their higher-order cognitive processes, suggesting para-reality interaction. In addition to the theoretic contribution, the implications of this study provide helpful suggestions and insights to create and use HMD VR content to create transformative learning experiences for students.
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I reflect that completing a dissertation is a process to discover the most important question that I have. This process took a long time with endless support and patience from people I love.

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dissertation. This luxury of intellectual freedom required patience from them. That might be the reason I found the motivation to learn is important, because I might have lost my motivation without their support.

At last, but most importantly, I remember the limited things that I could do with the first 8-bit computer that my father bought for me. I was an elementary school student and curious about “What can I and other people do with this computer other than providing mechanical conveniences?” in the middle of breaking that poor computer. I realized this dissertation is the process of answering that question and I owe the accomplishment of this dissertation to my father who helped me to find and pursue this question. He always felt sorry that he did not have any chance to have a higher education, but he showed me the vision of looking for what I want to know more.

I dedicate this dissertation to

YoungGu Yang

September 11, 1956 - November 19, 2015 at 2:48 pm
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CHAPTER 1

INTRODUCTION

In a classic experiment by Milgram (1965), more people obeyed more inhumane orders when they could not sense the painful reactions of others than when they could directly observe with close proximity. A more recent study by Burger (2009) showed only slight improvements. These study results imply that it is unfortunate that people do not tend to think or care about the consequences of their actions when the consequences are less perceivable. Nevertheless, it is also fortunate to know that some people can critically confront authority. Advances in communication technology seem to be able to provide more immersive experiences that create the perception of increased proximity. Could this increased proximity through technology help people to think critically?

Considering that obedience in general, as well as in the study of Milgram (1965), is considered as a learned and culturally constructed behavior (Bernard, Killworth, Evans, McCarty, & Shelley, 1988), some researchers proposed that educational measures can help people to be motivated to have deeper reflections about their actions. Another follow-up study by McNamee (1977) showed “moral development and motivation” (p. 27) increased the rate of people who defied the authority to help people in trouble (Krebs, 1975; McNamee, 1977). According to Taylor (2014), these interpretations of Milgram’s experiment seem to be based on the philosophical root from transformative learning (Dewey, 1938) and the sociocultural learning perspective of Vygotsky (1980) that has been transmitted to the current educational philosophy and theory (Taylor, 2014; Tharp & O’Donnell, 2016). However, it is questionable if current educational institutions are
aiming for this level of achievement and if advances of media technologies can contribute to these educators’ efforts.

Although it is impossible to make a definitive answer to these questions, it looks like they are important questions to researchers, educators, educational institutions, and content developers to use as they develop and apply media technology in educational settings. Although this study does not focus on dichotomous obey and disobey behaviors, Milgram’s obedience study (1965) provides a good example of why exploring these questions would be fundamental to make a better society. Unfortunately, some studies have criticized current education for not helping people be more motivated to think about the consequences of their actions even in higher education settings (Bledstein, 1978; Chin, Tang, & Chen, 2015; Cunningham et al., 1998; Evan & John, 2005; Garrison & Anderson, 2000; Harrison & Risler, 2015; Labaree, 2016; Rodríguez, 2007) and argued that the current advances of media technology contribute little to enhance teaching and learning experiences (Harrison & Risler, 2015; Mitchell & Leachman, 2015; Mitchell, Palacios, & Leachman, 2014; Moreno & Mayer, 2002; Moreno et al., 2001; Ravitch, 2010).

To address these concerns, the researcher explored whether a more immersive experience with media technology can help people to be motivated to deeper information processing in a higher education context. The researcher expected the more immersive experience could help motivate people to engage in deeper information processing about people in a remote location and indirect influences of their actions. For example, it is difficult to have first-hand experiences about the humanitarian crisis in a different
country, renewable energy and global warming, and problems with micro-plastics in the ocean. People feel it difficult to see direct consequences and so it is difficult to expect them to have deep processing concerning their actions. It would be promising if advanced communication technology can help with this, as some studies have shown media technology could enhance this deeper processing (Gardner, 1993; Hew & Cheung, 2010; Jensen & Konradsen, 2018; McLellan, 1994; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). More specifically, some studies support the idea that more immersive media technology could help people to perceive events through media technology better (Bracken & Lombard, 2004; Lombard, Biocca, Freeman, IJsselsteijn, & Schaevitz, 2015; Lombard, Ditton, Grabe, & Reich, 1997; Lombard, Lee, Sun, Xu, & Yang, 2017; Lombard, Reich, Grabe, Bracken, & Ditton, 2000). On the other hand, some research suggests these studies have limited implications (Gardner, 1993; Hew & Cheung, 2010; McLellan, 1994; Merchant et al., 2014) and the benefits of implementing new media technology would be negligible compared to their costs (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015; Kozma, 1994).

**Progressive Education in Higher Education**

Education is a pivotal part of human society and people expect their educational institutions to function well for their society. At the same time, people disagree about best practices for education, and there are criticisms that the ideology of professionalism (Bledstein, 1978) has distorted the role of higher education (Bledstein, 1978; Chin et al., 2015; Cunningham et al., 1998; Evan & John, 2005; Labaree, 2016; Schuck, Gordon, & Buchanan, 2008). The critical scholars were concerned about that the current ideology of
professionalism have a shared concern about valuing more quantifiable educational outcomes and achievements which are represented by the “quality-control culture of higher education” (Nixon, Marks, Rowland, & Walker, 2001, p. 231) than the quality of education. Nixon et al. (2001) described that professionalism is one of the characteristics of higher education’s institutional structures, practices, assessments, and curriculums, emphasizing “accountability and professional accreditation.” (p. 229) It is observed from some of the educators, for example in the interview records of Feather (2014), that several educators in their study passionately shared their experiences that they had to compromise on their teaching quality and expectation to avoid conflicts that can be linked to negative impressions to institutional reviewers.

Scholars who criticized the ideology of professionalism find some benefits of the “quality-control” in higher education are marginal because of the fundamental concerns that they found (Nixon et al., 2001; Schuck et al., 2008). Their concerns were prioritizing the nature of “quality-control” does not guarantee the goals of education and the increased emphasis of academic accountability expects educators’ commitment for fostering students’ ability to incorporate, instead of questioning, current professional practices (Nixon et al., 2001; Schuck et al., 2008).

Knowing and learning professional skill sets are important parts of education (Fenwick, 2016; Scanlon, 2011). But what most critical scholars are concerned about is that, now, it is a requirement for higher education institutions to teach professional skills to students for maintaining and advancing students’ careers, as Bledstein (1978) predicted. This neoliberalism trend in American society, as well as most of the countries
in the world as a part of globalization (Olssen & Peters, 2005), has continued (Cunningham et al., 1998; Evan & John, 2005; Olssen & Peters, 2005), discounting the greater societal goals of higher education. Going through an economic depression in the 1970s particularly made the discounting process faster and deeper (Chin et al., 2015), people discounted the roles of higher education in their society further and further. The underlying assumption of society driving this trend, that is not explicitly being said among people, would be higher education is for private merits rather than societal merits (Labaree, 2016; Olssen & Peters, 2005).

The aforementioned concerns of educators in higher education started much earlier. Dewey (1938, p. 17) suggested “progressive education” as a direction to embrace changes in society in education. Dewey (1983) suggested the “progressive education” as a goal of higher education that should help questioning everything to expand the boundaries of knowledge about everything. Considering it was 1938, when Dewey first suggested the educational goal, it is a disappointment that the current educational institutions are not more progressive, instead, they are even going back to the position where they simply teach conventional skills to meet the cost-effectiveness of running classrooms. As Rodríguez (2007) and Harrison and Risler (2015) pointed out, some educators who follow the idea of “progressive education” (Dewey, 1938, p. 17) also have shown similar concerns that the recent direction of education seems to mask the societal merits of higher education behind the individual student’s economic advantages, as well as educational institutions’ revenues. For example, as Garrison and Anderson (2000) pointed out, states’ federal grants for higher education institutions between 2000 and
2005 favored teaching job-related skills. Schuck et al. (2008) questioned what would be a consequence when higher education institutes set standards for professionalism and student satisfaction to evaluate teaching effectiveness. They criticized that the students’ evaluations have more value to administrative, bureaucratic, and marketing practices instead of contributing to instructors’ self-reflection to improve their teaching style (Schuck et al., 2008), and for both teachers and students educational professionalism is the biggest challenge (Biesta, 2015; Sethy, 2018). This is also reflected in the adoption of advanced communication technology in higher education institutions.

**Desire and Concern about Adopting New Technology in Higher Education**

Advances in media and communication technology in the daily life of people have made them wonder if advanced technology can improve students’ learning (Gikas & Grant, 2013; Spencer, 1998). Spencer (1998) saw the possibility of technology that can offer unique interpretations and constructive realities to students. For example, as Gikas and Grant (2013) insisted, the technological advancement of instructional measures in higher education courses can help students to discover, share, and create information better. Although people recognize the need for acclimating to technological changes in society, it is still difficult for some educational institutions to apprehend the educational benefits of new technology (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015; Garrison & Anderson, 2000).

The attitudes of the U.S. Congress reflect this desire and concern. Between 1994 and 2000, the U.S. Congress increased funding for adopting new technology in educational institutions while the funding required evidence of effectiveness (Garrison &
Anderson, 2000). According to Becker et al. (2017), the Technology Literacy Challenge Fund in 1997 and the Enhancing Education Through Technology program in 2002 experienced a funding decline and were eliminated in 2011. Also, the Department of Education’s Preparing Tomorrow’s Teachers to use Technology in higher education, started 1999 and ended in 2006 without further funding for their follow up projects because of the limited empirical evidence that supported the effectiveness of the projects in Preparing Tomorrow’s Teachers to use Technology (Becker et al., 2017).

Still, all of these research programs only focused on the easily countable and observable aspects of learning as evidence of educational effectiveness such as students’ memory and test results, instead of providing discussions about what should be the evidence of educational effectiveness and underline processes of making effective learning experiences with the help of technology. This type of discussion - for example, the “progressive education” that Dewey (1938, p. 17) suggested - has not been reflected much and has received little focus. The limitation illustrated in the trend of funding also reveals that the debate between Clark (1994) and Kozma (1994) is still ongoing until now (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015). It could be, as Clark (1994) claimed, that there are “no learning benefits from media” (p. 21) because media simply delivers instructional messages to students. However, this argument completely underestimates the effects that come from differences in types of media and the role of immersive experiences. As Kozma (1994) counter-argued to Clark’s argument, it is impossible to find evidence under “the stimuli and responses of the behavioral paradigm”
because conventional tests ignore the deeper psychological processes of students’ minds.

**Barriers for Adopting Communication Technology in Higher Education**

Advancements of media and communication technology have recently impressed, surprised, and worried many people when they evaluate how media and communication technology is changing the landscape of humans’ daily lives. Screens are bigger; images are clearer; texts are more interactive; data connections are faster and cover wider areas. These are helpful to create more immersive mediated experiences (Bracken & Lombard, 2004; Lombard et al., 2015; Lombard et al., 1997; Lombard et al., 2017; Lombard et al., 2000). In the same period, nevertheless, for some areas, such as educational institutions, the praises and concerns of people have had a marginal influence.

Instead of emphasizing societal merits and taking the best benefits of advanced media technology that people envisioned, it looks like the U.S. education system has been through a lot of changes following political directions (Preiss & Wheeless, 2014; Ravitch, 2010). Although students started to use more and more current media technology, many classrooms’ primary modes of instruction are still lectures and readings. As Kirkup and Kirkwood (2005) argued, information and communication technology have not made a significant change in the education system from the 1990s, including higher educational institution’s classrooms as well. Specifically, what Kirkup and Kirkwood (2005) criticized was that the adoption of the technology tends to simply support previous instructional tasks’ efficiency reducing costs of operations. Specifically, the online enrollment system, grading, and remote classes have led to changes that reduce various
costs of operational resources compared to making classroom experiences more motivational and engaging with the help of advances of technology. It is debatable whether the changes have made the learning environments of students and instructors better.

Further, although students pay more in tuition, they suffer from a decreasing or a limited level of educational technology adoptions in public colleges and universities (Mitchell & Leachman, 2015; Mitchell et al., 2014). This problem not only limits students’ learning but it also sacrifices the societal merits of education. Because of the gap between educational institutions and commercial uses of communication technology, it is harder to explore the societal issues and contributions of education when lenses for students are limited to conventional tools instead of current communication technologies. As Spencer (1998) pointed out, the implementation of media and communication technology in classrooms only emphasized offering conventional and politically driven instructional effectiveness rather than offering enhanced learning. Students are forced to see the world with the narrow and traditional modes of communication within a specific domain of interests and skills. The criticism of Harrison and Risler (2015) and Spencer (1998) make educators think again about the goals and merits of the current higher education system to end the detrimental influences that the technological gap creates. It is time to spend more resources and efforts to figure out how to make the best use of the advances in communication technology in classrooms. Without this effort, the detrimental influences of the technological gap (Mitchell & Leachman, 2015; Mitchell et
al., 2014) will get worse and worse because the changes in communication technology systems outside classrooms are getting faster and faster widening the gap.

What this dissertation responds to is not that technology can solve the current weakness of higher education. Rather, it will try to answer the questions if it is educationally effective to use technologically advanced content in higher education and what would be the educational benefits of adopting them. This can help researchers, educators, educational institutions, and students when they try to understand the role of the media and communication technology in education by exploring these research questions.

**Organization of the Dissertation**

The main purpose of this dissertation is to explore the deliberation regarding whether and how media technology can enrich learning bearing in mind the goals of higher education for serving societal enrichment through students’ intellectual achievements. To explore the inquiry, this dissertation explores how researchers can understand psychological processes and whether advances in media technology can enhance learning.

To design a dissertation study that can test the educational benefits of media and communication technology, this chapter first started with a question about the current issues of higher education institutions concerning educational effectiveness. This chapter also discussed the current limitations for adopting more advanced media and communication technology. Based on these discussions, this chapter suggested that higher education should be proactive to embrace the technological advances in higher
education reconsidering what we want to achieve through higher education. The following chapters of this dissertation will consider if advanced media and communication technology can contribute to educational uses, specifically HMD VR (Head Mounted Display Virtual Reality). Chapter two will review recent advances of HMD VR and studies provide promising suggestions for the educational uses of the technology, as well as their limitations.

Chapters three and four will review more specific arguments applying two theoretic approaches, the concept of presence (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018; Johnston, Berg, Pillon, & Williams, 2015; Nass, Steuer, & Tauber, 1994; Vanian, 2018; Weiser, 1991; Yoshida, Kihara, Takeshita, & Fujii, 2014) and motivation to learn in the theoretic frameworks of social cognitive theory (Bandura, 1978, 1989, 2011; Boekaerts, 2002; Glynn, Aultman, & Owens, 2005; Middleton, 2014; Stipek, 1988; Wiethoff, 2004) and Risk Information Seeking and Processing (Griffin, Dunwoody, & Neuwirth, 1999; Huurne & Gutteling, 2008; Johnson, 2005). These chapters will also provide these theories’ contribution to educational uses of media and communication technology to integrate these arguments to form hypotheses and research questions.

**Chapter summary**

Chapters five, six, and seven will describe a mixed method study and its analysis results. Chapter six will describe how the researcher conducted an experiment study along with in-depth interviews. Chapters six and seven will describe how the researcher
analyzed gathered data to test the hypotheses and research questions. Chapter eight will discuss the implications of the dissertation study.
CHAPTER 2

MEDIA TECHNOLOGY AND EDUCATIONAL GOALS

As discussed in Chapter one, it is important to consider the goals of education before exploring the benefits of integrating advances in media and communication technology education. Chapter one suggested it is important to help people explore their surroundings, such as people, spaces, objects, and themselves. Media and communication technology may contribute to this purpose, though there are some controversies, especially for the HMD VR (Head Mounted Display Virtual Reality) technology. This chapter will review the evidence and limitations of adopting the HMD VR technology in education. After reviewing these arguments, this chapter will suggest there is limited knowledge about the roles of media and technology for educational uses, especially in higher education, to serve the suggested purpose of education. These limitations will be discussed more specifically before mapping out suggestions incorporating psychological processing of presence (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018; Johnston et al., 2015; Nass et al., 1994; Vanian, 2018; Weiser, 1991; Yoshida et al., 2014) in chapter three and motivation to learn in social cognitive theory (Bandura, 1978, 1989, 2011; Boekaerts, 2002; Glynn et al., 2005; Middleton, 2014; Stipek, 1988; Wiethoff, 2004) in chapter four to address these limitations.

HMD (Head Mounted Display) VR and Advances of Technology

HMD uses wearable screens close to the user’s eyes to provide a wider “field of view” (Zeltzer, 1992, p. 127), as shown in Figure 1. “The CAVE” (Cruz-Neira, Sandin,
DeFanti, Kenyon, & Hart, 1992, p. 65), as shown in Figure 2, is another approach for its VR image projection to provide the wider field of view, as shown in Figure 3.

Figure 1.
An example of HMD

Figure 2.
Illustration of The CAVE
The increased field of view of both HMDs and The Cave is one of the unique features for creating more immersive visual perceptions compared to the other types of displays for the conventional displays of VR content such as flat-screen monitors, TVs, and even large theater screens. The CAVE uses walls in a room as displays instead of placing screens close to the viewers’ eyes. To provide images in the wider field of view for both types of technology, the contents and software need to include spatial information that can cover the entire spherical coordinates (Havig, McIntire, & Geiselman, 2011).

**Figure 3.**
*Illustration of the Field of View*
HMDs and The Cave also use the spherical coordinates to reduce black areas or to provide additional angles by matching the coordinates with the movements of users (Havig et al., 2011). The ability of coordinate-mapping in VR content also makes the VR experience interactive (Havig et al., 2011; Steuer, 1992). The conventional displays of VR also can provide coordinate mapping but the mapping of HMDs head movement tracking is more accurate compared to user interfaces for the conventional displays such as a mouse, keyboard, touch sensor, and game-pad.

**Immersive Displays: HMD and The CAVE**

Displays in The CAVE are easier to project images with higher pixel density to eyes than HMDs because they use large projection surfaces; the gap between the distance from eye to screen and the perceived distance from eye to graphic objects is relatively small, as shown in Figure 4, therefore it is more non-intrusive and natural (Havig et al., 2011).

**Figure 4.**
*The Distance of Eye-to-Screen vs Eye-to-Graphic Objects*
Compared to that, displays in the HMDs use smaller projection panels that make it difficult to project images with a higher pixel density and the distance of eye-to-screen is always much shorter than eye-to-graphic objects (Havig et al., 2011). Recent technological improvements that can display higher resolution images in smaller screens that can fit in the HMDs make the gap smaller, but The CAVE still has the advantage over HMDs’ screening mechanism for projecting more clear and natural images.

On the other hand, the biggest problem of The CAVE is that it always needs a big room. Further, users of The CAVE visually see the surfaces and edges of the room in projected images (Havig et al., 2011). This makes it hard for users to ignore the role of technology and have proper distance perception (Havig et al., 2011; Lombard & Ditton, 1997; Lombard et al., 2017). Recent attempts in The CAVE systems that use an increased number of displays to create a dome-style display room rather than rectangular ones reduce the gap compared to HMDs, but still, HMDs have advantages over The CAVE systems for making a more seamless and infinite field of view. Besides, HMDs require less computing power since they project partial images on displays depending on where users look and orient than The CAVE, which always projects the entire surfaces on all display walls. Due to current limited computing power in generating graphics, HMD contents can have more 3D graphical details than The CAVE systems. In addition, the reduced computing power required for HMD systems adds more portability to HMDs so that they can even be wireless.
**HMD VR**

Oculus VR’s launching in 2016 prompted the second renaissance of VR (Virtual Reality), following the first experiment when Minsky (1980) introduced the “teleoperation helmet,” which is similar to today’s HMD (Head Mounted Display) style VR technology (HMD VR). According to Krueger (1991) and Steuer (1992), VR is the term first introduced by Jaron Lanier in 1989 to describe a broad area of computer systems that can provide different types of interactions between human and computer-generated signals. Steuer (1992) criticized that the term VR that most of the people used at that time was oriented toward technology and industry too much because perceived VR contents, stories, characters, and environments in users’ consciousness are all different. Even with the criticism, the term is still widely used to describe any types of mediated experiences through computer-generated simulations. Although some recent studies separate immersive VR as a technology that can provide more sensory-rich experiences in education fields (Bailenson et al., 2008; Biocca & Delaney, 1995; Makransky, Terkildsen, & Mayer, 2017; Slater & Wilbur, 1997), the term VR still does not provide a clear picture of differences across technologies.

Although defining and verifying characteristics of VR are important and meaningful efforts, it is not yet a fully constructed concept. Therefore, among all other various types of VR technology, this dissertation specifies a type of VR display technology, which is HMD VR. HMD VR delivers various types of simulations, second-hand experiences, and remote operations in VR through HMD as a medium supposing it can enhance perceptions of immersiveness and realism (Srivastava, Rimzhim, Vijay,
Singh, & Chandra, 2019). In that way, it can identify and discuss a specific technology that is considered to provide the most “interactive and vivid” (Steuer, 1992) and immersive experiences (Bailenson et al., 2008; Biocca & Delaney, 1995; Makransky et al., 2017; Slater & Wilbur, 1997) from other VR systems and contents.

As shown in Figure 5, the researcher created a comparative search trend between 2004 and 2018 using the service of Google Trends. The interests of people around the world in VR as represented by Google searches peaked in December 2016, when new HMD devices were introduced. Continuing until January of 2018, the increased interest was twice as high compared to 2004-2015 (Google, n.d.). Technavio (as cited in "Global virtual reality in gaming market 2016-2020," 2017) predicted the Compound Annual Growth Rate (CAGR) in the overall HMD VR market between 2016 and 2020 to be 84.4%. Also, HMD VR will lead world AR and VR display development, projected as 21.8% of CAGR in the market during 2019-2024 (Markets and Markets, 2019).
Figure 5.  
*Relative Interest over Time in VR*

Note. Virtual reality (Worldwide) search trend in Google Trends shows comparative search frequencies of virtual reality compared to the most frequent time, which is December 2016 in percentages. The peak is used as 100%. There is no available data before January 1, 2004.

From the second renaissance of VR that was fueled by HMD VR, there has been much entertainment content produced for VR use, including games, movies, sports, and music applications. In addition to entertainment uses, which promise revenues for selling VR software packages, many organizations are also jumping in to create VR content and system for the benefits of education and society. For example, Facebook, which acquired Oculus company in 2014 and became one of the major HMD VR manufacturers and platforms (Markman, 2019), started the “Oculus Education pilot programs” in 2018 in the
U.S., Taiwan, and Japan to expand uses of their HMD VR devices and create more educational content (Vanian, 2018). That program teamed with many higher educational institutions including MIT, Harvard, Cornell, and NYU. Famous film festivals, including the South by Southwest Film Festival, Sundance, Tribeca, and Cinequest Film Festival, and the Oscar and Emmy awards, started to include VR divisions to explore the potential of VR as an art form (Cigainero, 2018; Solsman & Stein, 2018). Museums, for example, the National Museum of Natural History in Paris, The National Museum of Finland in Helsinki (Cigainero, 2018), and The Franklin Institute in Philadelphia started installing VR sections, exhibitions, and projects (Ileto, 2016). News providers, for example, The New York Times, Wall Street Journal, CNN, BBC, and NPR started to publish stories in VR format (BBC, n.d.; NPR, 2020; NYT, 2018; WSJ, 2015, 2018). Also, The National Aeronautics and Space Administration (NASA), Oxford University, Google, and Discovery started launching educational projects (Discovery Education, n.d.; Gillard, 2017; University of Oxford, n.d.).

As noted above, HMD VR is not a new technology at all. It just took 36 years to make significant improvements in VR technology that impressed many people again. Although people are again impressed with the potential of VR with the recent improvements in VR, the current HMD VR technology still requires the highest bandwidth, computing power, and many wires to accomplish the best quality. For many users, it is still not easy to use and access. Although it is still doubtful that the current level of technology is advanced enough for our daily uses, it is important to consider what people can achieve with this type of technology because this consideration is pivotal.
to guide future directions for developing HMD VR content and technology. There are more and more sections and placements for HMD VR in museums, VR stories in news organizations, and research projects concerning HMD VR in research and educational organizations. They reflect the expectations and visions of people who want to make our society better with this technology.

**Mixed Evidence for the Educational Effectiveness of HMD VR**

Martín-Gutiérrez et al. (2017) concerned that VR systems benefited only for educational fields and institutions that were full of resources and funds. Although the cost of the VR systems is now more accessible to more people, many educational institutions are still hesitant to implement it for pedagogical improvement (Martín-Gutiérrez et al., 2017). This is in part because of limited evidence of the educational effectiveness of HMD VR as explained in the first chapter. On the contrary, studies examining the educational effectiveness of VR technology tell us a mixed story.

*The Mixed Evidence*

In fact, many studies have supported using advanced media technology to enhance some essential educational outcomes (Gardner, 1993; Han, 2020; Hew & Cheung, 2010; Jensen & Konradsen, 2018; Kaufmann et al., 2000; McLellan, 1994; Merchant et al., 2014). The support of these studies seems promising but they are simply suggesting possibilities or do not have a coherent theory to explain the educational effectiveness that they find. For example, McLeod et al. (1999) assumed VR can provide good support for Gardner's multiple intelligence. Gardner (1993) proposed seven types of intelligence in their multiple intelligences theory: spatial, bodily-kinesthetic, logical-
mathematical, musical, linguistic, interpersonal, and intrapersonal. These “executive functions” are especially important for the development of young children (Bailey & Bailenson, 2017; St Clair-Thompson & Gathercole, 2006, p. 745). McLeod et al. (1999) explained that VR could improve most of the types of intelligence that Gardner suggested because it provides sensory-rich experiences and these are representational and presentation tools for instructors and learners. Although McLellan (1994) and some earlier studies also suggested VR technology has potential in educational uses enhancing all 7 types of Gardner’s multiple intelligence, their conclusions were always pointing out technological limitations and suggesting additional studies with more coherent theoretic concepts in the end.

The same problem was also evident by an omnibus study that the Defense Advanced Research Projects Agency (DARPA) conducted in 1998. Although it is a very old study, it still tells us what people have missed out when people and even researchers want to know the educational effectiveness of adopting media and communication technology. DARPA conducted a series of omnibus studies to test the benefits of Virtual Reality (VR) technology for diverse educational practices and applications (Youngblut, 1998). Around this time, several research projects followed, including Technology Literacy Challenge Fund started in 1997, Enhancing Education through Technology between 2002 and 2011, Preparing Tomorrow’s Teachers in higher education between 1999 and 2006, and many small independent studies (Becker et al., 2017; Hew & Cheung, 2010; Selverian & Hwang, 2003). For example, although DARPA’s series of studies tested many educational VR applications, they found that only a few of them
supported educational benefits (Youngblut, 1998). In addition, the study also suggested that flat-screens are the recommended display-type rather than HMDs (Head Mounted Display) for wide distribution and use. In their report, they argued the main reason for this was the primitive software that they tested in their studies (Youngblut, 1998). The applications were in the pre-developed stage that requires many additional guides from developers and researchers, and were too expensive as well, costing $15,000 per device. However, even the conclusions of Youngblut (1998) discounted discoveries in their studies that students commonly enjoyed and were motivated when they used VR materials without further investigation of this area. Later studies also reported similar limited effectiveness but only in traditional assessment methods (Jensen & Konradsen, 2018; Kaufmann et al., 2000; Merchant et al., 2014; Steinberg, 2000).

Many meta-analysis studies identified similar problems too. For example, Hew and Cheung (2010) reviewed 20 studies and concluded that while these studies suggest the VR can improve students’ learning environment, most of them were descriptive. In the studies they included in their meta-analysis, Hew and Cheung (2010) believed the problem is due to the limited variables and examined processes concerning the educational effectiveness of using VR. In addition, Hew and Cheung (2010) pointed out that these studies are focusing on only students’ attitudes and satisfaction for using technology. In another example, Selverian and Hwang (2003) also pointed out most of these studies were focusing on only memories in motor skills and navigations as elementary learning objectives and confidence in leadership as a more elaborated learning objective in the “virtual learning environment” (p. 512). Later, a similar meta-
analysis of Merchant et al. (2014) specifically focused on desk-top bases VR experiences also suggested that the studies that they reviewed were focused on only three types of learning outcomes: “Knowledge-based”, “abilities-based”, and “skill-based.” According to Merchant et al. (2014), compared to using games for instructional applications, there is limited evidence for supporting the instructional effectiveness of using virtual reality. Also, when Jensen and Konradsen (2018) reviewed 21 experimental studies that tested educational HMD VR applications, study designs were below average when they applied the Medical Education Research Study Quality Instrument (Jensen & Konradsen, 2018). Their analysis concluded only some study results are useful for supporting the effectiveness of VR, such as when enhancing spatial and visual skills and controlling stresses and psychological traumas (Jensen & Konradsen, 2018).

Jensen and Konradsen (2018) gathered 5,915 published articles about the technology adoption in education and noted that it reflects the growing interest in VR among researchers, but they found only 165 articles were HMD related studies, and only 21 studies were quasi-experimental designs or experimental studies that tested the effectiveness of educational uses of HMD VR. Among these studies, some studies did not have a control group at all or they simply compared HMD to “less immersive technologies or traditional classroom instruction” (Jensen & Konradsen, 2018, p. 1522). Among all of these studies, Jensen and Konradsen (2018) identified only one that clearly supported the idea that an HMD VR system performed better than CAVE and desktop-based systems in engineering education (Alhalabi, 2016; Jensen & Konradsen, 2018).
But, in that study by Alhalabi (2016), the educational outcomes in their tests are only related to memory, mathematics, and cognitive skills.

Meta-analysis studies revealed that studies supporting the educational benefits of virtual reality have limited implications (Gardner, 1993; Hew & Cheung, 2010; McLellan, 1994; Merchant et al., 2014); they commonly criticized that the studies that they reviewed have been focused only on building fluencies of important skills. If the primary goal of the education system is teaching society’s prevalent skill sets, such as reading, remembering, writing, and calculating as described in textbooks, the benefits of adopting new media technology would be marginal compared to their costs (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015; Kozma, 1994). For simply delivering information in a textbook and assessing how well students can show an ability to memorize and repeat knowledge, using the same mode of communication, which are reading and writing in papers, would be the most cost-efficient media technology.

**HMD VR Technology’s Limitation**

Besides, even the current VR technology, regardless of HMD VR, still may cause people to suffer from visual sickness and discomfort (Jensen & Konradsen, 2018; Kaufmann et al., 2000; Srivastava et al., 2019) that adds cognitive costs for students added to operational costs of devices for institutions. Kavanagh et al. (2016) also described difficulties for creating and delivering HMD VR content in educational settings. Jensen and Konradson (2018) and Srivastava et al. (2019) also noted there were some cases in which HMD VR applications were less effective than traditional instructions because of the visual discomfort. Especially in the experimental study of
Srivastava et al. (2019) that compared flat-screen VR and HMD VR’s effectiveness in spatial learning controlling for perceived visual discomfort, participants performed better with the flat-screen VR to memory and recall spatial information. These examples may also show the possibility that applying new media technology, for at least some educational purposes, may not be as good as what people expected. In addition to the mixed evidence of using HMD VR in an educational setting, it remains a barren area asking questions concerning what and how technology can contribute to achieving societal goals.

**Importance of Considering Transformative Learning**

Based on the reviews of prior studies, it looks like the narrow view of educational effectiveness in these studies was the most critical limitation. This could be a crucial reason why prior studies produced mixed results added to the limited number of studies that specifically tested HMD VR in education. The earlier study of Bloom, Engelhart, Furst, Hill, and Krathwohl (1956) and the later study of Jensen and Konradsen (2018) both are meta-analysis studies that pointed out that the main domains for the educational outcomes in the articles they reviewed were only cognitive, affective and psychomotor domains. These domains are important but they exclude the role of motivation which is the key element of transformative learning (Dewey, 1938; Katula & Threnhauser, 1999; Ramirez, 2009).

Going back to DARPA’s previous studies, they are important as first footprints because they did the first large and systematic efforts that considered VR as an educationally effective technology. However, their studies and later follow up studies still
do not provide a meaningful guide for educational institutions. Even recently, as Martín-Gutiérrez et al. (2017) noted, there are not enough drives and collaborative efforts to utilize advances of media and communication technology in the educational field because of the difficulties posed by traditional learning systems’ deep hesitations concerning cost-effectiveness.

It is clear that the underdeveloped technology they tested was not the only problem. For example, unlike the aforementioned study of Srivastava et al. (2019), that found flat-screen VR was more effective in spatial learning, the preliminary study result of Hsieh, Kuo, and Niu (2018) found that HMD VR is more effective for the accuracy and details of spatial memories while flat-screen VR is more effective for quickly locating objects. This result suggests the effectiveness of HMD VR is dependent on the educational goal and content design.

Most of the studies that tested educational effectiveness have certainly shared a limited view or perspective of conceptualizing educational effectiveness. On the other hand, as Dewey (1938, p. 25) insisted in his “theory of experiences,” in this progressive perspective the primary educational benefits are defined as overcoming oppressions and limitations that surround people through “transformative learning,” instead of simply absorbing knowledge (Dewey, 1938; Katula & Threnhauser, 1999; Ramirez, 2009). “Transformative learning,” the early 20th-century idea of Dewey (1938) and that Mezirow (1997) later developed, has received much interest from teachers and progressive educators (Taylor, 2007). The knowledge that is stored and presented in the traditional modes of communication is still important as a fundamental background.
Nevertheless, this is not as fundamental compared to the importance of students’ rich experiences when they actively explore surrounding environments. These rich experiences can help students to increase critical thinking for themselves and their society, as a form of transformative learning (Dewey, 1938; Katula & Threnhauser, 1999; Ramirez, 2009), instead of simply memorize and follow what they are given. Some researchers have started to realize the importance of this perspective, such as Steinberg (2000) who argued that students can become actively involved in simulated environments to make sense of them instead of simply witnessing materials. Even if there is no significant improvement found in standardized university-level physics exam results, Steinberg (2000) observed a critical role of technology that many people ignore, providing a new space for students to reach out and interact with unexplored areas.

Hodgson et al. (2019) also insisted that educational institutions should have considered that the use of HMD VR could promote historical and cultural understandings as well as professional skills.

**Chapter summary**

This chapter reviewed the evidence and limitations of adopting the HMD VR technology in educational uses and suggested there is limited knowledge about the roles of media and technology for educational uses to serve the societal purpose of education that the first chapter suggested.

The following chapters will explain how this study can address the limitations of prior studies. To do this with theoretic frameworks, Chapter 3 will introduce presence (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018;
Johnston et al., 2015; Nass et al., 1994; Vanian, 2018; Weiser, 1991; Yoshida et al., 2014). Chapter 4 will introduce motivation to learn under Social Cognitive Theory (SCT) (Bandura, 1978, 1989, 2011; Boekaerts, 2002; Glynn et al., 2005; Middleton, 2014; Stipek, 1988; Wiethoff, 2004) and Risk Information Seeking and Processing (Courneya, Karvinen, & Vallance, 2007; Deci & Ryan, 2000; Kelly, Zyzanski, & Alemagno, 1991). These theoretic concepts about psychological states will provide psychological processes behind the enhanced learning that may be possible with HMD VR and the last section of Chapter 4 will explain how this study incorporates these concepts.
CHAPTER 3

PRESENCE AND EDUCATION WITH HMD VR

Chapters one and two suggested the previous understanding is limited concerning the educational effectiveness of HMD VR in higher education. This is because these approaches missed considering some important educational goals. In addition, there were only a handful of studies that tested HMD VR with sound and solid methods that account for psychological processes. In addition to that, the evolving nature of technology makes it hard for these studies to provide complete and applicable conclusions.

This chapter introduces presence (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018; Johnston et al., 2015; Nass et al., 1994; Vanian, 2018; Weiser, 1991; Yoshida et al., 2014) as a useful theoretical guide that provides clearer psychological understandings behind media use. This chapter will first introduce presence and its applications in education, then provide specific studies concerning HMD VR’s educational uses. Through these steps, this chapter will explain the reasons why this study explores if the more immersive experiences of HMD VR can help to achieve the progressive goals of education. This chapter is important because the presence provides a key element of understanding the psychological processes behind HMD VR experiences so that the next chapters can refer and incorporate this element to unfold their theoretic roles to understand the educational effectiveness of HMD VR.
Presence

One of the benefits that advanced media and communication technology can provide is enhanced experiences of presence, a shortened term of telepresence (International Society for Presence Research, 2000). Presence is a concept that explains how people perceive content that is mediated through communication technology. According to this, when people have mediated experiences, they can perceive places and entities in these experiences but the intensity and significance of these experiences are different depending on technological, psychological, and contextual factors (Lombard et al., 2000; Minsky, 1980; Steuer, 1992). Therefore, the perceptions of spaces (IJsselsteijn, de Ridder, Freeman, Avons, & Bouwhuis, 2001; Minsky, 1980; Wirth et al., 2007) and people (Biocca, Harms, & Burgoon, 2003; Lee & Nass, 2003) in a mediated experience are a result of psychological processes of individuals (International Society for Presence Research, 2000).

The advances of communication technologies provide more intense presence experiences when they make the role of media less salient (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh, Catena, Arman, & Slater, 2000). Therefore, emerging media and communication technologies tend to have more interactivity and vividness (Steuer, 1992) to increase spatial presence and immersion. They also tend to embed more social conventions and cues to increase “social presence” and “social realism” (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018; Johnston et al., 2015; Nass et al., 1994; Vanian, 2018; Weiser, 1991; Yoshida et al., 2014). The immersive experiences are generally conceptualized as (tele)presence, and International
Society for Presence Research (2000) provides a commonly agreed definition of this concept:

Presence (a shortened version of the term “telepresence”) is a psychological state or subjective perception in which even though part or all of an individual’s current experience is generated by and/or filtered through human-made technology, part or all of the individual’s perception fails to accurately acknowledge the role of the technology in the experience. (International Society for Presence Research, 2000)

**Spatial Presence & Visual Perception**

Spatial presence is about the perception of a location, place, site, and position when people having mediated experiences. As one of the dimensions of presence, “A sense of being there” (International Society for Presence Research, 2000; Lombard et al., 1997; Minsky, 1980) is a commonly used phrase to describe this dimension of presence, and there is quite substantial evidence of this phenomenon (Wirth et al., 2007). Baumgartner, Valko, Esslen, and Jäncke (2006) explained that people sense spatial presence with the interactive responses between frontal and parietal brain activities and electro-dermal activations; that frontal brain activities tend to have a negative correlation with the feeling of spatial presence and positive correlation with parietal brain activities when people are experiencing mediated experiences.

Spatial presence can be applied to all types of media experiences with technology (Schubert & Crusius, 2002; Usoh et al., 2000) including HMD VR (Newbutt et al., 2016; Usoh et al., 2000; Zeltzer, 1992) that can provide wider “field of view” (Zeltzer, 1992, p. 127) than other types of displays. Both HMD VR and “The CAVE” (p. 65) (Cruz-Neira et al., 1992, p. 65) are good examples of technology concerning increased spatial
presence with the increased field of view. They can project images with a wider field of view than other types of displays for VR (Cummings & Bailenson, 2016). This generally tends to increase the level of spatial presence (Cummings & Bailenson, 2016; Lombard et al., 2015; Lombard et al., 2000).

**Social Presence & Parasocial Interaction**

Social presence is one of the dimensions of presence. Several arguments unfolded social presence phenomenons when people use technology. The origin of social presence can be found in social psychology studies (Short, Williams, & Christie, 1976), and according to Short et al. (1976, p. 65), social presence is defined as “the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships.” Social information processing model and theory (Fulk, Steinfield, Schmitz, & Power, 1987; Katz & Lazarsfeld, 1955/2017; Walther, 1992) and parasocial interaction (Lombard & Ditton, 1997; Rubin, Perse, & Powell, 1985) explained how people socially interact with other people and virtual agents through computer graphics. Computers Are Social Actors (CASA) (Nass, Lombard, Henriksen, & Steuer, 1995; Nass et al., 1994) and MASA (Medium as Social Actor) explained people also socially interact with computers and mediums. Lee and Nass (2003) argued that people have a natural tendency of making social interactions with a computer (Lee & Nass, 2003; Nass et al., 1994), and this dimension of presence is also important as the spatial dimension of presence.

Later, Nass et al. (1994) and Nass et al. (1995) implemented social elements in human-computer interactions from the social psychology theory into presence related
literature. This is considered as Computers Are Social Actors (CASA) (Nass et al., 1995; Nass et al., 1994). The study results of Bracken and Lombard (2004) added support to humans’ social interactions with computers. In their study’s experiment, 8 to 10 years old children also engaged in social interactions with computer-generated responses in a similar way as what adults did in other non-media studies. Their study illustrated the importance of constructed perceptions about social structure and manners, such as the effects of praise in learning, in human-computer interactions (Bracken & Lombard, 2004). Based on those results, this study suggests users of HMD VR can reflect or change their social relationships with computer-generated images of other people. In addition to simply showing manners and cultural responses to the computer-generated images of other people, the interaction in the VR, even if they just watch it, the experience also has the potential to reform the perceptions of social structure and frame that they have. Further, it is also important to explore if the same social response triggers or cues can make the different type of effects depending on the types of VR technology.

**Immersion and Social Realism as Presence**

In addition to spatial and social presence, psychological immersion and social realism are the dimensions of presence that describing perceptions about linking real and graphical representations through media (International Society for Presence Research, 2000) when people ignore the role of technology (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000). Therefore, ISPR (2000) defined immersion is a psychological state that people perceive more directed deeper toward the graphical representations of space and people in media content than surrounding real environments.
For the same reason, ISPR defined social realism is a psychological state that people perceive the graphical representations of space, objects, and people in media content that are similar to real-world environments, events, and cultural conventions. Unlike some researchers that separated immersion as a technological aspect (Slater, Linakis, Usoh, & Kooper, 1996), the immersion dimension in presence is a psychological state of mind (Lombard, Ditton, & Weinstein, 2013; Witmer & Singer, 1998). Studies have supported the aural and visual differences of simulations changed the level of immersion and social realism (Bracken, Pettey, Guha, & Rubenking, 2010).

Presence is a multidimensional concept (Lombard et al., 2015), it is suggested that technology that can minimize awareness of VR users’ surroundings can enhance dimensions of presence (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000). The following sections will review previous studies that applied presences in educational VR and suggest limitations of current studies in educational VR.

**Presence in Educational VR**

Studies that explored the educational uses of emerging communication technologies tend to describe the perceptual illusions, that presence explains, expected positive correlations with enhanced learning outcomes (Bracken & Lombard, 2004; Fowler & Mayes, 1997; Witmer & Singer, 1998). Advances of high-speed internet, faster computers, and mobile technologies have been enhanced in media and communication technology and some instructional devices to provide more immersive media experiences and an increased level of presence (Gillet, Salzmann, Longchamp, & Bonvin, 1997). In some educational studies, a similar concept is described as an immersion, interaction, or
imagination from the VR in art, science, and medical learning systems (Huang, Liaw, & Lai, 2016; Rauch, 2007), but these are not as soundly defined as presence.

Some studies have demonstrated that having a higher level of presence experiences does have educational benefits (Gunawardena & Zittle, 1997; Witmer & Singer, 1998). An evaluation survey by Gunawardena and Zittle (1997) first found that social presence has an influence on student learning as well as satisfaction with text-based online classes for both instructors and students. Although it is not based on an empirical study result, Witmer and Singer (1998) also borrowed Bandura’s “social learning theory” (as cited in Witmer & Singer, 1998, p. 238) that is known as Social Cognitive Theory (SCT) (Bandura, 1989) to suggest the association between presence and learning. Tu and McIsaac (2002) further investigated whether an enhanced level of social presence increased interactions in online classes. Their study concluded that computer-mediated classes have limitations compared to face to face classes, but applications of these computer-mediated classes can optimize the “self-images and interactions” (Tu & McIsaac, 2002, p. 146) when instructors or online class designers have effective tools to increase “intimacy” and “immediacy” of social presence.

The studies that tested the educational effects of communication technology share similar limitations with the studies that tested the effects of HMD VR. They are limited to explaining if more immersive experiences can also increase higher levels of learning outcomes (Han, 2020; Kaufmann et al., 2000; Witmer & Singer, 1998; Youngblut, 1998). For example, Kaufmann et al. (2000) tested whether HMD VR devices can provide an enhanced learning tool for mathematics and geometry education. In their study,
participants reported that they could more easily understand spatial relationships among objects in VR because they were directly visible compared to abstract descriptions in texts (Kaufmann et al., 2000). This study showed the benefits of more immersive experiences for delivering information more clearly (Kaufmann et al., 2000) but it does not provide more concrete explanations about why and how students could perceive the virtual representations more directly. Witmer and Singer (1998, p. 225) is an example that used a compound conceptual definition of presence. In their measure “Presence Questionnaire (PQ),” the involvement items in PQ’s sensory factors are compounded presence with an educational immersion and focus:

“Factors believed to increase immersion, such as minimizing outside distractions and increasing active participation through perceived control over events in the environment, may also enhance learning and performance.”
(Witmer & Singer, 1998, p. 238)

That leads to difficulties in interpreting the role of presence more specifically. Therefore, to understand the psychological process of students’ perceptions in education through technology, it is important to consider the dimensions of presence in immersive experiences with a measure such as Temple Presence Inventory (TPI) (Bracken & Lombard, 2004; Collins & Halverson, 2018; Jensen & Konradsen, 2018; Johnston et al., 2015; Nass et al., 1994; Vanian, 2018; Weiser, 1991; Yoshida et al., 2014). Because the TPI provides more conceptually sound and solid presence measurement because it has been tested in many studies demonstrating reliable results (Fox, Bailenson, & Binney, 2009; International Society for Presence Research, 2000; Liao, Jennings, Dell, & Collins, 2019; Lombard et al., 2013).
Using more immersive communication technologies seems to have different influences on students’ learning experiences than using traditional instructional mediums, controlling for influences of instructors’ efforts to make learning better (Baker, 2010; Kaufmann et al., 2000; Witmer & Singer, 1998). However, many of the studies that tested the educational effects of HMD VR have similar limitations, and adopting the more concrete concept along with more concrete measures of the immersive experience is necessary to overcome these limitations. Reflecting these limitations, presence is defined and shared by researchers who have been working on addressing the problem collectively (International Society for Presence Research, 2000), providing comprehensive measurement that related to the concept (Lombard et al., 2015).

Although earlier presence studies about VR were limited to connect presence and educational outcomes, they provided several insightful suggestions to understand why people experience increased presence in VR; for example, it could be seen as a novelty effect or immersion for having a larger apparent screen size (Fontaine, 1992; Lessiter, Freeman, Keogh, & Davidoff, 2001; Usoh et al., 2000; Witmer & Singer, 1998). Counter-arguing the novelty effect of Fontaine (1992) on presence in VR, Witmer and Singer (1998) pointed out that people in VR allocate more attention to the content in VR to create a more meaningful and coherent perception from simulated visuals than with other displays. For Witmer and Singer (1998), presence is similar to an educational immersion and focus when they developed the PQ to measure presence in VR in addition to immersive tendencies. Slater et al. (1996) find it difficult to support their argument that immersion is an important element to transfer knowledge via immersive experiences.
Slater et al. (1996) defined immersion between high immersion technology and low immersion technology. But the immersion that they defined ignored that the differences in technology are not always correlated with the psychological process of people. According to Baños et al. (2004), HMD VR’s large screen size covering 360 degrees of viewing sight that increases presence. Lessiter et al. (2001) also pointed out the importance of understanding psychological processes that HMD VR create and developed the ITC-Sense of Presence Inventory (ITC-SOPI). The problem of the ITC-SOPI is that it is difficult to separate spatial or social dimensions of presence because they are all in the same dimension.

**Need for Additional Studies for Higher Education**

A few previous studies suggested there is an association between interactive experiences and enhanced learning (Ang & Rao, 2008; Han, 2020; Hew & Cheung, 2010; Kaufmann et al., 2000; Martín-Gutiérrez et al., 2017; Moreno et al., 2001; Slater et al., 1996; Steinberg, 2000; Witmer & Singer, 1998) in many disciplines and research areas in higher education. A study by Ang and Rao (2008) is a good example. Ang and Rao (2008) surveyed 100 medical students; the survey results suggested that students are more motivated to learn by playing educational games when these games are available and it improved knowledge about medicine. This game design theory assumes this is because activities and narratives in games are enjoyable (Ang & Rao, 2008). They suggested the association between the enjoyment of educational games and learning outcomes broadly without explaining how they are associated claiming the need for more studies examining more specific applications and processes behind the association.
In another example, a study of Moreno and Mayer (2002) demonstrated the possibility that HMD VR multimedia materials could increase students’ motivation to learn in science education (Moreno & Mayer, 2002; Moreno et al., 2001). College students watched a multimedia game about botany in the study of Moreno and Mayer (2002) but the results did not find the effects of increased levels of presence in the HMD over a flat-screen on retention, transfer, and “program ratings” (p.585). However, in their study, although they did not find statistical support, they observed a possibility that an increased level of presence in an HMD condition seems to translate into educational outcomes (Moreno & Mayer, 2002; Moreno et al., 2001).

According to Hew and Cheung (2010), when they reviewed 20 academic studies that examined uses of immersive VR in K-12 and higher education, they found more than half of the studies were about students’ attitudes and satisfaction from using 3D technology in class (Hew & Cheung, 2010). Hew and Cheung (2010) suggested there is a need for more studies examining specific aspects of VR to know the educational benefits of VR.

Hew and Cheung (2010) also suggested a need for more studies employing qualitative perspectives. According to Johnson and Onwuegbuzie (2004), and Hew and Cheung (2010), and Liao et al. (2019) having a qualitative perspective can enhance evidence and open up unforeseen consequences by mixing contextual information. McIntosh and Morse (2015) added that qualitative analysis would enrich and broaden quantitative analysis. It is expected that it is not only useful to support or disprove statistical results it is also useful to navigate unobserved stories behind the numbers. In a
case study of Kavanagh et al. (2016) that described how they created and implemented VR content for HMD VR devices, they also acknowledged that they were not able to determine if the implementation was educationally effective without qualitative analysis results. Liao et al. (2019) tried a qualitative approach to measure the level of presence of children when they watched educational TV show because it is difficult to answer questionnaires for children. In the same vein, this study tries to test if more immersive experiences with HMD VR can help to achieve this goal of education when people have virtual experiences that are usually hard to relate to their surrounding environments and people with the scope of presence.

**Chapter summary**

This chapter introduced presence to guide and provide clearer psychological understandings behind the possible benefits of educational uses of HMD VR. This chapter explained the importance of understanding the role of immersive experiences to achieve the progressive goals of education that Chapter one and two discussed. Presence that this chapter discussed one key element that may explain the benefits of HMD VR. The next chapter will consider theories of motivation and learning, which may also play a major role in the psychological processes behind HMD VR experiences.
CHAPTER 4

STUDENTS’ MOTIVATION TO LEARN

Chapter three focused on presence as an important framework to understand the psychological processes behind media and communication technology and specifically the use of HMD VR in educational settings. This chapter will add motivation to learn in social cognitive theory (SCT) (Bandura, 1978, 1989, 2011; Boekaerts, 2002; Glynn et al., 2005; Middleton, 2014; Stipek, 1988; Wiethoff, 2004) as an important educational outcome for the progressive goals of education, which was discussed in chapters one and two.

This chapter will first introduce social cognitive theory and motivation to learn, and then provide more specific studies of immersive media and HMD VR’s educational uses. Based on the arguments of SCT, this chapter will finally suggest a positive and direct relationship between immersive experiences and motivation to learn. Based on these relationships, this chapter will suggest four hypotheses and six research questions.

Motivation in Learning

Human motivation is a broad and diverse area of study but there is still an ongoing debate about how we can understand and observe human motivation that can be applied in this context (Cook & Artino Jr, 2016; Kaplan, Katz, & Flum, 2012). Researchers do believe the existence of “motivation to learn, (para. 1) and there are countless theories of motivation (Cook & Artino Jr, 2016). In addition, many initial studies of motivation have shown correlations between motivation and positive learning outcomes (Cole, Harris, & Feild, 2004; Simmering, Posey, & Piccoli, 2009). In these
studies, better grades, jobs, recognitions, enjoyments, and personality, including self-efficacy, are all good indicators and gauges of students’ motivation. Social Cognitive Theory (SCT) (Bandura, 1989) falls into this type of contemporary motivation theory that could provide a useful theoretic framework to understand a psychological mechanism behind learning.

**Social Cognitive Theory (SCT)**

Social Cognitive Theory (SCT) (Bandura, 1989) was originated from social learning theory (Bandura, 2011), which explains that people learn through experiences within social interactions (Bandura, 1989). SCT (Bandura, 1989) is a good theory to understand how motivation to learn changes behaviors and learning. According to Boekaerts (2002), one of the important assumptions in SCT is that people learn from “symbolic modeling,” which is observing and evaluating the outcomes of others’ behaviors within social structures (Bandura, 1989, 2011). But studies employing SCT also have helped instructors to recognize the roles of motivation to achieve the learning goals of students (Boekaerts, 2002). For example, SCT-based instructional models of teaching (Kyriakides, Christoforou, & Charalambous, 2013) and how students learn (Ambrose et al., 2010; Moreno & Mayer, 2002) all claim the importance of students’ motivation for effective learning. That is one of the reasons researchers have studied students’ motivation as an important factor for effective learning (Ambrose et al., 2010; Maehr, 1984; Miltiadou & Savenye, 2003) that enhances participation, persistence, and cognitive processes of learning (Eccles & Wigfield, 1985; Stipek, 1988).
**Self-efficacy and Motivation**

SCT explains that self-efficacy is central to understanding the role of “human agency” to regulate motivation (Bandura, 1999, p. 28). Self-efficacy is a confidence that an individual can successfully do things they want to complete (Bandura, 1982). Although SCT does not directly measure motivation like other contemporary motivation theories, the mechanism of self-efficacy assumes that a higher induced level of self-efficacy increases performance and motivation to achieve goals and reduces aroused emotional state (Bandura, 1982). Schunk (1991) also pointed out there are five personality traits that influence students’ motivation to learn: self-efficacy, locus of control, attributions about causes, goal orientation, and self-regulation (Miltiadou & Savenye, 2003; Schunk, 1991). According to the value and expectancy model of motivation (Ambrose et al., 2010), these personality traits translate the importance of learning, which is a “subjective value” (p. 74), to motivational outcomes. Among these personality traits, in relation to SCT, Schunk (1991) also suggested self-efficacy can be transferred to motivation.

The self-efficacy as a “subjective value” in the expectancy model of motivation (Ambrose et al., 2010; Schunk, 1991; Schunk & Usher, 2012) explains that students need to value the learning goals and materials of classes that are important; at the same time, they also need to think that they can understand these materials well to have enough motivation to learn. They can think the learning goals and materials are important because they enjoy learning, which is an “intrinsic value” and/or because with it they find better jobs, receive better grades, and receive praises from their instructors and peers,
which are an “extrinsic values” (Ambrose et al., 2010, p. 75). Although the intrinsic and extrinsic motivations can lead to many different learning outcomes emphasizing the importance of understanding the role of motivation, there are more dimensions and aspects of motivation. For example, even if they recognize these intrinsic and extrinsic values, when the course’s materials are too difficult to understand or they lose their confidence, they also lose their motivation (Ambrose et al., 2010; Bandura, 1982).

**The Role of Agency**

Similarly, Bandura (1999) explained that the perception of self-efficacy regulates motivation through “outcome expectations” (p. 28) because the agency of people depends on their evaluations of the possibility of positive consequences of their action. In the process of evaluation, people reference social expectations and standards. The social expectations and standards people reference are compared to their perceived ability to control the process of their actions in the forms of “self-efficacy” (Bandura, 1999, p. 28) and “locus of control” (Rotter, 1990, p. 489) in SCT. “Locus of control” (Rotter, 1990, p. 489) is a degree of belief about how people weighting between internal and external factors. The perception of the degree can help people to speculate whether “personal characteristics” or “powerful others” (p. 489) are the reasons for the motivation underlining their behaviors. Further, Bandura (1999) invited studies that can expand SCT in areas of media and communication technology design. Because the perception of references keeps evolving through experiences and societal changes; media and communication technology could extend these experiences and their interactions.
Bandura (1999) already saw the importance of designing an information system to deliver perceptions of references properly.

Although the motivational process in SCT sounds like people actively adjust their level of motivation because of its agentic perspective (Moreno et al., 2001), in fact, Bandura (1999) also acknowledged it is difficult to ignore underlining influences of social structure. That is why Bandura (1999) believed society needs to keep improving the information system that can deliver good reference properties with effective measures, and media and communication technology is that system. Therefore, performances of educators, designers of media and communication technology, and producers of educational content are all important because they are moderators who can enhance or limit learning experiences through technology. They are the most important entities who need to constantly be self-questioning about what they think are the best reference properties of society and how to deliver them effectively.

Risk Information Seeking and Processing (RISP) Model

In addition to the intrinsic and extrinsic reasons to be motivated (Ambrose et al., 2010; Bandura, 1982; McFerran, Dahl, Gorn, & Honea, 2010), the perception of the level of their current knowledge deficiency can drive a person’s motivation to learn to avoid risks (Kahlor, 2007; Stern & Fineberg, 1996). Although learning is a different context from individuals’ information-seeking behaviors concerning risk avoidance, they share similar behavioral outcomes. For example, in general, reasons to be motivated to learn about global warming issues would be to avoid environmental risks, by following friends’ and family members’ suggestions, and information learned from media exposure, and a
science class that covered global warming issues. The classroom setting adds more types of reasons to be motivated to learn about global warming issues. These reasons include students’ better final grades and a teacher’s instruction quality added to the general reasons. Although the spectrum of these reasons to know more about global warming are broad and diverse, they can but don’t always, increase the psychological level of motivation to know more about global warming and it also increases the behaviors of information searching.

**RISP and Dual Processing Model**

Unlike the focus on the “symbolic modeling” theory of the SCT (Bandura, 1989, 2011), the Risk Information Seeking and Processing (RISP) model focuses on “risk” avoidance behaviors (Kahlor, 2007; Stern & Fineberg, 1996) especially for medical risks. According to Griffin et al. (1999), the RISP model is based on the Heuristic-Systematic Model (HSM)’s sufficiency principle (Chaiken & Eagly, 1989), the principle that people will make the elaborative efforts for their attitude formation until they believe it is sufficient (Chaiken & Eagly, 1989). Griffin et al. (1999) developed the sufficiency principle further to the concept of the “gap” between the level of perceived information sufficiency and the current confidence about their level of knowledge to avoid risks. Griffin et al. (1999) also added several moderators including individual differences, perceived level and types of risks, emotional element, and social pressure when they proposed the initial RISP model (Griffin et al., 1999). The “gap” was later called information insufficiency (Kahlor, 2007).
**Information Insufficiency**

The RISP model suggests information insufficiency changes behavior (Griffin et al., 1999). Although the model includes individual differences as moderators, the model does not include the level of motivation or intention, similar to SCT. Specifically, as Huurne and Gutteling (2008) noted, the RISP model is a quite solid model to explain behavioral changes with diverse predictors, but it is still unclear about the psychological links between information insufficiency and behavioral and motivational changes. In the RISP model, having relevant experience is one of the individual characteristics that could influence information insufficiency, sufficiency threshold, affective response, and informational subjective norms directly and indirectly (Griffin et al., 1999). Therefore, the model explains having more experiences increases behavioral motivation mediated by information insufficiency (Griffin et al., 1999; Huurne & Gutteling, 2008; Johnson, 2005), but there is no study tested having virtual experiences also have the same influences. Also the behavioral intention to seek information from multiple mass media sources and channels (Griffin et al., 1999; Wang & Ahern, 2015) of RISP model as an indicator of motivation, which is Motivation To Learn in Media (MTLM), is an area that is not explored yet (Zhang, York, Pavur, & Amos, 2013).

These goal-directed concepts of motivation theories such as SCT and RISP still underestimate the state of psychological “need” as a motivation that changes behaviors (Courneya et al., 2007; Deci & Ryan, 2000; Kaplan et al., 2012; Kelly et al., 1991). Therefore, it is important to see if information insufficiency also increases the motivation to seek information, which is the motivation to learn.
Motivation To Learn (MTL)

Kaplan et al. (2012) criticized that most of these motivational perspectives assume motivation is limited to the functional and stable nature of motivation and factors of individual differences. SCT and RISP aforementioned are the theories that assume “malleable” (p. 166) behavioral nature of motivation, which is better to understand the interaction between the individual and interventions (Kaplan et al., 2012). Therefore, are several factors that can increase or gauge students’ motivation to learn including “information insufficiency” (Deci & Ryan, 2000). Motivation in SCT, in general, is a state of a perceptual agency of people that determines the amount and number of allocated resources that they have (Bandura, 1999; Kahneman, 1973; McNamee, 1977; Schunk & Usher, 2012). Therefore, although SCT provides a broader landscape of motivation and suggests instructors’ efforts to create more interactive course environments can increase motivation (Bandura, 1977; Miltiadou & Savenye, 2003; Rotter, 1990), it is unlikely that simply proving more effective and immersive educational materials can increase the motivation. Because it is difficult to find an association between having these immersive experiences and the changes in personality traits in the SCT (Cook & Artino Jr, 2016; Wiethoff, 2004).

Wiethoff (2004) considered that self-efficacy and locus of control are personality trait factors of motivation, which are similar to attributions, goal orientation, and self-regulation. According to Miltiadou and Savenye (2003), motivation to learn has two dimensions, which are internal and external motivations. For Wiethoff (2004), an internal motivation to learn (Bandura, 1989) also seems to be a personality trait; external
motivation is slightly different because it involves external motivational causes, such as rewards, including grades, and social relationships with instructors. Instead, it is important to provide more concrete norms or standards of references (Bandura, 1999, p. 28; Kaplan et al., 2012) that students are learning and instructors believing it is important. Some of the identified norm or standards of references are perceptions to evaluate their actions’ ability to control the process of action in a form of “self-efficacy” (Bandura, 1999, p. 28) and “Locus of control” (Rotter, 1990, p. 489) in SCT.

**Importance of Integrating Sociocultural Perspectives of Motivation**

Education and media experiences’ actual and simulated experiences would be one of the most influential sources of changes in motivational states. Many educational settings use such indirect experiences as a learning tool. An in-class activity applying the ideas of course materials to past cases and current events would be a good example (Ambrose et al., 2010). To enhance learning environments in education through the effective uses of the indirect experiences, it is getting more relevant and important to recognize instructors’ role as a provider or as a guide of cultivating more motivation to the subject matter, topic, and activities in curriculums (Ambrose et al., 2010; Middleton, 2014; Schunk & Usher, 2012).

Sociocultural theories of motivation that assume motivation is an “adaptive mode of participation” (p. 167) within society connect motivation to social norms and procedures (Kaplan et al., 2012; Levy, Kaplan, & Patrick, 2004). This sociocultural perspective criticizes the contemporary perspectives of motivation as still missing important parts of motivation, especially when there is no direct benefit for students.
As an example, like pure curiosity, students can be motivated to learn more about certain subjects and issues. Which means, in addition to such various types of perceptual agencies that are in relation to the perception of socio-cultural and economic awareness, perception of self, and expected outcomes of behaviors (Bandura, 1982; Cole et al., 2004; Schunk & Usher, 2012), people might have additional reasons to be motivated to learn, the motivation to learn that is constantly changing through experiences and status changes (Lam & McNaught, 2006; Simmering et al., 2009). That might be the reason why the practical reasons to be motivated do not fully explain some parts of the motivation. In other words, the motivation of students is cultured, structured, and/or activated by transient psychological states via the life experiences of people (Cook & Artino Jr, 2016; Middleton, 2014). This study focuses on whether creating more immersive experiences with technology can enhance the effects of these classrooms’ indirect experiences on motivation to learn.

**Motivation To Learn (MTL) and Motivation**

Therefore, in this study, Motivation To Learn (MTL) is a level of the psychologically transient state of wanting to spend time and effort to know more about the main topic of the class or course material the changes of MTL reflect the effectiveness of the instructional method considering students’ sensitivity to the presented topic based on their personality traits and experiences in the sociocultural structure of society (Bandura, 1977; Cook & Artino Jr, 2016; Lam & McNaught, 2006; Noe & Schmitt, 1986; Yamashita, Cummins, Millar, Sahoo, & Smith, 2019). Noe and Schmitt (1986) defined motivation to learn as “a specific desire on the part of the trainee to learn
the content of the training program” (p. 501). Simmering et al. (2009) applied the same definition to the virtual learning environment showing a significant correlation between computer self-efficacy and motivation to learn. Many studies have shown motivation to learn is an important element to understand influences of technological and cultural aspects in learning (Barak, Watted, & Haick, 2016; Hauze & Marshall, 2020; Yamashita et al., 2019), which is the key element of transformative learning (Dewey, 1938; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007). Compared to the definition of Similar to Noe and Schmitt (1986) and Simmering et al. (2009), this study’s definition specifies a setting when an instructor provides immersive course materials. Although this MTL is a broad measure of motivation, considering motivation has too many dimensions, this is a useful index of motivation level in a learning context. Because this is more efficient than including all the factors of motivation and it is impossible to have a complete list of these factors.

**Effects of Immersive Experiences on Motivation with HMD VR**

The assumptions that Bandura (1989) asserted seem to have limitations to explain the role of an individual’s experiences and interactions that are mediated through technology (Wiethoff, 2004) and it is still unclear about the role of students’ direct or mediated experiences in classrooms. Although Bandura (1978) famously replicated the modeled behavior of aggression using TV (Bryant & Oliver, 2009), it would have provided better understandings if the study and following studies considered technological factors in motivation when people’s experiences and interactions are
mediated. Therefore, these factors of SCT are limited in explaining the effects of immersive experiences in the HMD VR on motivation.

With a different theoretical framework, many studies point out that increased motivation is the key to understand the effects of more immersive experiences (Moreno & Mayer, 2002; Moreno et al., 2001) and learning with computers in education (Bracken & Lombard, 2004). Although they did not provide solid theoretical explanations between effective instructional technology and student motivations, these studies supported that mediated experiences through technology can enhance motivation (Moreno & Mayer, 2002; Moreno et al., 2001). It is possible that when the mediated experiences are more immersive and users are less aware of roles of technology and have more sense of presence (International Society for Presence Research, 2000; Lombard et al., 1997), people might process the experience as more direct and relevant to themselves with the increased motivation to know more. It is also possible that more realistic visuals in immersive experiences than in less immersive views can reduce a cognitive burden to understand abstract concepts, helping to build up motivation more easily.

Moreno and Mayer (2002) assumed that a greater sense of presence will enhance engagement and learning of students because of increased motivation and participation and reduced cognitive load. Moreno and Mayer (2002) assumed the more immersive VR experience could help students to maximize their use of cognitive resources. Their study did not find significant support for whether an immersive medium can improve or hurt learning, it only pointed out the importance of the differences of instructional directions and guides (Moreno & Mayer, 2002). In addition, they used one of the earlier versions of
VR technology. Because of the technological advances of HMD VR, the results may well be different from their study results today.

By manipulating immersiveness between two display-types, the proposed study will explicitly test the idea that more immersive experiences can increase motivation specifically, the level of Motivation To Learn (MTL). Therefore, based on the discussions so far, the following hypotheses are proposed:

**H1** VR experience with HMD will result in more motivation to learn than a flat-screen condition.

**H2.1** VR experience with HMD will result in a) more perceived current knowledge, b) increased information sufficiency threshold, c) more intense affective response, and d) stronger informational subjective norms than flat-screen condition.

**H2.2** Information insufficiency will increase MTL.

**H2.3** The effects of the information insufficiency on MTL in the VR experience with HMD will be bigger than the effects in the flat-screen condition.

**Presence and Motivation Studies**

The previous hypotheses suggested the causal relationship between immersive experiences and MTL. However, that relationship cannot be supported in all circumstances and settings. To improve the development and uses of technology, it is important to understand underlying processes in this relationship. Associating presence concept with the MTL in the SCT framework can provide detailed psychological processes behind the benefit of using HMD VR.
In terms of spatial presence, people will report more presence when they use HMDs (Ritchey, 1996; Seo, Park, & Yang, 2003) compared to flat-screens because the technology provides more interactivity and vividness of experiences (Steuer, 1992) because of the increased field of view and more natural head position tracking of HMD than flat-screen (Bailenson et al., 2008; Biocca & Delaney, 1995; Makransky et al., 2017; Slater & Wilbur, 1997). Therefore, people should sense the higher level of spatial presence in the HMD.

In terms of social presence, in addition to the SCT that asserted the importance of motivation and the role of constructed perceptions about social norms and the environment through experiences and observations (Bandura, 1978, 2011; Bryant & Oliver, 2009), Bracken and Lombard (2004), found that a type of social presence (Biocca et al., 2003; Bracken, Jeffres, & Neuendorf, 2004; Bracken & Lombard, 2004; Lee & Nass, 2003), in which responses are to a medium, had positive influences on 10-year-old children’s learning, especially for motivation. Their experiment found that children’s social presence increased their educational learning. Further, they found social presence had more influence on educational outcomes than “intrinsic motivation” (Bracken & Lombard, 2004, p. 26). This result demonstrated that computer-generated “personal attention” (Bracken & Lombard, 2004, p. 32) increases involvement and mental effort to process given information.

Although the positive effect of VR on motivation to learn for students has been proposed earlier (Bricken, 1991; Youngblut, 1998), there is a small number of studies that supported the claim that increased presence increase students’ motivation. Further,
they are either not under the SCT framework (Hung, Sun, & Yu, 2015), the focus does not include spatial presence (Bracken & Lombard, 2004), or they do not test effects of HMD VR (Bracken & Lombard, 2004; Hung et al., 2015) on dimensions of motivation to learn (Miltiadou & Savenye, 2003; Schunk, 1991). Therefore, based on the discussions so far, the following hypothesis and research questions are proposed:

**H2.** VR experience with HMD will result in more a) spatial presence and b) social presence than using a flat-screen.

**RQ1.** How do the dimensions of presence mediate the effects of display-type on the motivation to learn?

**RQ2.** How do factors of motivation to learn interact with the dimensions of presence in VR?

**HMD VR and Visual Discomfort**

From the time when Minsky (1980) introduced the "teleoperation helmet," which is similar to today’s HMDs (Head Mounted Display), there has been a huge technological leap. Minsky (1980) emphasized the long-term goal of providing natural sensory feedback and human-like teleoperation systems to users. Now the advances of VR technology provide more natural simulations. In the same vein, scientists and businesses have come a long way to improve technology to improve graphics quality and multi-channel sensory interfaces. On the other hand, even if HMDs can provide more immersive experiences, still, flat-screen uses are more widespread because of technological limitations and costs.
Sharples, Cobb, Moody, and Wilson (2008) compared types of VR displays and reported that 60-70% of people experienced discomfort with HMD displays compared to flat-screen displays. The types of discomfort, called “simulation sickness,” that Sharples et al. (2008, p. 58) explored were thought to be due to users’ anxiety and psychological processing burdens. These burdens include “sensory rearrangement” (Reason, 1978, p. 820) similar to a psychological reafference (Holst & Mittelstaedt., 1971) to adjust visual perceptions caused by active and passive head and body movements. Reason (1978) figured one of the causes was this different pattern of sensory rearrangement in VR experiences from prior patterns of sensory rearrangement in natural experiences that are accumulated in a neural system. Because simulated experiences in VR are not exactly matched to non-simulated experiences and they showed going through repeated prior adaptation-sessions reduced visual discomfort (Reason, 1978).

Researchers have long figured sensory rearrangement is one of the main reasons for the simulation sickness (Reason, 1978). According to Kennedy, Lane, Berbaum, and Lilienthal (1993), this is a burden of VR that users may experience the visual sickness, which includes “general discomfort,” “fatigue,” “headache,” “eyestrain,” “difficulty focusing,” “increased salivation,” “sweating,” “nausea,” “difficulty concentrating,” “fullness of head,” “blurred vision,” “dizziness,” “vertigo,” “stomach awareness,” and “burping” depending on types of VR technology specifications, software configurations, and user characteristics (Balk, Bertola, & Inman, 2013; Brooks et al., 2010; Howarth & Costello, 1997; Kennedy et al., 1993). Sharples et al. (2008) strongly suggested that improved VR displays and software are needed to reduce users’ discomfort. To reduce
rearrangement burdens and visual discomfort, Balk et al. (2013) suggested to minimize users’ movements and turns for navigating in VR. Biocca (1992) also identified visual discomfort as the biggest hurdle in VR adoption. Therefore, based on the discussions so far, the following hypothesis and research questions are proposed:

**H3.** VR experience with HMD will result in more visual discomfort than the VR experience with the flat-screen.

**RQ3.** How do the dimensions of presence and visual discomfort interact?

**Presence and Transformative Learning**

In addition to the general importance of “transformative learning,” the detailed processes of the “transformative learning” that Dewey (1938) and Mezirow (1997) explained were similar to educational influences of presence evoking experiences (Dewey, 1938; Mezirow, 1997; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007). “Transformative learning” is a learning theory that emphasizes “harmony with principles of growth” with carefully chosen artificial experiences (Dewey, 1938, p. 30) and “transforming our frames of reference through critical reflection on the assumptions upon which our interpretations, beliefs, and habits of mind or points of view are based” (Mezirow, 1997, p. 7). What this idea explains is that learning is a process of restructuring the schematics in individuals and experiences are essential to restructure schematics (Dewey, 1938; Mezirow, 1997) in a context of autobiographical reflection and in an environment that supports a social, cultural, economic, political, educational or psychological system (Mezirow, 1997).
For many higher educational institutions, this is the most important direction, at least in their statements of educational goals. It has invited much interest and effort from scholars to practically apply the idea (Taylor, 2007). The main limitation of this idea is that it is extremely difficult to know if the results of the curricula designed to accomplish transformative learning are effective (Ravitch, 2010). Boyer, Maher, and Kirkman (2006) and Provident et al. (2015) were able to find fundamental changes in students’ preconceived assumptions based on qualitative evidence. Their studies found that some elements of curricula, such as active learning and practical assignments, are effective to foster transformative learning with a qualitative analysis of students’ reflection papers. But Boyer et al. (2006) and Provident et al. (2015) also acknowledge it is difficult to control the context of learning and the role of the instructor to make more systematic and universal evaluations. Because of this limitation, it will take longer to apply the “transformative learning” approach to general education. This limitation suggests, either qualitative or quantitative, it is difficult to evaluate educational effectiveness with only one research discipline.

In addition, previous studies were focused more on the roles and limitations of assistive online communication technology instead of focusing on the roles of technology that can provide more immersive experiences; none of the prior studies pointed out student’s motivation to learn as an important aspect of learning. That might be the reason why students found it difficult to face difficult tasks with the assistive technology when they experienced a “disorienting dilemma” (Boyer et al., 2006, p. 358). Even if the disorienting dilemma can trigger transformative changes inside the students’ mind,
without the increased level of motivation the disorienting dilemma is not enough to trigger transformative changes. This problem was found in the study of Boyer et al. (2006) even when students believed that they did critically reflect and discuss and received enough support from an instructor, students were not motivated enough to face challenging tasks. Therefore, to examine if the more immersive experiences can enhance “transformative learning” with the enhanced motivation to learn, this study asks participants about how they respond to the educational content that comes with a more immersive experience. More specifically, they were asked to identify elements that made them feel the difference between using the two VR display types and how the differences affected their motivation to learn more about the topics in the VR clip. This will tell us whether and how immersive experiences can contribute to the motivation to learn and transformative learning. (Dewey, 1938; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007). Therefore, based on the discussions so far, the following research questions are proposed and presented in Figure 6 along with all hypotheses and research questions that were previously proposed.

**RQ4.** How does a VR experience with HMD promote people to know more about presented topics?

**RQ5a.** What is the role of presence within the psychological processes that help people to know more about presented topics?

**RQ6.** How do people describe their motivation to learn and transformative learning in different VR display-type conditions?
Chapter summary

This chapter applied presence in conjunction with the motivation theories of SCT and RISP to explore learning and the psychological processes behind HMD VR experiences. These theories suggested the hypotheses and research questions of this study. Next, Chapter 5 will explain how this study was conducted to test the hypotheses and explore these research questions.
CHAPTER 5

METHOD

This chapter describes the method that this study employed to test the hypotheses and research questions in the previous chapter. It first presents an overview of the mixed method and design with details about the experiment and the in-depth interviews. The second section of this chapter describes the procedures, recruitment of participants, experiment design, manipulation, and data handling. The details of each step include participants’ demographics, equipment, stimulus, measurements, and in-depth interview.

Overview of a Mixed-Method Study

This study employs mixed methods (Johnson & Onwuegbuzie, 2004) that incorporate interdisciplinary perspectives utilizing an experiment and in-depth interviews. It is an interdisciplinary approach that uses multiple methods to collect and analyze empirical data systematically (Donsbach, 2006; Johnson & Onwuegbuzie, 2004; McIntosh & Morse, 2015). An experiment was designed to test hypotheses and answer research questions that are testable with statistical methods (H1, H2, RQ1, RQ2, & RQ3). In-depth interviews were used to examine more abstract processes and concerns (RQ4 & 5). Specifically, RQ4 revealed that the educational effects of HMD VR content. RQ 3 and 4 demonstrated the values of immersive media experiences to achieve a higher goal of education. In-depth interview results of RQ5 and 6 demonstrated the psychological processes behind the educational value of the more immersive media technology. The in-depth interview results also contributed to the groundwork for creating more valid measurements or new measurements.
The mixed method is an “expansive and creative” (Johnson & Onwuegbuzie, 2004, p. 17) research design that is an effective way to understand research questions because it acknowledges the dynamics of social science. It also invites researchers to embrace that it is impossible to make absolute and complete conclusions. For this study, because the experiment provides unfamiliar media experiences to participants compared to their daily media uses, the researcher expected this study to find some ideological reactions or unidentified patterns that researchers have not yet discovered. Instead of trimming out these insights, adopting the mixed methods approach provides better understandings and directions for follow up studies.

In conjunction with the statistical analysis, as Johnson and Onwuegbuzie (2004) explained, the results of the qualitative analysis can add meaning to the statistical results and can generate broader understandings with stronger evidence. According to McIntosh and Morse (2015), it is particularly useful when there is some prior knowledge that is described by numbers compared to the limited qualitative knowledge. Specifically, this study explored if there are further research breakthroughs to examine relationships between presence and SCT theory with holistic and integrated design (Cameron, 2009; Creswell, 1994). This study designed the holistic and integrated mixed-method design because the complex and value guided hypotheses and research questions that require an integration of quantitative and qualitative perspectives (Creswell, 1994; Lawrenz & Huffman, 2002).

To design the holistic and integrated mixed-method study, this study first involved a within-subject design experiment comparing the effects of display-type (HMD
vs flat-screen) and content-type (international issues vs global warming) accompanying two experimental orders. In all of these conditions, participants watched two spherical 360-degree videos. They watched one of the videos on a flat-screen and the other in an HMD screen in counter-balanced orders. After watching each spherical VR video, participants said that questions about presence and motivation to learn and their intention to study more about the issues in the content they watched.

Next, after the experiment, the researcher conducted an in-depth interview to ask about the participants’ VR experiences. Half of the experiment participants were randomly selected from across all conditions. All interviews were audio-recorded with participants’ consent. Recorded audio files were then transcribed and analyzed by the researcher.

**Participants and Recruitment**

This study recruited 60 participants who were 18 years or older attending Temple University in Philadelphia in the U.S. in 2019. The average age was 21.02 years old (Min. =18, Max. =59, SD=6.12); 36 participants identified themselves as female (60%); 24 participants identified themselves as male (40%); 11 participants wore glasses (18.4%). All the participants were undergraduate students who were more geographically accessible to the Temple University’s M.I.N. D. Lab in the Klein College of Media and Communication. This was because the study needed the lab space that had VR equipment. They were offered either extra credit in their courses or a $5 gift card; 58 participants selected to receive the extra credit and 2 participants selected to receive the gift card.
The study design and procedure were subject to the approval of the IRB (Institutional Review Board) at Temple University to ensure the safety and voluntary participation of participants. Temple IRB approved this study’s protocol on May 17, 2019.

From May 17, 2019, the researcher started to recruit participants who were taking courses at Temple University’s Klein College of Media and Communication. The researcher contacted instructors to see if their students could participate in this study. When the researcher and instructors came to agree that students’ participation would be beneficial to students, the researcher or instructor announced the study participation requests at the beginning of classes or the instructors of some courses made online announcements. Instructors who offered extra credit for participating in the research also offered an equivalent amount of extra credit for a project/exercise that did not require participating in the research. In addition to the announcements, instructors also sent out a printable handout with a map of the Lab’s location, contact information, and a link address to an online sign-up page with a brief explanation of the study.

Participants were able to register for this study by visiting the web address (http://bit.ly/templevr) on the handout that also described the experiment location and time. When participants visited the online site, they filled out a form to indicate their available time and dates along with their names. They could modify their participation date and time. Unless participants directly contacted the researcher, all the communication with participants was through their instructors and the signup system. In the handout, announcement, and online sign-up page for the recruitment, the researcher
consistently asked participants needed for a VR research study and explained the purpose of the VR study is to understand viewers’ opinions about interactive media content. The researcher also provided instruction to sign-up, location, compensation, contact information, IRB approval, and descriptions about the expected amount of time for trying out 2 VR video software packages and filling out questionnaires.

Experiment

Manipulation

This study manipulated the VR display-type between the VR experience with HMD and flat-screen displays. The HMD supported the surrounding field of view with a head-tracking controller and sensors to control viewing directions. The ranges of the horizontal field of view that HMD supported was between 90 and 110 degrees depending on face shape and calibration settings. This increased field of view created a sense of surrounding view compared to the flat-screen display, with a horizontal field of view between 30 to 40 degrees depending on participants sitting’ posture and height.

The Graphical Specifications of HMD and Flat-screen Displays

The HMD device used was the first consumer version of the Oculus Rift released in 2016. Participants wore HMD on their heads. The HMD display’s resolution was 1080 by 1200 per eye with a 90 Hz refresh rate small screen producing a 456 PPI (Pixels Per Inch) pixel density. It supported rotational and positional tracking through an accelerometer, gyroscope, magnetometer, and 360-degree positional tracking.

The flat-screen display supported 16:9 image ratio in a 22-inch size (20.1-inch x 8-inch x 16.4-inch) with a mouse controller to control viewing directions. The flat-screen
display's resolution was 1680 by 1050 with a 60 Hz refresh rate LCD producing a 90 PPI pixel density. It was fixed on a desk in the lab space. Figure 7 describes both HMD and flat-screen devices.

Figure 7.
*Experiment Space Setting*

The Audio Specifications of HMD and Flat-screen Displays

The HMD produced sounds through its headphones while the flat-screen condition produced sounds through speakers on each side of the desk next to the flat-screen. Although the HMD was capable of handling spatial audio, the two VR contents
for this study did not provide spatial audio tracking. Therefore, the sound signal between the HMD and the flat-screen conditions was the same.

To control sound volumes for both HMD and flat-screen display conditions, sound volume was calibrated to 65dB ± 3dB at 1kHz using a sound level meter at the point of participants’ ear. The distance between the headphones of HMD and the sound meter was 1 cm. The distance between the speakers for the flat-screen and sound meter was 35cm, and participants sat on a chair at a distance 30-40 cm from the center of the left and right speakers. Figure 8 and 9 present calibrated sound volumes at 1 kHz tone for both conditions.

**Figure 8.**
*Calibrated Sound Volume at 1 kHz Tone in the HMD*
Figure 9.
*Calibrated Sound Volume at 1 kHz Tone in Flat-screen Condition*

![Calibrated Sound Volume Graph]

**Stimuli**

This study used two video clips that were playable to both HMD and flat-screen displays. One of the VR titles (Stimulus A) was about international issues. It was about the lives of people in a war in Syria. The title of it was “The Displaced” (Solomon & Ismail, 2017) and it was distributed by The New York Times Magazine on March 24, 2017. The VR content featured stories of Oleg, Hana, and Chuol who were suffering from the war in Syria. The original screening time of it was 10 minutes but the researcher screened the first half of the content for 5 minutes. Figure 10 presents sample images from scenes showing text descriptions of these VR contents.
The other content (Stimulus B) was about global warming and its environmental effects. The title of it was “The Crystal Reef” and it was distributed by Time Inc. on February 10, 2016 (Karutz, Bailenson, & Knapp, 2016). The original screening time for it was 5 minutes and the researcher screened all of it. The content resolution of both VR content was 4K.

The researcher selected these two titles among the important issues around the world because the topics they covered were difficult to have first-hand experiences with and difficult to learn about these issues because of their complexity. They are therefore appropriate for observing how immersive experiences can help to address these difficulties in learning. In the stimulus A, the interviews of the three children with several B-rolls in “The Displaced” represent around 30 million children among 60 million people who are suffering away from their home in Syria (Solomon & Ismail, 2017). It is unlikely
that the students in the U.S. had first-hand experiences related to these children and people living in Syria because of the distance and travel advisories. Although it is a significant humanitarian crisis in the 21 century, it is also difficult to know the reasons for the problem because of the complex international relations and cultural history. Involved in stimulus B, the scenes of dying coral reefs in the ocean in “The Crystal Reef” were good examples of showing global warming (Karutz et al., 2016). But it is also unlikely that the students had first-hand observations about these dying coral reefs as well as other places that only a limited number of passionate scientists have explored. In addition, it is difficult to learn how to evaluate the impact of global warming on earth and people because of the complex political debates surrounding the issue.

Procedure

Participants were requested to appear at the M.I.N. D. Lab located in Annenberg Hall at Temple University’s Klein College of Media and Communication. On the arrival of the participants, the researcher provided IRB-approved consent forms. Then, for participants who agreed to participate in the study, the researcher randomly assigned participants to one of four ordering groups that counter-balanced VR display type and stimulus, as shown in Table 1.
Table 1.
Ordering Conditions and Sample Size

<table>
<thead>
<tr>
<th>Ordering groups</th>
<th>N</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stimulus</td>
<td>Screen</td>
</tr>
<tr>
<td>Order 1</td>
<td>15</td>
<td>A</td>
<td>HMD</td>
</tr>
<tr>
<td>Order 2</td>
<td>15</td>
<td>A</td>
<td>Flat</td>
</tr>
<tr>
<td>Order 3</td>
<td>15</td>
<td>B</td>
<td>HMD</td>
</tr>
<tr>
<td>Order 4</td>
<td>15</td>
<td>B</td>
<td>Flat</td>
</tr>
</tbody>
</table>

To randomly assign participants to one of the four conditions, the researcher used a random number from random.com as shown in Figure 11. Random.com randomly listed 60 cases in the order that is listed in Figure 11. Participants were assigned to ordering groups based on that list.

Figure 11.
Randomized List

Note 1: The first number indicates ordering groups
Note 2: The second and third numbers indicate participant orders from 1-15 in the group
Participants generally spent 35-60 minutes for this experiment. Specifically, participants spent 5 to 10 minutes completing one pre-test and two post-tests’ questionnaires, spending a total of 15-25 minutes. Participants spent 5 minutes watching each VR content on flat-screen and HMD displays for a total of 10 minutes. The Lab space’s lights were turned off while participants were watching the stimuli and the lights were turned on when they were answering questionnaires. The researcher presented and stored all of the multiple-choice and open-ended questionnaires through Google Forms’ online service with a tablet PC (Amazon’s kindle fire HDX) with the size of 10-inch. Participants who were selected for an in-depth interview spent an additional 20-30 minutes on it. The researcher simply asked participants to sit and watch these VR video clips, for example:

Please have a sit. You will use this computer this time. I will play a content about global warming and coral reefs. Let me know if you find any difficulties to watch it.

Please have a sit. You will wear this on your head this time. Let me help you to wear it. I will play a content about international issues in Syria. Please keep stair play button until it plays. Let me know if you find any difficulties to watch it.

At the end of the study, the researcher debriefed about this study to participants when they complete all the assigned sessions. The content of debriefing was about the purpose of this study, compensation choices and processes, and a confidentiality notice.

**Measurements**

Participants filled out questionnaire items that measure of presence, MTL, self-efficacy, information insufficiency, motivation to learn in media, and visual discomfort. Among these, measurements for presence, MTL, self-efficacy, and visual discomfort had
more than three questionnaire items, which were combined by taking their mean scores after assessing reliability with Cronbach's alpha. Appendix A lists all questionnaire items for these measures.

Participants first said that questionnaires about their age, sex, self-efficacy, and pre-test of information insufficiency before viewing the VR videos. After playing each video, they filled out questionnaires that measuring presence, motivation to learn, motivation to learn in media, visual discomfort, and the post-test of information insufficiency. For demographic questions, there was the option of “do not want to answer” so the participant could avoid answering any questions that they felt uncomfortable to answer.

**Presence.** To measure levels of presence, this study used spatial presence, social presence, immersion, and social realism from the Temple Presence Inventory (TPI) (Lombard et al., 2013). To reduce the participants’ stress and cognitive load, three questions were selected for each presence dimension; the three items with the highest factor loading values listed in the TPI were selected (Lombard et al., 2013). Factor loading values are a form of coefficient in factor analysis that represents a correlation between the factor and observed measurements (Yang, 2010). Because of the higher factor loadings, these three questions can represent most of the variance in all of the items. For example, one of the questionnaire items for spatial presence was “How much did it seem as if the objects and people you saw/heard had come to the place you were? (1: Not at all – 7: Very much)”; a quotation for social presence was “How often did you have the sensation that people you saw/heard could also see/hear you? (1: Not at all – 7:
Very much); a quotation for immersion was “To what extent did you feel mentally immersed in the experience? (1: Not at all – 7: Very much)”; a quotation for social realism was “The events I saw/heard would occur in the real world (1: Strongly disagree – 7: Strongly agree).” (Lombard et al., 2013)

**MTL.** To measure Motivation To Learn (MTL), this study created a measure by modifying other studies’ measures, specifically 3 items using 7-point Likert scales of Noe and Schmitt (1986) and Simmering et al. (2009). These are “I will try to learn as much as I can from _______” (Noe & Schmitt, 1986), “I will exert considerable effort to learn the class material,” (Simmering et al., 2009), and “I am learning as much as I can of this material” (Cole et al., 2004; Noe & Schmitt, 1986). For example, “I will try to learn as much as I can from _______” (Noe & Schmitt, 1986) was transformed to “I will try to learn as much as I can about this topic (1: Strongly disagree – 7: Strongly agree).”

**Self-efficacy.** To measure self-efficacy, this study used the College Self-Efficacy Inventory (CSEI)’s course dimension with 7 items (Gore, Leuwerke, & Turley, 2005; Solberg & Viliarreal, 1997). This dimension is about college students’ self-efficacy regarding writing research papers, taking exams, note-taking, and time management. Social and roommate dimensions were not included. An example of a CSEI questionnaire item is, “Please indicate how confident you are as a student at TEMPLE University that you can successfully manage time effectively (1: Not at all confident – 7: Extremely confident).”

**Information insufficiency.** To measure information insufficiency, this study used current knowledge, sufficiency threshold, affective response, and informational
subjective norm items from the Risk Information Seeking and Processing (RISP) model (Griffin, Neuwirth, Dunwoody, & Giese, 2004). For example, current knowledge was assessed with this questionnaire item: “Please rate your current knowledge about global warming on a scale of 0 to 100, where zero means knowing nothing and 100 means knowing everything you could possibly know about this topic.” To estimate information insufficiency, all of these items were entered in Structural Equation Modeling (SEM) analysis to avoid problems by creating a scale with multiple items (Griffin et al., 2004; Huurne & Gutteling, 2008).

**MTLM.** To measure Motivation To Learn in Media (MTLM), this study created a set of questions asking about how likely it is that students will make an effort to learn about a given topic specifically using textbooks, news articles, journal articles, Wikipedia, social media (Facebook, Instagram, YouTube, Twitter, etc.), podcasts, movies, TV Programs, virtual reality experiences, and augmented reality experiences. An example of the MTLM questionnaire items is “Please indicate how likely it is that you will make an effort to learn about the topic using each of the following: Textbooks (1: Pretty much unlikely – 7: very likely).”

**Visual discomfort.** To measure visual discomfort, this study used a modified version of the “general discomfort” dimension from the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993). The SSQ has 7 full sub-dimensions of visual discomfort and provides weights to be compared to other studies. However, including all sub-dimensional measures would have been too lengthy. Therefore the study included only the general discomfort dimension that has the highest factor loading, correlates with
other sub measures, and represents overall severity as an index (Kennedy et al., 1993). Further, this study does not perform symptomatology of the VR experience, so applying the general discomfort measure would be the best fit to report presence of visual discomfort and relationships with presence and motivation variables. An example of a visual discomfort questionnaire item is “During your viewing, did you experience discomfort with your head? (1: None – 7: Severe)”

**In-depth Interviews**

After viewing all the VR videos and finishing the questionnaires, a total of 28 participants, who had been previously selected randomly and in equal numbers from the four order conditions were interviewed. Seven participants who were assigned even serial numbers out of the 15 participants in each of the four ordering groups were selected. The researcher interviewed them for 10-20 minutes in the same room. In a “semi-structured in-depth interview” for a text-analysis (Campbell, Quincy, Osserman, & Pedersen, 2013; Carter & Henderson, 2005, p. 218; McIntosh & Morse, 2015; Popping, 2015), the researcher asked questions about their experiences of using the VR contents with the different displays. The interviewer took notes and made audio recordings of interviews with participants’ agreement.

In addition to the quantitative analysis, in-depth interview results were used to provide a broader understanding of HMD VR’s educational uses. Also, this guided the direction of statistical analysis that revealed the relationships between presence and motivation to learn. The insider perspectives of the in-depth interview results provided more insights about how people associate meanings and their experiences (Brennen,
The questions were designed to create a flexible flow of interviews in a planned structure as McIntosh and Morse (2015) suggested. The researcher first broadly debriefed the experiment they had just participated in, asking about what technological elements made for a more or less immersive experience. Example questions were: “How and what elements made the more or less immersive experience” and “What would make you more motivated to learn?” Second, the researcher asked questions that are more specific about presence and MTL. Example questions were: “If you have a limited time to study the environmental issue or international issue” and “Which topic would you like to spend more time on?” Finally, the researcher asked catching up and supplementary questions. An example question was: “Could you identify the most impressive moment, scene, place, event, or person in these experiences?” Appendix B lists all of the questions for the interview.

Mixed-Method Data Processing

Although the typology of mixed-method does no capture the unlimited combinations of methodological diversity that studies deploying mixed-method and multi-method designs, the type of mixed method in this study can be categorized as an embedded type (Cameron, 2009; Creswell, 1994). Because as described in the previous sections, this study concurrently deployed quantitate and qualitative studies broadly and the design for individual participants has a quantitate and qualitative sequence (Cameron, 2009) with the impartial arrangement of two methods to test hypotheses and research
questions (Palinkas et al., 2011), which is useful for holistic integrated design of mixed-method (Cameron, 2009; Creswell, 1994; Lawrenz & Huffman, 2002).

Data from the experiment questionnaires were collected and stored first through the Google Forms system. The account was password protected and the access of the data was given only to the research team that IRB approved. In the logging of the data, participants were assigned participant numbers for the analysis of data. The researcher stored all information that could link the participant number to a particular participant in a locked file under the investigator’s control and deleted it at the end of the study.

After the data collection, the researcher downloaded the dataset of multiple-choice and open-ended questionnaire responses to analyze the dataset using SPSS and AMOS. Once the download was complete, the data on Google Forms were deleted. Specifically, to perform ANOVA (Analysis of variance) and SEM (Structural equation modeling) analyses to compare the differences between conditions and indirect effects, as described in Chapter 6, the researcher reformatted the data in a spreadsheet format to scales and transformed variables for SPSS analysis.

After the statistical analysis, the researcher transcribed and analyzed the audio recordings of the interviews as described in Chapter 7. Audio files were first stored in an audio recorder’s memory card. The researcher moved these files to a computer to transcribe them. After completing the transcription of all the audio recordings, the researcher deleted all of these files from the memory card.
Chapter summary

This chapter described the method that this study employed to test the hypotheses and research questions in the previous chapter. Next, Chapter 6 will provide how this study analyzed the data.
CHAPTER 6

QUANTITATIVE DATA ANALYSIS AND RESULTS

This chapter presents the data analysis of the quantifiable responses that were recorded from the experiment explained in Chapter 5. The first section of this chapter describes ANOVA (Analysis of variance) and SEM (Structural equation modeling) that this study employed for its statistical analysis method including data processing and assumption tests. The second section of this chapter lists descriptive analysis results. The third section of this chapter lists the results of hypothesis tests. Chapter 7 will present the results of qualitative data analysis.

Statistical Analysis Procedure

In the analysis, statistical tests were processed with an IBM SPSS software. To test H1, 2, and 3, the researcher applied repeated measures ANOVA. The repeated measures ANOVA test is similar to the ANOVA for comparing variances with categorical independent variables and a continuous dependent variable. But it assumes individual variability error can be minimized with a within-subject experiment design compared to a between-subject design (Huck & McLean, 1975; Rogan, Keselman, & Mendoza, 1979).

Random assignment and normality of data are the assumptions of ANOVA that also apply to the repeated measures ANOVA test (Scheiner & Gurevitch, 2001). First, as described in the method, participants were randomly assigned to experimental conditions. Second, the normality of data was examined by checking skewness and kurtosis (Scheiner & Gurevitch, 2001).
Some variables showed significant skewness. Although both ANOVA and repeated measures ANOVA tests are generally considered robust to the normality violation, these significantly skewed variables were transformed to increase the statistical tests’ validity (Huck & McLean, 1975; Rogan et al., 1979). As Tabachnick, Fidell, and Ullman (2007) suggested, variables that showed significantly positive skewness were computed by applying equation (1) below; variables that showed significantly negative skewness were computed by applying equation (2). In these equations, $X_n$ represents transformed values, $X$ represents original values, and $C$ represents a constant, which is the largest value of $X$.

\[
F(X_n) = \log_{10}(1 + X) \quad (1)
\]

\[
F(X_n) = \log_{10} [(C + 1) - X] \quad (2)
\]

In addition to the general assumptions of the ANOVA test, the repeated measures ANOVA test assumes sphericity, which is also called a circularity assumption (Scheiner & Gurevitch, 2001), that differences between the response on the dependent variable for levels or categories of the independent variable have equal variance. Mauchly’s $\chi^2$ significance test of sphericity was used to check this assumption but none of the results showed the statistically significant level of the Chi-square indicating the violation of the sphericity assumption.

To test RQ 1-3, instead of applying the causal-steps approach of Baron and Kenny (1986), SEM analysis was completed to avoid Type 2 error (Cheung & Lau, 2007;
MacKinnon, Lockwood, & Williams, 2004) because of the underestimation caused by measurement errors that Cheung and Lau (2007) demonstrated. Cheung and Lau (2007), argued that other mediation analysis methods, including the causal-steps approach of Baron and Kenny (1986) and PROCESS model of Preacher and Hayes (2004), generated less clear and accurate confidence intervals than SEM.

Also, as Preacher and Hayes (2004) and MacKinnon, Fairchild, and Fritz (2006) recommended, the analysis applied a nonparametric bootstrapping of 5,000 samplings with a 95% confidence interval to test indirect effect to assess the significance of indirect effects by providing Confidence Intervals (CI) for testing null-hypothesis. Cheung and Lau (2007) explained the confidence interval is similar to the parameter estimate when applying the bootstrapping in SEM. To test mediation effects, bootstrapping was essential (MacKinnon et al., 2006; Mooney & Duval, 1993); because it creates estimates from a sampling distribution by a random resampling method from data (Mooney & Duval, 1993).

Descriptive Results

Except for the current knowledge and sufficiency threshold for estimating information insufficiency that used the range of 0 to 100, all the variables used the range of 1 to 7. Except for the measurements of information insufficiency, all the Cronbach’s alpha of scales showed acceptable levels of reliability.

Motivation To Learn (MTL)

As shown in Table 2, the overall level of the MTL in the flat-screen condition was 4.79 (alpha = .94); in the HMD condition, it was 5.17 (alpha = .94). Across both VR
display-types, the overall MTL about global warming was 4.98 \((\alpha = .95)\) and international issues was 4.98 \((\alpha = .93)\). The reliability tests with Cronbach’s alpha showed these scales have acceptable reliability.

Within the flat-screen condition, the MTL about global warming was 4.67 (Shapiro-Wilk’s \(p\)-value = .35) and international issues was 4.91 (Shapiro-Wilk’s \(p\)-value = .26). Within the HMD condition, the MTL about global warming was 5.28 (Shapiro-Wilk’s \(p\)-value = .24) and international issues was 5.05 (Shapiro-Wilk’s \(p\)-value = .08). Shapiro-Wilk’s \(p\)-values did not indicate the violation of normality.

### Table 2.
Descriptive Statistics of MTL

<table>
<thead>
<tr>
<th></th>
<th>Flat-screen</th>
<th>HMD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N)</td>
<td>(M)</td>
</tr>
<tr>
<td><strong>Motivation to learn</strong></td>
<td>60</td>
<td>4.79</td>
</tr>
<tr>
<td>Global warming</td>
<td>30</td>
<td>4.67</td>
</tr>
<tr>
<td>International issues</td>
<td>30</td>
<td>4.91</td>
</tr>
</tbody>
</table>

### Presence

**Spatial presence.** As shown in Table 3, the overall level of spatial presence in the flat-screen condition was 3.23 \((\alpha = .90)\); in the HMD condition, it was 5.27 \((\alpha = .82)\). Across both VR display-types, the overall level of spatial presence for the content about global warming was 4.02 \((\alpha = .91)\) and international issues was 4.49 \((\alpha = .91)\).
The reliability tests with Cronbach’s alpha showed these scales have acceptable reliability.

Within the flat-screen condition, the level of spatial presence for the VR content about global warming was 4.67 (Shapiro-Wilk’s $p$-value = .02) and international issues was 4.91 (Shapiro-Wilk’s $p$-value = .13). Spatial presence for the VR content about global warming showed significant normality violations in the Shapiro-Wilk tests, but this variable does not require transformation because the Kolmogorov-Smirnov test was not significant ($p = .10$); Q-Q and box plots did not yield a significant outlier.

Within the HMD condition, the level of spatial presence for the VR content about global warming was 5.31 (Shapiro-Wilk’s $p$-value = .06) and international issues was 5.23 (Shapiro-Wilk’s $p$-value = .04). Both the global warming condition (Kolmogorov-Smirnov’s $p$-value = .04) and international issues condition (Kolmogorov-Smirnov’s $p$-value = .01) showed a significant negative skewness. This negative skewness represents upper clipping and ceiling effects because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (2) above. After the transformation, both the global warming condition (Kolmogorov-Smirnov’s $p$-value $\geq .20$ & Shapiro-Wilk’s $p$-value = .09) and international issues condition (Kolmogorov-Smirnov’s $p$-value $\geq .20$ & Shapiro-Wilk’s $p$-value = .63) did not show a significant negative skewness.

**Social presence.** As shown in Table 3, the overall level of social presence in the flat-screen condition was 2.89 ($alpha = .86$); in the HMD condition, it was 4.65 ($alpha
Across both VR display-types, the overall level of social presence for the content about global warming was 3.45 ($alpha = .87$) and international issues was 4.08 ($alpha = .88$). The reliability tests with Cronbach’s alpha showed these scales have acceptable reliability.

Within the flat-screen condition, the level of social presence for the VR content about global warming was 2.47 (Shapiro-Wilk’s $p$-value = .01) and international issues was 3.33 (Shapiro-Wilk’s $p$-value = .01). Although the level of social presence for both VR contents showed significant normality violations in Shapiro-Wilk tests, this variable did not require transformation because Kolmogorov-Smirnov’s test was not significant ($p = .17$); Q-Q and box plots did not yield a significant outlier.

Within the HMD condition, the level of social presence for the VR content about global warming was 4.82 (Shapiro-Wilk’s $p$-value = .28) and international issues was 4.48 (Shapiro-Wilk’s $p$-value = .17). Shapiro-Wilk’s $p$-values did not indicate the violation of normality.

**Presence as immersion.** As shown in Table 3, the overall level of immersion in the flat-screen condition was 4.31 ($alpha = .95$); in the HMD condition, it was 6.03 ($alpha = .88$). Across both VR display-types, the overall level of immersion for the content about global warming was 4.93 ($alpha = .96$) and international issues was 5.41 ($alpha = .93$). The reliability tests with Cronbach’s alpha showed these scales have acceptable reliability.

Within the flat-screen condition, the level of immersion for the VR content about global warming was 3.90 (Shapiro-Wilk’s $p$-value = .31) and international issues was
4.72 (Shapiro-Wilk’s *p*-value = .15). Shapiro-Wilk’s *p*-values did not indicate the violation of normality.

Within the HMD condition, the level of immersion for the VR content about global warming was 6.10 (Shapiro-Wilk’s *p*-value ≤ .001) and international issues was 5.97 (Shapiro-Wilk’s *p*-value = .01). Both the global warming condition (Kolmogorov-Smirnov’s *p*-value = .001) and international issues condition (Kolmogorov-Smirnov’s *p*-value = .09) showed a significant negative skewness. This negative skewness represents upper clipping and ceiling effects because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (2). After the transformation, both the global warming condition (Kolmogorov-Smirnov’s *p*-value ≥ .20 & Shapiro-Wilk’s *p*-value = .12) and international issues condition (Kolmogorov-Smirnov’s *p*-value ≥ .20 & Shapiro-Wilk’s *p*-value = .49) did not show a significant negative skewness.

**Presence as social realism.** As shown in Table 3, the overall level of social realism in the flat-screen condition was 6.14 (*alpha* = .90); in the HMD condition, it was 6.56 (*alpha* = .72). Across both VR display-types, the overall level of social realism for the content about global warming was 6.13 (*alpha* = .90) and international issues was 6.58 (*alpha* = .78). The reliability tests with *Cronbach’s alpha* showed these scales have acceptable reliability.

Within the flat-screen condition, the level of social realism for the VR content about global warming was 5.90 (Shapiro-Wilk’s *p*-value ≤ .001) and international issues
was 6.39 (Shapiro-Wilk’s \( p\text{-value} \leq .001 \)). Both the global warming condition (Kolmogorov-Smirnov’s \( p\text{-value} = .001 \)) and international issues condition (Kolmogorov-Smirnov’s \( p\text{-value} = .09 \)) showed a significant negative skewness. This negative skewness represents upper clipping and ceiling effects because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (2). Both the global warming condition (Kolmogorov-Smirnov’s \( p\text{-value} \geq .20 \) & Shapiro-Wilk’s \( p\text{-value} = .10 \)) and international issues condition (Kolmogorov-Smirnov’s \( p\text{-value} \geq .20 \) & Shapiro-Wilk’s \( p\text{-value} = .63 \)) did not show a significant negative skewness.

Within the HMD condition, the level of social realism for the VR content about global warming was 6.77 (Shapiro-Wilk’s \( p\text{-value} \leq .001 \)) and international issues was 6.36 (Shapiro-Wilk’s \( p\text{-value} \leq .001 \)). Both the global warming condition (Kolmogorov-Smirnov’s \( p\text{-value} = .001 \)) and international issues condition (Kolmogorov-Smirnov’s \( p\text{-value} = .09 \)) showed a significant negative skewness. This negative skewness represents upper clipping and ceiling effects because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (2). Both the global warming condition (Kolmogorov-Smirnov’s \( p\text{-value} = .08 \) & Shapiro-Wilk’s \( p\text{-value} = .12 \)) and international issues condition (Kolmogorov-Smirnov’s \( p\text{-value} \geq .20 \) & Shapiro-Wilk’s \( p\text{-value} = .23 \)) did not show a significant negative skewness.
Table 3.  
*Descriptive Statistics of Presence*

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<tbody>
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<td>6.77</td>
</tr>
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</table>

*Normality violation addressed

**Visual Discomfort.**

As shown in Table 4, the overall level of visual discomfort in the flat-screen condition was 1.51 (alpha = .77); in the HMD condition, it was 1.83 (alpha = .65).

Across both VR display-types, the overall level of visual discomfort for the content about global warming was 1.55 (alpha = .70) and international issues was 1.79 (alpha = .75).

The reliability tests with *Cronbach’s alpha* showed these scales have marginally acceptable reliability.
Table 4.

Descriptive Statistics of Visual Discomfort

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<td>1.23</td>
<td>1.88++</td>
</tr>
</tbody>
</table>

++Normality violation remains

Within the flat-screen condition, the level of visual discomfort for the VR content about global warming was 1.21 (Shapiro-Wilk’s p-value ≤ .001) and international issues was 1.80 (Shapiro-Wilk’s p-value ≤ .001). Both the global warming condition (Kolmogorov-Smirnov’s p-value ≤ .001) and international issues condition (Kolmogorov-Smirnov’s p-value ≤ .001) showed a significant positive-skewness. This positive-skewness represents lower clipping and flooring because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both the global warming condition (Kolmogorov-Smirnov’s p-value ≤ .001 & Shapiro-Wilk’s p-value ≤ .001) and international issues condition (Kolmogorov-Smirnov’s p-value ≤ .001 & Shapiro-Wilk’s p-value ≤ .001) still showed a significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.
Within the HMD condition, the level of visual discomfort to the VR content about global warming was 1.78 (Shapiro-Wilk’s *p*-value ≤ .001) and international issues was 1.88 (Shapiro-Wilk’s *p*-value ≤ .001). Both the global warming condition (Kolmogorov-Smirnov’s *p*-value ≤ .001) and international issues condition (Kolmogorov-Smirnov’s *p*-value ≤ .001) showed a significant positive-skewness. This positive-skewness represents lower clipping and flooring because Q-Q and box plots did not yield a significant outlier or the other types of severe deviations (Tabachnick et al., 2007). To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both the global warming condition (Kolmogorov-Smirnov’s *p*-value = .052 & Shapiro-Wilk’s *p*-value = .056) and international issues condition (Kolmogorov-Smirnov’s *p*-value = .001 & Shapiro-Wilk’s *p*-value = .002) still showed a significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.

**College Self-Efficacy Inventory (CSEI)**

The overall level of CSEI was 5.40 (*SD = 0.73, N = 60, & alpha = .81*) in the pre-test. This variable measured only in the pre-test. The reliability test with *Cronbach’s alpha* showed CSEI has acceptable reliability. According to an ANOVA test, there was no significant difference across the four ordering conditions (*p = .54, F (1, 3) = .73*); it did not show a significant skewness (Kolmogorov-Smirnov’s *p*-value ≥ .20 & Shapiro-Wilk’s *p*-value = .74).
**Information Insufficiency: Pre-test**

As described in the Chapter 5, current knowledge, sufficiency threshold, affective response, and informational subjective norm are all single-item measurements in the RISP model. These four items were used to estimate information insufficiency in a Structural Equation Modeling (SEM) model. These variables’ normality was tested in the descriptive statistics section for both pre and post-test results. They were measured first in the pre-test and the next section describes the results of the post-tests. Although participants reported significantly higher current knowledge and more affective response about global warming than international issues, there were no significant differences among the four ordering conditions in the pre-test.

**Current Knowledge.** As shown in Table 5, the overall level of reported current knowledge in the pre-test was 46.30. Specifically, the level of reported current knowledge about global warming was 51.13 (Shapiro-Wilk’s *p*-value = .100) and international issues was 41.47 (Shapiro-Wilk’s *p*-value = .092). Shapiro-Wilk’s *p*-values did not indicate the violation of normality.

Although the difference in the content-types was significant [*p* = .001, *F*(1, 59) =11.70], there was no significant difference across the four ordering conditions [*p* = .81, *F*(3, 56) = 0.32].

**Sufficiency Threshold.** As shown in Table 5, the overall level of reported sufficiency threshold in the pre-test was 68.83. Specifically, the level of reported sufficiency threshold about global warming was 66.57 (Shapiro-Wilk’s *p*-value = .014) and international issues was 71.08 (Shapiro-Wilk’s *p*-value = .013). Both the global
warming condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) and international issues condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) showed a significant positive-skewness but Q-Q and box plots did not yield a significant outlier. To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both conditions still showed significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.

The difference in the content-types was not significant [$p = .071, F (1, 56) = 3.34$] and there was no significant difference across the four ordering conditions [$p = .89, F (3, 56) = 0.20$].

**Affective Response.** As shown in Table 5, the overall level of reported affective response in the pre-test was 5.51. Specifically, the level of reported affective response about global warming was 5.83 (Shapiro-Wilk’s $p$-value $\leq .001$) and international issues was 5.13 (Shapiro-Wilk’s $p$-value $\leq .001$). Both the global warming condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) and the international issues condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) showed a significant positive-skewness but Q-Q and box plots did not yield a significant outlier or the other types of severe deviation. To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both conditions still showed significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.
Although the difference in the content-types was significant \( p = .001, F (1, 59) = 12.97 \), there was no significant difference across the four ordering conditions \( p = .85, F (3, 56) = 0.26 \).

**Informational subjective Norms.** As shown in Table 5, the overall level of reported informational subjective norms in the pre-test was 4.42. Specifically, the level of reported informational subjective norms about global warming was 4.33 (Shapiro-Wilk’s \( p\text{-value} \leq .001 \)) and international issues was 4.50 (Shapiro-Wilk’s \( p\text{-value} \leq .001 \)). Both the global warming condition (Kolmogorov-Smirnov’s \( p\text{-value} \leq .001 \)) and international issues condition (Kolmogorov-Smirnov’s \( p\text{-value} \leq .001 \)) showed a significant positive-skewness but Q-Q and box plots did not yield a significant outlier. To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both conditions still showed significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.

The difference in the content-types was not significant \( p = .074, F (1, 56) = 0.74 \) and there was no significant difference across the four ordering conditions \( p = .58, F (3, 56) = 0.67 \).

**Information Insufficiency: Post-test**

As described in Chapter 5, current knowledge, sufficiency threshold, affective response, and informational subjective norm were measured again after participants watched VR contents in the flat-screen and HMD conditions. These variables’ normality assumption was tested for both flat-screen and HMD conditions.
Current Knowledge. The total average level of reported current knowledge was 46.68 (SD = 21.10, N = 120) across content and display-types. As shown in Table 5, the overall level of reported current knowledge in the flat-screen condition was 43.58; in the HMD condition, it was 47.28. The overall level of reported current knowledge about global warming was 45.43 (Shapiro-Wilk’s p-value = .817) and international issues was 47.94 (Shapiro-Wilk’s p-value = .134). Shapiro-Wilk’s p-values did not indicate a violation of normality.

Sufficiency threshold. The total average level of reported sufficiency threshold was 70.92 (SD = 15.90, N = 120) across content and display-types. As shown in Table 5, the overall level of reported sufficiency threshold in the flat-screen condition was 70.65 and in the HMD condition was 70.63. The overall level of reported sufficiency threshold about global warming was 70.64 (SD = 17.86, N = 60, & Shapiro-Wilk’s p-value ≤ .001) and international issues was 71.20 (SD = 13.94, N = 60, & Shapiro-Wilk’s p-value ≤ .001). Both the global warming condition (Kolmogorov-Smirnov’s p-value ≤ .001) and international issues condition (Kolmogorov-Smirnov’s p-value ≤ .001) showed a significant positive-skewness but Q-Q and box plots did not yield a significant outlier. To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both conditions still showed significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.

Affective Response. The total average level of reported affective response was 5.78 (SD = 1.20, N = 120) across content and display-types. As shown in Table 5, the
overall level of reported affective response in the flat-screen condition was 5.53 and in the HMD condition was 6.02. The overall level of reported affective response about global warming was 5.89 (Shapiro-Wilk’s $p$-value $\leq .001$) and international issues was 5.67 (Shapiro-Wilk’s $p$-value $\leq .001$). Both the global warming condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) and international issues condition (Kolmogorov-Smirnov’s $p$-value $\leq .001$) showed a significant positive-skewness but Q-Q and box plots did not yield a significant outlier. To address the normality violations, this variable was transformed for statistical tests using eq. (1). Both conditions still showed significant positive-skewness. Because of the normality violation, it is recommended to perform non-parametric statistic tests to analyze this variable.

**Informational Subjective Norms.** The total average level of reported informational subjective norms was 4.48 ($SD = 1.55, N = 120$) across content and display-types. As shown in Table 5, the overall level of reported informational subjective norms in the flat-screen condition was 4.23 and in the HMD condition was 4.72. The overall level of reported informational subjective norms about global warming was 4.52 (Shapiro-Wilk’s $p$-value $= .083$) and international issues was 4.44 (Shapiro-Wilk’s $p$-value $= .056$). Shapiro-Wilk’s $p$-values did not indicate the violation of normality.
Table 5.
*Descriptive Statistics of variables in the RISP Model*

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</table>

++Normality violation remains
Motivation To Learn in Media (MTLM).

The total average level of reported MTLM was 4.21 ($SD = 1.75$, $N = 60$). As shown in Table 6, participants reported their MTLM in the flat-screen and HMD conditions.

Table 6.
Descriptive Statistics for MTLM

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<td>$SD$</td>
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Hypothesis Tests

**Hypothesis 1: Effects of HMD on MTL**

H1 predicted that VR experiences with HMD will result in more motivation to learn than the flat-screen condition. The researcher completed three one-way repeated measure ANOVAs, as shown in Table 7. H1 was tested with a one-way repeated measure ANOVA and it is supported. As shown in Table 7(A), participants in the HMD condition ($M = 5.17$, $SD = 0.16$, $N = 60$) reported significantly more motivation to learn than those in the flat-screen condition ($M = 4.79$, $SD = 1.41$, $N = 60$). Figure 12 presents the group differences.

Further, as shown in Table 7(B), to control the effects of content-type, the effects of content-type were tested with additional one-way repeated measures ANOVA and no significant main effect was observed. Besides, as shown in Table 7(C), two way within ANOVA was followed to eliminate an interaction effect and no significant interaction effect was observed.
Figure 12.

*MTL* between the Flat-Screen and HMD conditions

![Graph showing MTL between Flat-screen and HMD conditions](image)

**Table 7.**

*Repeated Measures ANOVA Results for H1*

<table>
<thead>
<tr>
<th></th>
<th>Wilks’ Lambda</th>
<th>F (df1, df2)</th>
<th>ηp²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Display-type</td>
<td>0.89</td>
<td>6.99 (1, 58)</td>
<td>.11*</td>
</tr>
<tr>
<td>(B) Content-type</td>
<td>0.89</td>
<td>0.00 (1, 58)</td>
<td>.00</td>
</tr>
<tr>
<td>(C) A by B: Interaction</td>
<td>0.97</td>
<td>0.73 (1, 28)</td>
<td>.02</td>
</tr>
</tbody>
</table>

*Note: *p ≤ .05
Dependant variable: MTL
**Hypothesis 2.1: Effects of HMD VR in the RISP Model**

H2.1 predicted that VR experiences with HMD will result in a) more perceived current knowledge, b) increased perceived sufficiency threshold, c) more intense affective response, and d) stronger informational subjective norms than in the flat-screen condition. As Table 8 summarizes, a one-way repeated measures ANOVA with three levels tested each hypothesis. The ANOVA analysis compared the levels of pre-test, flat-screen condition post-test, and HMD condition post-test measures.

**Table 8.**
*Summary of Repeated Measures ANOVA Results for H2.1*

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Flat-screen</td>
</tr>
<tr>
<td></td>
<td>$F(\eta^2_p)$</td>
<td>$\chi^2$</td>
</tr>
<tr>
<td><strong>H2.1a:</strong> Current knowledge+</td>
<td>1.24 (.04)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>H2.1b:</strong> Sufficiency threshold+</td>
<td>1.04 (.04)</td>
<td>6.18*</td>
</tr>
<tr>
<td><strong>H2.1c:</strong> Affective response++</td>
<td>9.24 (.24)**</td>
<td>14.91***</td>
</tr>
<tr>
<td><strong>H2.1d:</strong> Informational subjective norms++</td>
<td>4.99 (.15)**</td>
<td>6.46*</td>
</tr>
</tbody>
</table>

Note 1: *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$*
Note 2: + 0-100 scale, ++0-7 scale
Note 3: $F(\eta^2_p)$ used for parametric tests, $\chi^2$ of the Friedman test used for non-parametric tests
As Table 9 summarizes, post-hoc analyses applied two-way repeated measures ANOVAs (content-type by pre and post-tests) in flat-screen and HMD conditions, one-way repeated measures ANOVA (flat-screen and HMD conditions), and one-way ANOVA (global warming and international issues topics).

Table 9.

Summary of H2.1: Post Hoc Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>H2.1-a Current knowledge</th>
<th>H2.1-b Sufficiency threshold</th>
<th>H2.1-c Affective response</th>
<th>H2.1-d Informational subjective norms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flat-screen vs baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>6.62 (.10)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Global warming</td>
<td>0.62 (.02)</td>
<td>0.47</td>
<td>0.07</td>
<td>0.47</td>
</tr>
<tr>
<td>International issues</td>
<td>9.01 (.24)**</td>
<td>0.47</td>
<td>0.80</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>HMD vs baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>10.72 (.16)**</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Global warming</td>
<td>7.49 (.21)*</td>
<td>4.57*</td>
<td>1.00</td>
<td>5.33*</td>
</tr>
<tr>
<td>International issues</td>
<td>3.60 (.11)</td>
<td>0.80</td>
<td>15.70***</td>
<td>0.53</td>
</tr>
<tr>
<td><strong>HMD vs flat-screen</strong></td>
<td>2.35 (.04)</td>
<td>0.24</td>
<td>3.79</td>
<td>9.97 (.15)**</td>
</tr>
<tr>
<td>Interaction</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Global warming</td>
<td>2.60 (.04)</td>
<td>-.24</td>
<td>-.32</td>
<td>0.95 (.02)</td>
</tr>
<tr>
<td>International issues</td>
<td>0.52 (.00)</td>
<td>-.05</td>
<td>-2.20*</td>
<td>2.08 (.04)</td>
</tr>
</tbody>
</table>

Note 1: *p ≤ .05, **p ≤ .01, ***p ≤ .001
Note 2: $F (\eta^2_p)$ used for parametric tests, $\chi^2$ of the Friedman test and $Z$ used for non-parametric tests
Current knowledge. The repeated measures ANOVA tested H2.1-a to see if HMD experiences result in more perceived current knowledge. The analysis results did not support H2.1-a [Wilks’ Lambda = 0.96, \( p = .297 \), \( F (1, 58) = 1.24 \), & \( \eta_p^2= .04 \)] as shown in figure 13.

**Figure 13.**
Changes in Current Knowledge

In the first post-hoc analysis for the flat-screen condition comparing pre and post tests, comparing pre and post tests, as shown in Table 9, there was no significant main effect of flat-screen experience [Wilks’ Lambda = 0.97, \( p = .169 \), \( F (1, 58) =1.94 \), & \( \eta_p^2=.03 \)]. But there was a significant interaction effect between content-type and baseline change [Wilks’ Lambda = 0.90, \( p = .013 \), \( F (1, 58) = 6.62 \), & \( \eta_p^2=.10 \)].
The level of reported current knowledge about a global warming increased to 46.40 (SD = 22.45, N = 30) from 44.1 (SD = 19.34, N = 30, Wilks’ Lambda = 0.98, p = .438, F (1, 29) = .62, & ηp²=.02). The level of reported current knowledge about international issues significantly decreased to 40.77 (SD = 20.79, N = 30) from 48.50 (SD = 18.49, N = 30, Wilks’ Lambda = 0.76, p = .005, F (1, 29) = 9.01, & ηp²=.24).

In the second post-hoc analysis for the HMD condition comparing pre and post-tests, as shown in Table 9, there was no significant main effect of HMD experience [Wilks’ Lambda = 0.99, p = .569, F (1, 58) = 0.33, & ηp²=.01]. But there was a significant interaction effect between content-type and baseline change [Wilks’ Lambda = 0.84, p = .002, F (1, 58) = 10.72, & ηp²=.16].

The level of reported current knowledge about global warming significantly increased to 55.10 (SD = 19.24, N = 30) from 44.1 (SD = 19.34, N = 30, Wilks’ Lambda = 0.80, p = .010, F (1, 29) = 7.49, & ηp²=.21). The level of reported current knowledge about international issues decreased to 39.47 (SD = 23.45, N = 30) from 44.10 (SD = 19.34, N = 30, Wilks’ Lambda = 0.89, p = .068, F (1, 29) = 3.60, & ηp²=.11).

In the third post-hoc analysis for comparing flat-screen and HMD conditions’ post-test responses, as shown in Table 9, there was no significant difference [Wilks’ Lambda = 0.96, p = .131, F (1, 59) = 2.35, & ηp²=.04]. The level of reported current knowledge in the HMD condition was higher (M = 47.28, SD = 22.68, N = 60) than those in the flat-screen condition (M = 43.58, SD = 21.64, N = 60).

To check interaction effects, additional set of one-way ANOVAs between the flat-screen and HMD conditions followed. The level of reported current knowledge about a
global warming was higher in the HMD condition \( [M = 55.10, SD = 19.24, N = 30, p = .113, F (1, 58) = 2.60, & \eta^2_p = .04] \) than those in the flat-screen condition \( (M = 40.77, SD = 20.79, N = 30) \). The level of reported current knowledge about international issues was lower in the HMD condition \( [M = 39.47, SD = 23.45, N = 30, p = .821, F (1, 58) = 0.52, & \eta^2_p = .00] \) than those in the flat-screen condition \( (M = 46.40, SD = 22.45, N = 30) \).

**Sufficiency threshold.**

The repeated measures ANOVA tested H2.1-b to see if VR experiences with HMD will result in an increased perceived sufficiency threshold. The analysis results did not support the H2.1-b \( [\text{Wilks’ Lambda} = 0.97, p = .359, F (1, 58) = 1.04, & \eta^2_p = .04] \). As described in the descriptive statistic section, the transformation of the variable via eq (1) and (2) did not resolve the violation of normality because of the significant distortion.

Non-parametric ANOVA tests were also added to confirm the hypothesis. As shown in figure 14, although a Friedman test \( (\chi^2 (2) = 6.18 & p = .046) \) supported H2.1-b, the post-hoc analysis did not support the hypothesis.
In the first post-hoc analysis for the flat-screen condition comparing pre and post tests, as shown in Table 9, there was a significant main effect of flat-screen experience [Friedman test’s $\chi^2 (1) = 5.23$ & $p = .022$]. The level of reported sufficiency threshold significantly increased to 70.65 ($SD = 16.36, N = 60$) from 68.83 ($SD = 19.26, N = 60$).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests were followed. The level of reported sufficiency threshold about a global warming decreased to 67.38 ($SD = 23.88, N = 30$) from 69.18 ($SD = 19.20, N = 30$, Friedman test’s $\chi^2 (1) = 0.47, & p = .491$]. The level of reported sufficiency threshold
about international issues also decreased to 73.47 ($SD = 12.95$, $N = 30$) from 68.47 ($SD = 13.23$, $N = 30$), Friedman test’s $\chi^2 (1) = 0.47$, & $p = .491$] and an interaction effect was not observed.

In the second post-hoc analysis for the HMD condition comparing pre and post-tests, as shown in Table 9, there was no significant main effect of the HMD [Friedman test’s $\chi^2 (1) = 1.14$ & $p = .286$]. The level of reported sufficiency threshold increased to 70.63 ($SD = 16.46$, $N = 60$) from 68.83 ($SD = 16.36$, $N = 60$).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests were followed. The level of reported sufficiency threshold about a global warming significantly increased to 68.93 ($SD = 14.93$, $N = 30$) from 64.63 ($SD = 15.13$, $N = 30$, Friedman test’s $\chi^2 (1) = 4.57$, & $p = .033$]. The level of reported sufficiency threshold about international issues also increased to 72.33 ($SD = 17.96$, $N = 30$) from 69.87 ($SD = 22.43$, $N = 30$, Friedman test’s $\chi^2 (1) = 0.80$, & $p = .371$].

In the third post-hoc analysis for comparing flat-screen and HMD conditions’ post-test responses, as shown in Table 9, there was no significant difference [Friedman test’s $\chi^2 (1) = 0.24$ & $p = .622$]. The level of reported sufficiency threshold was higher in the HMD condition ($M = 70.63$, $SD = 16.46$, $N = 60$) than those in the flat-screen condition ($M = 70.65$, $SD = 19.26$, $N = 60$).

To check interaction effects, additional set of non-parametric one-way ANOVA tests were followed. The level of reported sufficiency threshold about a global warming in the HMD condition increased to 68.93 ($SD = 14.93$, $N = 30$) from 67.83 ($SD = 23.88$, $N = 30$, Wilcoxon $W = 899$, $Z = -.24$, & $p = .812$]. The level of reported sufficiency
threshold about international issues in the HMD condition decreased to 72.33 ($SD = 17.96, N = 30$) from 73.47 ($SD = 12.95, N = 30$, Wilcoxon $W = 911, Z = -.05, & p = .958$).

**Affective Response**

The repeated measures ANOVA tested H2.1-c to see if VR experiences with HMD will result in a more intense affective response. The analysis results supported the H4.1-c ($p$-value of Mauchly’s test of sphericity = .03, Wilks’ Lambda = 0.76, $p ≤ .001$, $F (1, 58) = 9.24$, $η_p^2 = .24$). But the result was adjusted with the Greenhouse-Geisser report to reflect non-sphericity because Mauchly’s test of sphericity was significant [$F (1.80, 105.90) = 6.37$, $η_p^2 = .10$]. As described in the descriptive statistic section, the transformation of the variable via eq (1) and (2) did not resolve the violation of normality because of the significant distortion. Non-parametric ANOVA tests were also added to confirm the support of the hypothesis. As shown in figure 15, Friedman test ($χ^2 (2) = 14.91$ and $p = .001$) also supported H4.1-c. The following post-hoc tests used the Friedman test.
Figure 15. 
Changes of Affective Response

In the first post-hoc analysis for the flat-screen condition comparing pre and post tests, as shown in Table 9, there was no significant main effect of flat-screen experience [Friedman test’s $\chi^2 (1) = 3.03$ & $p = .080$]. The level of reported affective response increased to 5.53 ($SD = 1.43, N = 60$) from 5.51 ($SD = 1.01, N = 60$).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests followed. The level of reported affective response about a global warming decreased to 5.60 ($SD = 1.55, N = 30$) from 5.97 [$SD = 1.19, N = 30$, Friedman test’s $\chi^2 (1) = 0.07$, & $p = .796$]. The level of reported affective response about
international issues increased to 5.47 ($SD = 1.33, N = 30$) from 5.27 ($SD = 1.46, N = 30$), Friedman test’s $\chi^2 (1) = 0.80$, & $p = .371$] and an interaction effect was not observed.

In the second post-hoc analysis for the HMD condition comparing pre and post-tests, as shown in Table 9, there was a significant main effect of the VR experience with HMD [Friedman test’s $\chi^2 (1) = 13.52$ & $p \leq .001$]. The level of reported affective response increased to 6.02 ($SD = 0.97, N = 60$) from 5.51 ($SD = 1.01, N = 60$).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests followed. The level of reported affective response about a global warming increased to 5.87 ($SD = 1.04, N = 30$) from 5.70 ($SD = 1.24, N = 30$, Friedman test’s $\chi^2 (1) = 1.00$, & $p = .317$]. The level of reported affective response about international issues also increased to 6.17 ($SD = 0.87, N = 30$) from 5.10 ($SD = 1.13, N = 30$, Friedman test’s $\chi^2 (1) = 15.70$, & $p \leq .001$].

In the third post-hoc analysis for comparing flat-screen and HMD conditions’ post-test responses, as shown in Table 9, there was no significant difference [Friedman test’s $\chi^2 (1) = 3.79$ & $p = .052$]. The level of reported affective response was higher in the HMD condition ($M = 6.02, SD = 0.97, N = 60$) than those in the flat-screen condition ($M = 5.53, SD = 1.43, N = 60$).

To check interaction effects, additional set of non-parametric one-way ANOVA tests were followed. The level of reported affective response about a global warming in the HMD condition increased to 5.87 ($SD = 1.13, N = 30$) from 5.60 ($SD = 1.54, N = 30$, Wilcoxon $W = 894$, $Z = -.32$, & $p = .746$]. The level of reported affective response about
international issues in the HMD condition significantly increased to 6.17 (SD = 0.87, N = 30) from 5.47 (SD = 1.33, N = 30, Wilcoxon W = 780, Z = -2.20, & p = .036)

**Informational Subjective Norms.**

The repeated measures ANOVA tested H2.1-d to see if VR experiences with HMD result in stronger informational subjective norms. The analysis results supported the H4.1-d [Wilks’ Lambda = 0.85, p = .010, F=4.99, ηp²=0.15, & (df = 1, 58)]. As described in the descriptive statistic section, the transformation of the variable via eq (1) and (2) did not resolve the violation of normality in the pre-test because of the significant distortion. Non-parametric ANOVA tests were also added to confirm the hypothesis. As shown in figure 16, Friedman test (χ² (2) = 6.46 and p = .040) also supported H4.1-d.
Figure 16.
Changes in Informational Subjective Norms

In the first post-hoc analysis for the flat-screen condition comparing pre and post tests, as shown in Table 9, there was no significant main effect of flat-screen experience [Friedman test’s $\chi^2 (1) = 0.35$ & $p = .555$]. The level of reported informational subjective norms decreased to 4.23 ($SD = 1.64$, $N = 60$) from 4.42 ($SD = 1.27$, $N = 60$).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests were followed. The level of reported informational subjective norms about a global warming decreased to 4.30 ($SD = 1.75$, $N = 30$) from 4.47 [$SD = 1.22$, $N = 30$, Friedman test’s $\chi^2 (1) = 0.47$, & $p = .491$]. The level of reported informational subjective norms about international issues decreased to 4.17 ($SD = 1.56$, $N$
= 30) from 4.30 [SD = 1.78, N = 30], Friedman test’s $\chi^2 (1) = 0.05, & p = .819$] and an interaction effect was not observed.

In the second post-hoc analysis for the HMD condition comparing pre and post-tests, as shown in Table 9, there was no significant main effect of the VR experience with HMD [Friedman test’s $\chi^2 (1) = 1.39 & p \leq .238$]. The level of reported informational subjective norms increased to 4.72 (SD = 1.44, N = 60) from 4.41 (SD = 1.27, N = 60).

To check interaction effects, additional set of non-parametric one-way repeated measures ANOVA tests were followed. The level of reported informational subjective norms about a global warming significantly increased to 4.70 (SD = 1.42, N = 30) from 4.20 [SD = 1.63, N = 30, Friedman test’s $\chi^2 (1) = 5.33, & p = .021$]. The level of reported informational subjective norms about international issues slightly increased to 4.73 (SD = 1.48, N = 30) from 4.47 [SD = 1.22, N = 30, Friedman test’s $\chi^2 (1) = 0.53, & p = .467$].

In the third post-hoc analysis for comparing flat-screen and HMD conditions’ post-test responses, as shown in Table 9, there was a significant difference [Wilks’ Lambda = 0.86, $p = .003$, $F (1, 59) = 9.97$, & $\eta^2_p = .15$]. The level of reported informational subjective norms in the HMD condition was significantly higher ($M = 4.72$, $SD = 1.44, N = 60$) than those in the flat-screen condition ($M = 4.23$, $SD = 1.64, N = 60$), one-way ANOVA tests were applied because the post-test results did not show a significant normality violation.

To check interaction effects, additional set of one-way ANOVAs between the flat-screen and HMD conditions were followed. The level of reported informational subjective norms about a global warming was higher in the HMD condition [$M = 4.70$, $SD = 1.44, N = 60$] than those in the flat-screen condition ($M = 4.23$, $SD = 1.64, N = 60$).
$SD = 1.42, N = 30, p = .334, F (1, 58) = 0.95, \eta^2_p = 0.02$] than those in the flat-screen condition ($M = 4.30, SD = 1.75, N = 30$). The level of reported informational subjective norms about international issues was higher in the HMD condition [$M = 4.73, SD = 1.48, N = 30, p = .154, F (1, 58) = 2.08, \eta^2_p = 0.04$] than those in the flat-screen condition ($M = 4.17, SD = 1.56, N = 30$) and an interaction effect was not observed.

**Hypothesis 2.2 & 2.3: Effects of HMD on MTL in the RISP model**

H2.2 predicted information insufficiency will increase MTL and H2.3 predicted the effects of the information insufficiency in the HMD experience will be bigger than for flat-screen. To test both hypotheses multi-group Structural Equation Modeling (SEM) was applied (Hox, Moerbeek, & Van de Schoot, 2010; Qureshi & Compeau, 2009; Ullman, 2003). According to Qureshi and Compeau (2009), multi-group SEM is part of the SEM analysis that can identify group differences and compare indirect effects using covariance-based structural equation modeling. Because the information insufficiency in the RISP model should be estimated and analyzed in SEM to avoid issues from creating an index (Johnson, 2005), the researcher compared groups with multi-group SEM. The absolute value of the C.R. (Critical Ratio) exceeding 1.96 indicates two-sided statistical significance at a 5% error rate (Hox et al., 2010).

First, as shown in Figure 17, the information insufficiency was estimated with current knowledge, sufficiency threshold, affective response, and informational subjective norms in SEM (Johnson, 2005). To test the indirect effects of exogenous variables, nonparametric bootstrapping of 5,000 samplings and 95% significance level
criterion were applied. The model was fitted well to the data \((CMIN = 3.05, df = 2, p = .218; AGFI = .78; RMSEA = .70)\).

**Figure 17.**
*Information Insufficiency in RISP: Beta for Flat-Screen / HMD*

The structural weights model indicated that including both flat-screen and HMD conditions increased the model fit \((CMIN = 4.23, df = 5, p = .517; AGFI = .93; RMSEA \leq .001)\). Also, current knowledge \((CMIN = 0.01, df = 1, p = .935)\), affective response \((CMIN \leq 0.01, df = 1, p = .961)\), and informational subjective norms \((CMIN = 0.83, df = 1, p = .362)\) did not show a significant difference between the two conditions, indicating the model fits to both display type conditions.

Second, the effects of information insufficiency on MTL was assessed in SEM to test H2.2 and H2.3. Adding MTL to the RISP model, as shown in Figure 18, significantly decreased the model fit \((CMIN = 7.32, df = 11, p \leq .001; AGFI = .51; RMSEA = .23)\). But, as Kahlor (2010) suggested, affective response and the informational
subjective norms are expected to have direct effects on MTL. The corrected model based on the suggestion, as shown in Figure 19, was fitted well to the data ($CMIN = 20.43, df = 13, p = .085; AGFI = .86; RMSEA = .07$).

**Figure 18.**
The Initial Theoretic Model of RISP and MTL

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**H2.2.** According to the SEM analysis results with the final model, although information insufficiency increased MTL in the flat-screen condition ($B = .09$) and the HMD condition ($B = .09$), the SEM analysis with the final model did not support the hypothesis H2.2 ($p = .220$) that predicted information insufficiency will increase MTL.

On the other hand, there were significant main effects of affective response and informational subjective norms. The affective response significantly ($p = .004$) increased MTL in the flat-screen condition ($B = .24$) and in the HMD condition ($B = .23$). Informational subjective norms significantly ($p \leq .001$) increased MTL in the flat-screen condition ($B = .42$) and the HMD condition ($B = .48$). There were no significant indirect
effects of current knowledge, affective response, and informational subjective norms on MTL.

**Figure 19.**
*Final Model of the RISP Model and MTL: Beta for Flat-Screen / HMD*

H2.3. H2.3 predicted the effects of information insufficiency in the VR experience with HMD will be bigger than the flat-screen. The SEM analysis with the final model did not support the hypothesis. Although there was a .007 increase in the estimate, the difference was not significant in a pairwise parameter comparison result (C.R. = .35).

The effect of affective response was reduced in the HMD condition (C.R. = -.23) and the effect of informational subjective norms was increased in the HMD condition (C.R. = .68), while the effects of affective response and informational subjective norms were not significantly different between the two condition groups.
Hypothesis 3: Effects of VR Experience with HMD on Presence

H3 predicted VR experience with HMD will result in more a) spatial presence, b) social presence, c) immersion, and d) immersion than using a flat-screen. H3 was tested with the set of one-way repeated measures ANOVA tests and it is supported by all dimensions of presence. Table 10 summarizes results the all repeated measures ANOVA analysis for H3.

Spatial presence. H3-a was tested with a one-way repeated measures ANOVA and it is supported. Participants in the HMD condition reported a significantly higher level of spatial presence than those in the flat-screen condition [Wilks’ Lambda = 0.25, p ≤ .001, F (1, 59) = 176.12, \( \eta_p^2 = .75 \)].

Further, to control the effects of content-type, effects of content-type were tested with a one-way repeated measures ANOVA and no significant effect was observed [Wilks’ Lambda = 0.97, p = .148, F (1, 58) =2.15, \( \eta_p^2 = .04 \)].

Social presence. H3-b was tested with a one-way repeated measures ANOVA and it is supported. Participants in the HMD condition reported a significantly higher level of social presence than those in the flat-screen condition [Wilks’ Lambda = 0.41, p ≤ .001, F (1, 59) = 92.61, \( \eta_p^2 = .59 \)].

Further, to control the effects of content-type, effects of content-type were tested with a one-way repeated measures ANOVA, and a significant main effect was also observed [Wilks’ Lambda = 0.93, p = .037, F (1, 58) =4.55, \( \eta_p^2 = .07 \)].

Based on a post-hoc analysis in the flat-screen condition, participants reported a significantly higher level of social presence toward international issues than global
warming \( [p = .026, F (1, 58) = 5.20] \). In the HMD condition, participants reported a higher level of social presence toward international issues than global warming \( [p = .40, F (1, 58) = 0.72] \).

**Immersion.** H3-c was tested with a one-way repeated measures ANOVA and it is supported. Participants in the HMD condition reported a significantly higher level of immersion than those in the flat-screen condition \( \text{Wilks’ Lambda} = 0.16, \ p \leq .001, \ F (1, 59) = 303.15, \ \eta^2_p = .84 \).

Further, to control the effects of content-type, effects of content-type were tested with a one-way repeated measures ANOVA, and no significant effect was observed \( \text{Wilks’ Lambda} = 0.96, \ p = .099, \ F (1, 59) = 2.81, \ \eta^2_p = .05 \).

**Social realism.** H3-d was tested with a one-way repeated measures ANOVA and it is supported. Participants in the HMD condition reported a significantly higher level of social realism than those in the flat-screen condition \( \text{Wilks’ Lambda} = 0.87 \ p = .004, \ F (1, 59) = 8.74, \ \eta^2_p = .13 \).

Further, to control the effects of content-type, effects of content-type were tested with a one-way repeated measures ANOVA, and a significant main effect was also observed \( \text{Wilks’ Lambda} = 0.87, \ p = .005, \ F (1, 59) = 8.45, \ \eta^2_p = .13 \).

Based on a post-hoc analysis in the flat-screen condition, participants reported a higher level of social realism toward international issues than global warming \( [p = .117, F (1, 58) = 2.53] \). In the HMD condition, participants reported a significantly higher level of social realism toward international issues than global warming \( [p = .007, F (1, 58) = 7.69] \).
Table 10.
Repeated Measures ANOVA Results for H3

<table>
<thead>
<tr>
<th></th>
<th>Display-type</th>
<th>Content-type of content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$ (df1, df2)</td>
<td>$\eta^2$</td>
</tr>
<tr>
<td>Spatial presence</td>
<td>176.12 (1, 59)</td>
<td>.75***</td>
</tr>
<tr>
<td>Social presence</td>
<td>92.61 (1, 59)</td>
<td>.62***</td>
</tr>
<tr>
<td>Immersion</td>
<td>303.15 (1, 59)</td>
<td>.84***</td>
</tr>
<tr>
<td>Social realism</td>
<td>8.74 (1, 59)</td>
<td>.13**</td>
</tr>
</tbody>
</table>

Note: *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$
Research Question 1: Indirect effects of Presence on MTL in SCT

RQ1 asked how the dimensions of presence mediate the effects of display-type on the motivation to learn. To explore this research question, SEM was applied with the AMOS statistical software package. The HMD VR condition was entered as a dummy variable, which makes the flat-screen condition a control group in the analysis. Content-type and self-efficacy, that measured with College Self-Efficacy Inventory (CSEI), were added as control variables. Content about international issues was entered as a dummy variable, which makes content about global warming as a control group. To test indirect effects, nonparametric bootstrapping of 5,000 samplings and 95% significance criterion level for Lower Level Confidence Interval (LLCI) and Upper-Level Confidence Interval (ULCI) were calculated. LLCI and ULCI estimate the lower and upper limits of the confidence interval. Table 11 summarizes the indirect effects of HMD on MTL from the SEM analysis.

Table 11.
Indirect Effects of HMD on MTL

<table>
<thead>
<tr>
<th>Indirect effects of HMD VR via</th>
<th>Indirect effect</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial presence VR via</td>
<td>.20 (.08)**</td>
<td>0.06</td>
</tr>
<tr>
<td>Social presence</td>
<td>.18 (.08)**</td>
<td>0.06</td>
</tr>
<tr>
<td>Immersion</td>
<td>.21 (.08)**</td>
<td>0.07</td>
</tr>
<tr>
<td>Social realism</td>
<td>.05 (.08)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: *p ≤ .05, **p ≤ .01, ***p ≤ .001
**Spatial presence.** In the SEM analysis result, HMD VR significantly increased the level of spatial presence ($B = .57, p \leq .001$) and spatial presence significantly increased MTL ($B = .36, p \leq .001$), as shown in Figure 20 with solid lines. Although the direct effects of HMD decreased MTL ($B = -.06, p = .57$), indirect effects of HMD significantly increased MTL ($B = .20, S.E. = .22, p = .006, LLCI = 0.15, & ULCI = 1.02$), as shown in Figure 20 with a dash line. This result implies that spatial presence is a suppressor variable that increases the predictive validity of the model (Tzelgov & Henik, 1991), which means adding spatial presence is important to estimate the effects of HMD VR on MTL.

**Figure 20.**
*Indirect Effects of HMD VR via spatial presence*

![Diagram showing the indirect effects of HMD VR via spatial presence]

**Table 12.**
*Results of the Mediation Analysis of Spatial Presence on MTL*

<table>
<thead>
<tr>
<th></th>
<th>Direct effect</th>
<th>Indirect effect</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$B$ (S.E.)</td>
<td>$B$ (S.E.)</td>
<td>LLCI</td>
</tr>
<tr>
<td>HMD VR</td>
<td>-.06 (.26)</td>
<td>.20 (.08)**</td>
<td>0.06</td>
</tr>
<tr>
<td>Spatial presence</td>
<td>.36 (.08)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content-type</td>
<td>-.05 (.23)</td>
<td>.00 (.03)*</td>
<td>0.00</td>
</tr>
<tr>
<td>CSEI</td>
<td>.11 (.16)</td>
<td>.06 (.04)*</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$*
**Social presence.** In the SEM analysis results, HMD VR significantly increased the level of social presence ($B = .49, p \leq .001$) and social presence significantly increased MTL ($B = .37, p \leq .001$), as shown in Figure 21 with solid lines. Although the direct effects of HMD VR decreased MTL ($B = -.04, p = .72$), the indirect effects of HMD VR significantly increased MTL ($B = .18, S.E. = .06, p = .002$, LLCI = 0.07, & ULCI = 0.37), as shown in Figure 21 with a dash line. This result implies social presence is a suppressor variable that increases the predictive validity of the model (Tzelgov & Henik, 1991), which means adding social presence is important to estimate the effects of HMD VR on MTL.

**Figure 21.**
*Indirect Effects of HMD VR via social presence*

Table 13.
*Results of the Mediation Analysis of Social Presence on MTL*

|                      | Direct effect $B$ (S.E.) | Indirect effect $B$ (S.E.) | 95% CI |  |
|----------------------|--------------------------|-----------------------------|--------|
|                      |                          |                             | LLCI   | ULCI |
| HMD VR               | $.04 (.26)***            | $.18 (.08)**                | 0.06   | 0.37 |
| Social presence      | $.37 (.07)***            |                             |        |      |
| Control              |                          |                             |        |      |
| Content-type         | -.06 (.23)               | .06 (.03)*                  | 0.01   | 0.15 |
| CSEI                 | .12 (.16)                | .06 (.04)*                  | 0.01   | 0.14 |

Note: *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$*
**Immersion.** In the SEM analysis results, HMD VR significantly increased the level of immersion ($B = .53, p \leq .001$) and immersion significantly increased MTL ($B = .40, p \leq .001$), as shown in Figure 22 with solid lines. Although the direct effects of HMD VR decreased MTL ($B = -.07, p = .52$), the indirect effects of HMD VR significantly increased MTL ($B = .18, S.E. = .06, p = .002, LLCI = 0.07, & ULCI = 0.36$), as shown in Figure 22 with a dash line. This result implies immersion is a suppressor variable that increases predictive validity of the model (Tzelgov & Henik, 1991), which means adding immersion is important to estimate the effects of HMD VR on MTL.

**Figure 22.**
Indirect Effects of HMD VR via immersion

![Diagram of indirect effects](image)

**Table 14.**
*Results of the Mediation Analysis of Immersion on MTL*

<table>
<thead>
<tr>
<th></th>
<th>Direct effect</th>
<th>Indirect effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$B$ (S.E.)</td>
<td>$B$ (S.E.)</td>
</tr>
<tr>
<td>HMD VR</td>
<td>-.07 (.27)***</td>
<td>.21 (.08)**</td>
</tr>
<tr>
<td>Immersion</td>
<td>.40 (.09)***</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content-type</td>
<td>-.06 (.23)</td>
<td>.06 (.04)*</td>
</tr>
<tr>
<td>CSEI</td>
<td>.07 (.16)</td>
<td>.10 (.04)**</td>
</tr>
</tbody>
</table>

Note: *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$*
**Social realism.** In the SEM analysis results, HMD VR significantly increased the level of social realism \( (B = .22, p = .013) \) and social realism significantly increased MTL \( (B = .23, p = .014) \), as shown in Figure 23 with solid lines. Although direct effects of HMD VR increased MTL \( (B = .10, p = .28) \), the indirect effects of HMD VR on MTL were not significant \( (B = .05, S.E. = .04, p = .064, LLCI = 0.07, & ULCI = 0.31) \), as shown in Figure 23 with a dash line. This result implies social realism does not mediate the relationship between HMD VR and MTL.

**Figure 23.**
*Indirect Effects of HMD VR via Social Realism*

![Diagram of indirect effects](image)

**Table 15.**
*Results of the Mediation Analysis of Social Realism on MTL*

<table>
<thead>
<tr>
<th></th>
<th>Direct effect</th>
<th>Indirect effect</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( B ) ( (S.E.) )</td>
<td>( B ) ( (S.E.) )</td>
<td>LLCI</td>
</tr>
<tr>
<td>HMD VR</td>
<td>.10 (.24)</td>
<td>.05 (.08)</td>
<td>0.00</td>
</tr>
<tr>
<td>Social realism</td>
<td>.23 (.13)*</td>
<td>.05 (.08)</td>
<td>0.00</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content-type</td>
<td>-.05 (.24)</td>
<td>.05 (.04)</td>
<td>0.00</td>
</tr>
<tr>
<td>CSEI</td>
<td>.15 (.16)</td>
<td>.02 (.04)</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

Note: \(*p \leq .05, **p \leq .01, ***p \leq .001\)
**Research Question 2: Dimensions of Presence and MTL**

RQ2 asked how Motivation To Learn (MTL) and dimensions of presence interact. To explore this research question, multi-group SEM between the flat-screen and HMD conditions was applied with the AMOS statistical software package. Content-type and CSEI are added as control variables. Content about international issues was entered as a dummy variable, which makes content about global warming a control group in the analysis.

As shown in figure 24, in the flat-screen condition, only immersion significantly increased MTL \((B = .35, S.E. = .11, p = .008)\). In the HMD condition, spatial presence \((B = .24, S.E. = .11, p = .049)\) and social presence \((B = .25, S.E. = .09, p = .031)\) significantly increased MTL.

**Figure 24.**
Dimensions of Presence and MTL between Flat-Screen and HMD VR
Pair-wise parameter comparisons method evaluated the differences in beta coefficients between the two conditions. According to the results, as shown in Table 16, only the effects of spatial presence on MTL between the flat-screen and HMD conditions were significantly different \((C.R. = 2.43)\). The effects of social presence \((C.R. = 0.75)\), immersion \((C.R. = -1.13)\), and social realism \((C.R. = -0.88)\) on MTL between the flat-screen and HMD conditions were not significantly different.

**Table 16.**
*Multi-group Comparison between Flat-screen and HMD VR for MTL*

<table>
<thead>
<tr>
<th></th>
<th>Flat-screen</th>
<th>HMD</th>
<th>C.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Presence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial presence</td>
<td>-.18 (.11)</td>
<td>.24 (.11)*</td>
<td>2.43*</td>
</tr>
<tr>
<td>Social presence</td>
<td>.09 (.11)</td>
<td>.25 (.09)*</td>
<td>0.75</td>
</tr>
<tr>
<td>Immersion</td>
<td>.35 (.11)**</td>
<td>.08 (.14)</td>
<td>-1.13</td>
</tr>
<tr>
<td>Social realism</td>
<td>.13 (.14)</td>
<td>-.06 (.25)</td>
<td>-0.88</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content-type</td>
<td>.00 (.39)</td>
<td>-.14 (.29)</td>
<td></td>
</tr>
<tr>
<td>CSEI</td>
<td>.01 (.26)</td>
<td>.18 (.21)</td>
<td></td>
</tr>
</tbody>
</table>

Note: *\(p \leq .05\), **\(p \leq .01\), ***\(p \leq .001\)
Hypothesis 4: Effects of HMD VR on Visual Discomfort

H4 predicted that the HMD VR experience would result in more visual discomfort than the flat-screen. H4 was tested with a one-way repeated measures ANOVA. As noted in the descriptive statistics section, the transformation of the visual discomfort variable via eq (1) and (2) did not resolve the violation of normality because of significant flooring distortion.

Although the one-way repeated measures ANOVA result indicated participants in the HMD condition reported significantly more visual discomfort than those in the flat-screen condition [Wilks’ Lambda = 0.89, p = .010, F (1, 59) = 7.25, \( \eta^2_p = .11 \)], it is difficult to conclude that H4 was supported because of the violation of normality. Therefore, non-parametric ANOVA tests were conducted to confirm the hypothesis. Friedman test (\( \chi^2 (1) = 16.2 \) and \( p \leq .001 \)) and Wilcoxon signed-rank test (\( Z = -3.3 \) and \( p \leq .001 \)) both supported H4.
**Research Question 3: Effects of Visual Discomfort on MTL in SCT**

RQ3 asked how the dimensions of presence and visual discomfort interact with each other in their effects on Motivation To Learn (MTL). To explore this research question, mediation analysis was applied in SEM with the AMOS statistical software package. The HMD condition was entered as a dummy variable, which makes the flat-screen condition a control group. Content-type and CSEI were added as control variables. Content about international issues was entered as a dummy variable makes content about global warming a control group. To test the indirect effects of exogenous variables, nonparametric bootstrapping of 5,000 samplings and 95% significance level were applied. Table 17 summarizes the results of the mediation analysis of presence on MTL in SEM.

**Table 17.**
Results of the Mediation Analysis of Presence on MTL

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spatial presence</td>
<td>Social presence</td>
<td>Immersion</td>
<td>Social realism</td>
</tr>
<tr>
<td><strong>B (S.E.)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HMD VR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>.04 (.29)</td>
<td>.02 (.26)</td>
<td>.04 (.27)</td>
<td>.12 (.24)</td>
</tr>
<tr>
<td>Indirect</td>
<td>.18 (.08)*</td>
<td>.16 (.06)**</td>
<td>.19 (.08)*</td>
<td>.03 (.05)</td>
</tr>
<tr>
<td>Presence</td>
<td>.37 (.08)***</td>
<td>.40 (.07)***</td>
<td>.40 (.09)***</td>
<td>.21 (.13)*</td>
</tr>
<tr>
<td>Visual discomfort</td>
<td>-.16 (.12)</td>
<td>-.19 (.12)*</td>
<td>-.15 (.12)</td>
<td>-.10 (.13)</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content-type</td>
<td>-.03 (.23)</td>
<td>-.04 (.22)</td>
<td>-.04 (.23)</td>
<td>-.03 (.24)</td>
</tr>
<tr>
<td>CSEI</td>
<td>.09 (.16)</td>
<td>.09 (.16)</td>
<td>.05 (.16)</td>
<td>.14 (.16)</td>
</tr>
</tbody>
</table>

Note: *p ≤ .05, **p ≤ .01, ***p ≤ .001
Spatial presence. As shown in Table 17 and Figure 25, in the SEM analysis model 1 with spatial presence, HMD VR significantly increased the level of spatial presence ($B = .57, p \leq .001$), and spatial presence significantly increased MTL ($B = .37, p \leq .001$). Also, HMD VR increased the level of visual discomfort ($B = .13, p = .24$), and the visual discomfort increased spatial presence ($B = .06, p = .40$) and decreased MTL ($B = -.16, p = .06$). Although the direct effects of HMD VR decreased MTL ($B = -.04, p = .57$), the indirect effects of HMD VR significantly increased MTL ($B = .18, S.E. = .08, p = .018, LLCI = -0.03, & ULCI = 0.31$). No significant interaction effect with visual discomfort was observed.

Figure 25.
Indirect Effects of HMD VR via Spatial Presence: Model 1
Social presence. As shown in Table 17 and Figure 26, in the SEM analysis model 2 with social presence, HMD VR significantly increased the level of social presence ($B = .47, p \leq .001$), and social presence significantly increased MTL ($B = .40, p \leq .001$). Also, HMD VR increased the level of visual discomfort ($B = .17, p = .058$), and the visual discomfort increased social presence ($B = .13, p = .104$) and significantly decreased MTL ($B = -.19, p = .026$). Although the direct effects of HMD VR decreased MTL ($B = -.02, p = .85$), the indirect effects of HMD VR significantly increased MTL ($B = .16, S.E. = .06, p = .007$, LLCI = 0.47, & ULCI = 0.30). No significant interaction effect with visual discomfort was observed.

Figure 26.
Indirect Effects of HMD VR via Social Presence: Model 2
**Immersion.** As shown in Table 17 and Figure 27, in the SEM analysis model 3 with immersion, HMD VR significantly increased the level of immersion ($B = .53, p \leq .001$), and immersion significantly increased MTL ($B = .40, p \leq .001$). Also, HMD VR increased the level of visual discomfort ($B = .17, p = .058$) and the visual discomfort increased immersion ($B = .01, p = .876$) and decreased MTL ($B = -.15, p = .089$). Although the direct effects of HMD VR decreased MTL ($B = -.04, p = .68$), the indirect effects of HMD VR significantly increased MTL ($B = .19, S.E. = .08, p = .018, LLCI = 0.03, & ULCI = 0.34$). No significant interaction effect with visual discomfort was observed.

**Figure 27.**
*Indirect Effects of HMD VR via Immersion: Model 3*
Social realism. As shown in Table 17 and Figure 28, in the SEM analysis model 4 with social realism, HMD VR significantly increased the level of social realism ($B = .25$, $p = .004$) and social realism significantly increased MTL ($B = .21$, $p = .028$). Also, HMD VR increased the level of visual discomfort ($B = .17$, $p = .058$) and the visual discomfort significantly decreased social realism ($B = -.21$, $p = .016$) and decreased MTL ($B = -.15$, $p = .089$). Direct effects of HMD VR increased MTL ($B = .12$, $p = .20$) and indirect effects of HMD VR increased MTL ($B = .03$, $S.E. = .05$, $p = .473$, LLCI = -0.05, & ULCI = 0.13). No significant interaction effect with visual discomfort was observed.

Figure 28.
Indirect Effects of HMD VR via Social Realism: Model 4
Summary of Results for Hypothesis Tests and Research Questions

Effects of HMD VR on MTL

H1 examined the direct effects of HMD VR on MTL. As H1 predicted, viewing VR with an HMD resulted in more motivation to learn than in the flat-screen condition. The one-way repeated measures ANOVA result supported H1 without interaction effects from the different content-types.

H2.1, H2.2, and H2.3 also examined the direct effects of HMD VR on MTL by applying the main variables from the RISP model. H2.1 predicted that VR experiences in the HMD would result in a) more perceived current knowledge, b) increased perceived sufficiency threshold, c) more intense affective response, and d) stronger informational subjective norms than flat-screen condition. Only H2.1-c and H2.1-d were supported. As predicted, HMD VR experiences resulted in a significantly higher level of affective response and informational subjective norms compared to the levels in the baseline of pre-test and the levels in the flat-screen condition’s post-test. H2.1-a and b were supported only for their interaction between the content-types and pre-post tests, which is in the same global warming content-type. But the differences in post-tests were not significant when they were compared to the effects of the flat-screen condition.

Specifically, the one-way repeated measures ANOVA did not support H2.1-a, but there were two significant interaction effects between content-types and trials among three post-hoc analysis results. First, the flat-screen experience increased the level of reported current knowledge about global warming, but it significantly decreased the level of reported current knowledge about international issues from the levels of baseline in
pre-tests. Second, the HMD experience significantly increased the level of reported current knowledge about global warming, but it significantly decreased the level of reported current knowledge about international issues from the levels of baseline in pre-tests. Third, the flat-screen experience and HMD experience did not have a different effect on the level of reported current knowledge.

Although a non-parametric one-way repeated measures ANOVA test result indicated a significant difference, a post-hoc analysis did not support H2.1-b. Instead, there were significant main and interaction effects in the three post-hoc analysis results. First, the flat-screen experience significantly increased the level of reported sufficiency threshold from the levels of baseline in pre-tests for both content-types and there was no difference between global warming and international issues. Second, although the HMD experience did not increase the level of reported sufficiency threshold from the levels of baseline in pre-tests, the HMD experience significantly increased the level of reported sufficiency threshold about global warming and it increased the level of reported sufficiency threshold about international issues. Third, the flat-screen experience and HMD experience did not have a different effect on the level of reported sufficiency threshold.

The non-parametric one-way repeated measures ANOVA test and post-hoc analysis results supported H2.1-c. As predicted, HMD VR experiences resulted in significantly more affective response and there were two significant interaction effects with content-type among three post-hoc analysis results. First, the flat-screen experience did not make a significant difference in the level of reported affective response from the
levels of baseline in pre-tests and there was no difference between global warming and international issues. Second, the HMD experience significantly increases the level of reported affective response from the levels of baseline in pre-tests. Specifically, while the HMD experience slightly increased the level of reported affective response about global warming, it significantly increased the level of reported affective response about international issues. Third, although the HMD experience did not significantly increase the level of reported affective response compared to the level of flat-screen experience, while the HMD experience slightly increased the level of reported affective response about global warming, it significantly increased the level of reported affective response about international issues.

The non-parametric one-way repeated measures ANOVA test and post-hoc analysis results supported H2.1-d. As predicted, HMD VR experiences resulted in significantly more informational subjective norms and there were two significant interaction effects between content-types and trials among three post-hoc analysis results. First, the flat-screen experience did not make a significant difference in the level of reported informational subjective norms from the levels of baseline in pre-tests and there was no difference between global warming and international issues. Second, although the HMD experience did not significantly increase the level of informational subjective norms from the levels of baseline in pre-tests, the HMD experience significantly increased the level of reported informational subjective norms about global warming, while it slightly increased the level of reported informational subjective norms about international issues. Third, the HMD experience significantly increased the level of
reported informational subjective norms compared to the level of flat-screen experience without the interaction effects from the different content-types of two contents.

The SEM analysis did not support hypothesis H2.2 or H2.3. Information insufficiency did not significantly increase MTL as H2.2 predicted and the effect of information insufficiency in the HMD VR experience was not bigger than that in the flat-screen as H2.3 predicted. Instead, there were significant main effects of affective response and informational subjective norms on MTL in both the HMD VR and flat-screen experiences.

**Effects of HMD VR on Presence and MTL**

H3 examined the direct effects of HMD VR on presence. The set of one-way repeated measures ANOVA tests supported all of the relationships as H3 predicted. HMD VR resulted in more a) spatial presence, b) social presence, c) immersion, and d) social realism than using a flat-screen. Further, social presence and social realism showed the interaction effects with the content-type. First, in the flat-screen condition, participants reported a significantly higher level of social presence toward international issues than global warming, but in the HMD condition, participants reported a slightly higher level of social presence toward international issues than global warming. Second, in the flat-screen condition, participants reported a slightly higher level of social realism toward international issues than global warming, but in the HMD condition, participants reported a significantly higher level of social realism toward international issues than global warming.
RQ 1 examined how the different dimensions of presence mediate the effects of display-type on the motivation to learn. The set of mediation analyses in SEM, controlled for self-efficacy to apply the SCT framework, revealed that spatial presence, social presence, immersion, and social realism all significantly increased MTL. But only spatial presence, social presence, and immersion are suppressor variables that significantly increase the predictive validity of the model to estimate the effects of HMD VR experience on MTL.

RQ2 examined how MTL interacts with the dimensions of presence and the multi-group SEM analysis, controlled for self-efficacy to apply the SCT framework, revealed that only immersion significantly increased MTL in the flat-screen condition, while in the HMD condition, spatial presence and social presence significantly increased MTL. Among these differences, the effects of spatial presence on MTL was significantly different between the flat-screen and HMD conditions.

**Effects of HMD VR on Visual Discomfort, Presence, and MTL**

H4 examined the direct effects of HMD VR on visual discomfort. As H4 predicted, the use of HMD resulted in more visual discomfort than the use of flat-screen. Both parametric and non-parametric one-way repeated measures ANOVA results supported H4.

RQ3 examined how the dimensions of presence and visual discomfort are interacting with each other. The set of mediation analyses in SEM, controlled for self-efficacy to apply the SCT framework, revealed that HMD VR increased the level of visual discomfort, and the visual discomfort significantly decreased MTL only in the
social presence model, but visual discomfort did not show significant effects on MTL with spatial presence, immersion, and social realism models.

**Chapter summary**

This chapter presented quantitative analysis and results to test the hypotheses and research questions in the previous chapter. The results supported HMD VR increased MTL and integrating presence in the SCT and RISP frameworks is useful to understand the effects of HMD VR’s immersive experiences. Next, Chapter 7 will present the results of qualitative data analysis.
CHAPTER 7

QUALITATIVE DATA ANALYSIS AND RESULTS

In addition to Chapter 6 that presented quantitative analysis results, this chapter presents the data analysis of the qualitative audio-recorded in-depth interviews. The first section of this chapter describes the “semi-structured in-depth interview” that this study employed for its analysis method including data processing and interview participants. The second section of this chapter explores the effects of using HMD VR on students’ Motivation To Learn (MTL); the third section explores presence and transformative learning. Chapter 8 will provide discussion and explore implications based on the results from Chapters 6 and 7.

Qualitative Analysis Procedure

To analyze in-depth interview data, all the audio-recorded interviews were transcribed and cleaned by the researcher (McIntosh & Morse, 2015). First, following a guide from Campbell et al. (2013), information that can lead to participants’ identity was removed from the transcript, resulting in 34,279 words in a document. To summarize and describe patterns in the data for a text-analysis that acknowledges the judgment of researchers (Popping, 2015), the researcher read through answers to the “semi-structured in-depth interview” (Campbell et al., 2013; Carter & Henderson, 2005, p. 218; McIntosh & Morse, 2015), and tried to identify important phrases, words, contexts, and patterns to answer research questions 4, 5, and 6. This process was first guided by the constructs from the quantitative analysis and further explored more complex concepts that were
difficult to examine by the quantitative analysis. QDA Miner software, as shown in figure 29, was used to add notes to the transcription for notable responses and relationships.

By completing the analysis, the researcher cited representative phrases from the transcripts. These quotes were edited to increase readability for readers of this study. The researcher carefully edited these quotes to minimize the differences of meaning in the cited quotes from the original transcriptions. To edit these quotes, the researcher eliminated un-necessary filler words and repetitions; corrected grammatical errors including tense, article, punctuation, and spelling; added contextual information of pronouns and identification of experimental conditions.

Figure 29.
An Example of the Analysis Process
All of the interviews used English. The total selected 28 participants’ average age was 28 years old (Min. =18, Max. =28, $SD=2.50$); 17 participants identified themselves as female (60.7%); 11 participants identified themselves as male (39.3%); 6 participants wore glasses (21.5%). Participants who wore glasses watched HMD video by fitting their glasses to HMD. The researcher did not find a notable behavior for using HMD with glasses and these participants did not mention the effects of wearing glasses. The researcher expected Table 18 lists the arbitrary numbers assigned to participants and their experimental conditions and ordering groups.
### Table 18.

*Descriptive Information of Interviewees*

<table>
<thead>
<tr>
<th>Participant number</th>
<th>Wearing glasses</th>
<th>Order</th>
<th>VR content</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>Yes</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
<td>104</td>
<td>No</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
<td>106</td>
<td>No</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
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<td>Yes</td>
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<td>International issues</td>
</tr>
<tr>
<td>110</td>
<td>Yes</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
<td>112</td>
<td>No</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
<td>114</td>
<td>Yes</td>
<td>Flat-screen × HMD</td>
<td>International issues</td>
</tr>
<tr>
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<td>No</td>
<td>HMD × Flat-screen</td>
<td>Global warming</td>
</tr>
<tr>
<td>204</td>
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<td>HMD × Flat-screen</td>
<td>Global warming</td>
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<tr>
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</tr>
<tr>
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<td>No</td>
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<td>International issues</td>
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<tr>
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</tr>
<tr>
<td>414</td>
<td>No</td>
<td>HMD × Flat-screen</td>
<td>International issues</td>
</tr>
</tbody>
</table>
**HMD vs Flat-screen for MTL**

To explore the effective use of HMD VR content in educational contexts, research question 4a asked: “How does immersive HMD VR promote people to know more about global warming actively?” The research question 4b also asked: “How does immersive HMD VR promote people to know more about international issues actively?” These questions were examined by reviewing the reflections of participants’ transformative experiences as Boyer et al. (2006) and Provident et al. (2015) observed in their studies, to see if HMD VR technology can help to create transformative learning experiences. Most of the participants felt it was difficult to decide on only one topic to learn more about because they believed that both global warming and international issues in Syria are important.

In general, 26 participants indicated that they thought HMD VR was more effective for having more immersive experience and achieving educational outcomes than the flat-screen except 2 participants who pointed out the flat-screen was more effective. First, most of the participants explained they thought the HMD VR experience was better because it was more realistic, engaging, emotional, focused, impactful, personal, connected, enjoyable, and involving, for example:

I think you would definitely with the headset [HMD], probably more engaging umm……I still thought it was interesting and learned a lot from this dragging down the screen [flat-screen], but yeah, I think the headset was definitely better. [It] is a big boost of just an engagement. (participant N. 214)

Cuz you're more immersed and [know] what’s going on. And I feel like if you feel like you're actually there, then you’ll care more about it. (participant N. 302)
I think that, you know, I really enjoyed being around that type of technology [HMD] to learn that type of stuff. (participant N. 402)

Participants reported that they felt more of these impressions and emotions because of the fully surrounded field of view and head tracking interface of the HMD condition, for example:

I preferred the VR headset [HMD] because it seemed like I could……. I had a more immersed experience. Look around and see everything in the [HMD], whereas the 1st VR thing [flat-screen] I was like clicking through, it [was] just cool, but I do not like it. (participant N. 402)

I have to say the VR experience [HMD] was definitely immersing. I like the sounds around you [that I] can hear……it was almost like you were there. The computer one [flat-screen] was a little bit less but it was still interactive to an extent with the mouse. (participant N. 104)

In the end, as educational benefits, they find having more immersive experiences in the HMD VR made them be motivated and focused to learn more about what they experienced, especially when they are visual learners (Ambrose et al., 2010), for example:

I like the second one [HMD], you’ve kind of feel more there, but the first one [flat screen] is more lectury [lecture like] than the second one. I just thought its really good idea to use it [HMD] as a source of technology especially when it comes to like real-life issues and moments where you’re talking about something on another part of the world and it is really cool like putting students in that position. It would definitely help them learn at least a little bit more what it’s like and make it seem real. (participant N. 210)

It was easier to forget about where I was right now watching it in the VR headset [HMD]. If I was just on the [flat-screen] it's kind of easy to be distracted by like my life things so like my phone or anything else around me. (participant N. 108)
Me personally, I see as the value in it [HMD] like how much more of an impact you can make, especially for like visual and audio learners and stuff like that. It has things very tangible. (participant N. 310)

In terms of the usability of HMD VR, participants tend to prefer the interface that they are accustomed to. First, most of the participants reported that the HMD VR was more comfortable, easier to use, and more natural similar to what participant N. 106 reported: “I think like just like it’s easier to turn around and [it is natural to turn] compared to a mouse” In another example:

Flat-screen felt like, it wasn’t tense. It felt more like dizzier than the VR headset [as I felt. Because, most of the time, I have to keep following it with my hands and kind of being pushed away. VR headset [HMD] definitely made me felt funny at first, but I got very used to it, pretty quick. (participant N. 104)

Next, the only 2 participants who explained that they thought the flat-screen experience was better said it was because it “dealt with people and it was a lot clearer to see so……the picture quality would be a little fuzzy [with HMD VR] (participant N. 110) and with the flat-screen, it was “kind of easier to digest for me it’s actually take away something (Participant N. 102).” These are valid self-reflections considering the technological limitations of HMD VR and usability. The image clarity on HMD VR was lower because of the close distance between the display and the user’s eyes.

On the other hand, it is difficult to not conclude that these participants’ response, reflected their personal preference toward the topic when they evaluated the technological differences. This is because both participants watched “The Displaced” (Solomon & Ismail, 2017) in the flat-screen condition and showed a strong personal preference toward the international issues in Syria over global warming.
While these two participants can be treated as exceptional cases, it is important to note that some students might have different expectations. It suggests that offering a diverse mode of access to educational content could help to meet these students’ expectations. It also suggests that the effects of their personal preference in the content that they watched may have affected the effects of technological differences on the level of presence.

**Research Question 4a: MTL and Global Warming**

In addition to the general benefits of using HMD VR on participants MTL, RQ4a focuses on the global warming context. Sixteen participants said that they would personally prefer to learn more about global warming than international issues. Most of them pointed out the importance of global warming because of the universal nature of the topic that also directly changes their daily lives. For example: “If we don't have work a living then it's no point in a saving anybody else (participant N. 204) and “I just like traveling kinds of stuff……. I want my future generations to see everything the way I was able to see. (participant N. 404)

They said the reasons why they think learning about global warming is important came from their prior experiences including with friends and family, travel, high school and university classes, social media interactions, and current news coverage. Those who watched the video about global warming with the HMD VR reported that they became more engaged and interested in global warming than international issues, for example: “I think the second [HMD] experience was definitely more like engaging and it made me like want to learn more about what it talked about [global warming]. (participant N. 412)
Especially for the global warming topic, many participants already had a view about the importance of the issue and some basic understanding of it. Some of them said that they already actively seek more information and take action to prevent global warming. In addition to increasing and reaffirming the importance of global warming to these highly motivated participants, having more immersive experience in the HMD VR activated some of the participants who had knowledge about the topic but who were not as motivated to take further actions or study. They even felt increased motivation to learn, similar to participant N. 406 with the realization that they also want to do something after having VR experiences with HMD:

Yes, I feel like because I feel like when you are put in that situation [one of the scenes in the global warming content] or like here [HMD] is the specific story about that situation you are like. I wanna know more about that and I forgot about that the acidification when you were like [in the HMD VR content]. I was like I am interested in this topic, so I wanna do know more. (participant N. 406)

**Research Question 4b: MTL about International Issues**

Regarding RQ4b, 10 participants said that they would personally choose to learn more about international issues than global warming. Most of them pointed out reasons having to do with equality, immediacy, and emotion such as “you got to kind of get like a whole world together we are in the same page before global warming can be dealt with (participant N. 104), “Because people are dying and people are getting hurt, being affected now (participant N. 114), “I think that was more emotional than the climate change (participant N. 408), and “this is going to be a bigger impact now like it is happening every day. (participant N. 210)
Compared to the global warming topic, participants reported more emotional responses to the topic of international issues. They explained how they felt when they saw children suffer in the war-torn environment in the video. They tended to specifically point out scenes and locations where they felt emotionally moved during their experiences, for example:

[In the content about international issues] like there was like war-torn environment with bullets everywhere like a child having to go through, the swamp [scene], and like food drop [scene]. I mean, what affects our planet is eventually going to affect all of us alike some part of me like but they are like people issues. (participant N. 110)

It seems like they were about to have a more emotional connection than just knowing what these children feel, for example:

I think it helps, get that connected feeling, like I think the shots where the kids were standing right in front of you and [they are] young……because it [the content about international issues] did give that the depth like you could reach out to them, that is this life like that you are kind of want to live? (participant N. 306)

Similar to the global warming topic, these participants reported the increased and strengthened MTL among those who already cared about the international issues in Syria, for example:

Kinda already knew about it umm.. but it definitely strengthens my understanding and my motivation to help in South-Eastern problems. (participant N. 312)
Further, participants who used HMD VR for this topic reported the increased MTL as well, because the intense experiences that they had in the HMD VR helped them to have a new point of view and/or even wished to have more information, for example:

They showed like three little kids to try to get people to just feel sorry for these kids and like......I’d want to see like why. Like why it’s happening. What would start these problems, why are they fighting, and not just looking at these three kids and seeing they were separated from their family. (participant N. 404)

Probably [HMD] increased my interests toward Syrian stuff when you actually see like all the destruction and like the children’s faces. Stuff like that definitely did. (participant N. 410)

**Presence and Transformative Learning**

To explore the role of presence in transformative learning, research question 5a, 5b, and 6 were added to questions 4a and 4b that showed how immersive experiences enhanced MTL and transformative learning based on the reconstruction of schematics (Dewey, 1938; Mezirow, 1997), that explained in Chapter 4. To investigate the reconstruction of schematics, in other words, the transforming of point of view (Mezirow, 1997, p. 7), as psychological processes behind transformative learning, research question 5a asked: “What is the role of presence within the psychological processes that help people to know more about global warming actively?” Research question 5b asked: “What is the role of presence within the psychological processes that help people to know more about international issues actively?” Research question 6 asked: “How do people describe their “motivation to learn” and “transformative learning” experiences?”

Although RQ 1 and 2 already revealed some patterns with statistical methods, the results were not able to link presence and MTL with transformative learning. RQ 5a and
b. first explored how spatial presence, social presence, and immersion increased MTL and how they are related to transformative learning. Then RQ6 evaluates this relationship between MTL and transformative learning.

**Presence in the HMD VR**

All of the eleven of the participants (participant N. 108, 114, 202, 206, 210, 212, 214, 304, 306, 308, and 408) reported that it was the HMD VR that made them feel less about their surroundings and pointed out that using a mouse was very noticeable in the flat-screen condition (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000). Spatial and social presence were the most frequently and distinctively identified dimensions of presence. Immersion and social realism were more subtle and indirectly identified dimensions of presence. Many of the reports of these participants encode the multiple dimensions of presence in a sentence or expression. This section provides some of the most representative and unique examples of these expressions.

Even if they reported that HMD VR helped them to have an increased level of presence, most of these participants had difficulty identifying specific technical differences between the two display-types. But the increased field of view (8 participants) and natural head tracking (9 participants) in the HMD VR were the most noticeable differences that participants pointed out. Most of the responses were from these questions: “You have used both a flat-screen TV and a VR headset. Could you explain the differences?” and “If you have felt being in a different place or being with a person in the experience, what technology gave you more of the feeling? Could you explain why?”
**Spatial presence.** Eighteen participants (participant N. 104, 108, 110, 112, 114, 202, 206, 208, 210, 214, 302, 304, 310, 312, 314, 402, 406, and 410) described *spatial presence* similar to participant N. 104: “It was almost like you were there. The computer one was a little bit less, but it was still interactive to an extent with the mouse.” Ten of the participants (participant N. 104, 110, 112, 202, 208, 302, 304, 310, 312, and 314) exactly described the famous phrase “*being (am, was, are, were) there*” (International Society for Presence Research, 2000; Lombard et al., 1997; Minsky, 1980) and they said HMD VR was much better for that sense.

**Social presence.** Seventeen of the participants (participant N. 102, 106, 108, 110, 202, 204, 210, 214, 304, 306, 308, 310, 312, 408, 410, 412, and 414) described *social presence* and they said it was stronger when they watched content in the HMD condition. They described social presence similar to what participant N. 414 described: “You feel much stronger social connections in VR than when looking at normal [flat screen].” This participant felt that the participant could make social interactions with the characters on the screen even when what the participant could only observe the scene in the HMD content, as an example of “parasocial interaction” (Lombard & Ditton, 1997; Rubin et al., 1985). This is a tendency of making social interactions with computer-generated messages and participants reported it stronger with HMD, as shown in another example of participant N. 204: “Like I can ask questions and I can reach out and touch somebody. I felt like right next to you. I felt more real like that with the VR [HMD].” This parasocial interaction might seem to be consistent with CASA (Lee & Nass, 2003; Nass et al., 1994) or MASA (Lombard & Ditton, 1997) paradigms but considering their responses are not
directly pointing to VR hardware it would be difficult to apply CASA and MASA. In addition, it was difficult to find an example of the MASA paradigm’s “medium as social actor” (Lombard & Ditton, 1997) out of the medium, because none of the participants pointed out the social cues of the HMD and flat-screen equipment in this study.

On the other hand, they reported as if the characters in the HMD VR as a type of medium that telling a story similar to participant N. 310. “You were with those people and they were directly telling you their story instead of a story being sort of told.” Participant N. 110 further described a sense of trust of that storyteller that was higher with a more immersive experience. This example could develop the debate of CASA and MASA about what is a boundary of computer, technology, and medium. As Participant N. 110 described: “I connected more than just hearing a voice about Ocean because……I could like connect with that person and kind of trust what they're telling me (participant N. 110), researchers might want to explore if agents, people, and recorded videos of people can be considered as a medium in addition to the computer and technology as a medium.

**Immersion.** Fifteen of the participants (participant N. 104, 108, 114, 202, 204, 206, 208, 210, 212, 214, 302, 308, 310, 314, and 412) described *immersion*, using expressions such as immersive, engaging, involved, focused, and attention-grabbing. They said it was stronger when they watched content in the HMD condition, describing immersion in similar ways as participant N. 314, as attention-grabbing: “virtual reality [HMD VR], I thought that was a lot better because I felt like I was kind of there and held my attention.”
When participants described their immersion, they tended to point out examples when they were not immersed in the flat-screen condition. For example:

I definitely felt more like engaged in the second one [HMD] where like the first one [flat-screen], it was kind of like longer pauses [not fully engaged] and you could get like distracted maybe. (participant N. 412)

This is consistent with studies that emphasized the aspect of technology such as increased field of view that make people feel less aware of the role of technology (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000).

**Social realism.** Six of the participants (participant N. 114, 206, 210, 310, 308 & 312) described *social realism*. The descriptions of social realism usually accompanied with other dimensions of presence, similar to participant N. 310 who described social realism with immersion:

The headset [HMD] was more like immersive. Everything I felt more real. I’d say that the impact of the actual message that the videos getting a little bit more noticeable. (participant N. 310)

Also, they all pointed out that they felt more perceptual social realism. For example, they felt increased awareness in the HMD condition that the events and stories in the VR are “really” happening in a physical world instead of describing the experiences as similar to real (but not in a physical world), such as:

I definitely felt like I was more immersed in there [HMD] and like focused on everything in. Like there was much more going on all around me. Like it was much more real in 3D [HMD VR]. (participant N. 308)
Except participants N. 308 and 312, who linked spatial presence with social realism, all of the participants who described social realism seemed to link it with the sense of immersion, for example:

Umm, just everything looked so real and I feel like they are looking right at you and walking towards you. (participant N. 308)

So for the one with the headset, I like it, I felt more of like a real experience like I felt more like I was there cuz everywhere I looked like there was something different like it looks like it's like I was just walking through the same field like or walking through the same boat. (participant N. 312)

It suggests immersion and social realism dimensions share the same underlying psychological mechanism which is “the perceptual illusion of non-mediation” (n. p), as Lombard and Ditton (1997) pointed out. The previous example of participant N. 312 also described the sense of non-mediation when the participant described the sense of social realism and spatial presence.

Psychological processes. Similar to social realism, the researcher was able to identify 6 participants (participant N. 110, 202, 214, 306, 308, and 312) who reported multi-dimensional descriptions that can provide more understanding about the psychological processes behind their increased level of presence. For example, participants N. 110, 214, and 306 mixed spatial presence with social presence in their reflections, for example:

Marine biologist in the first video [HMD]. [It’s] like be there right in front of me and talked about it and got into the ocean together. [It] sounds like I was talking like I was there. (participant N. 110)
I think it [HMD] helps, get that connection feeling like I think the shots [in the content about international issues] where the kids were standing right in front of you. (participant N. 306)

Further, participant N. 214 mixed spatial presence and social presence with immersion:

You really felt like you are also in the truck with them [characters in the content about international issues]......I’m like the [scene about] food was dropped off, you’re right there and they’re running and picking up food and yelling and everything you just feel totally immersed. (participant N. 214)

These mixed descriptions suggest, in the higher level of perception, perceptions are often merged when participants process sensory information. It is especially salient whey they reflect on the sense of social realism. As for participant N. 312, 214, and 202, in order to describe a sense of genuine-ness the descriptions usually accompany other dimensions of presence or a sense of real-people behind the technology. That is how they linked these increased levels of cognition with other types of higher-order psychological states such as emotion, motivation, and attitudes, for example:

I felt that their stories [international issues] are genuine. Their emotions are genuine......like being like in VR headset [HMD]. [It’s] like you can up close to them like you can see their expressions really clearly and hear their voices, like when they tell their story, such as when he [a character in the content] talks about how is like dad and grandfather like we’re trapped in the house and it burned down. [It’s] like I can feel his emotions through it. (participant N. 312)

When you can actually see the person [in the content about international issues], especially that the first shot introducing it makes you - you know, a lot of news reports are like faceless people, you know, this many people died today, but then when you see a child has actually been affected by the war then - it’s oh okay well this is a real person, [it] is real people that are dying being hurt being displaced......It actually made you feel like you were there and it definitely triggered a little more empathy. (participant N. 202)
Cases of participant N. 312 and 214 show that the more immersive experience helps them to make associations among the higher level of psychological states as a director or an instructor intended. On the other hand, these associations do not seem to be a universal process. Unlike real-time video conferencing or live broadcasting, all the participants are aware that these contents were made a few years ago and edited by professional producers, even the experiment did not specify when these contents were produced. Participants described a precondition that triggers the association, for example:

You know, you watch the news that’s like how what was happening 5,000 miles away. [But] when you were in the experience [HMD] it’s more in-your-face I guess……I don’t feel like I was one with them, I felt like I was still outside of it [the scene] but I definitely feel like I was in there and kind of videotaping it and capturing it. (participant N. 210)

Participants reported a couple of expectations that trigger or prevent the association among the psychological states. Their social responses were clearly toward the computer-generated graphics, specifically within the computer as MASA claimed than CASA (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Lee & Nass, 2003; Lombard & Ditton, 1997; Nass et al., 1994; Rubin et al., 1985; Usoh et al., 2000). But this “parasocial interaction” (Lombard & Ditton, 1997; Rubin et al., 1985) adds that there are cultural conventions that trigger or attenuate the association in their final appraisals of their experiences. One of the examples was genre expectation as documentary-style stories are based on a “real” story, as participants N. 210 and 304 described. They both revealed that they would have felt less of the sense of immersiveness and emotion if these contents were filmed in a studio, for example:
Definitely not acting. I feel like I was watching more like a documentary. (participant N. 210)

Yes it could be Hollywood, I guess I like the same authenticity would come across. I guess I wasn’t even really thinking of such a kind of thing. [I] just kind of felt like it was like in a more documentary-style. So I never really even thought to consider it. (participant N. 304)

Because of the cultural triggers and attenuators, the psychological association among the higher-order perceptions were more closely examined by exploring how participants processed their experiences when they watched the global warming content and the international issues content. These are reviews in separate sections below.

**Research question 5a: Presence in global warming content**

Eight of the eighteen participants who described spatial presence in their experiences (participant N. 104, 108, 110, 112, 114, 402, 406, and 410) watched the content about global warming: “The Crystal Reef” (Karutz et al., 2016). They all watched the content with the HMD VR and they described the content helped make them feel connected, engaged, aware clear, and focused. Participant N. 108 described these as making it possible to “grasp it more” when they were in the HMD condition, similar to participant N. 114:

> Visually seeing the differences between [dying and healthy] coral reefs. That’s interesting. It’s important and also visualizing inside of it [ocean]. I think a lot of people know that story about dying coral reefs, but it’s difficult to see how it actually looks like. (Participant N. 114)

Eight of the seventeen participants who described social presence in their experiences (participant N. 102, 106, 108, 110, 408, 410, 412, and 414) watched the content about global warming with HMD VR and they described it was helpful for them
to be connected and engaging, as participant N. 106 described: “I feel like it's easy to connect because all I see all I can see is the person.”

Four of the fifteen participants who described immersion in their experiences (participant N. 104, 108, 114, and 412) watched the content about global warming with the HMD VR. They described it was helpful for them to feel focused and engaged. As participant N. 114 explained, it was less distracting in the HMD VR than the flat-screen condition:

What they [HMD VR] want you to look at and see differences like they made you aware of what they wanted you to observe. And, you could also observe what you wanted to go with it. While the second video [flat-screen] like I was getting distracted by. Like, something happening visually, then I remembered that I need to move the mouse to see the English translation. (participant N. 114)

One of the five participants who described social realism in their experiences (participant N. 114) watched the content about global warming with HMD VR. The participant described it was helpful for them to extend their awareness in the quote above. Also, as participant N. 114 explained, it is because the virtual interactions are now a part of the participant’s own experience:

That will come understanding to want the issue more [because] I think it’s you are kind of experiencing it. And there is more interaction, [it] gets your emotions going. (participant N. 114)

The sense of spatial presence, social presence, immersion, and social realism first helped these participants to see visuals more clearly and directly, as participant N. 108 said as “grasp it more,” in the HMD condition. In other words, the increased level of presence that accompanies a wider bandwidth of the channels for sensory and perceptual
systems in psychological processes somehow helped them to be more connected, focused, engaged, and aware of the problem, as participants N. 106, 114, and 412 described above.

The increased bandwidth in the channels for sensory and perceptual systems in visual processing seems to help them to reconstruct their cognitive structure about the topic and content that they experienced. This is consistent with the bottom-up cognitive process through sensory perceptions (Vetter & Newen, 2014). For example, participant N. 108 felt a stronger connection with the person in a distant location, and participant N. 110 more specifically linked responsibility to other people with their spatial presence experiences.

You can look around your entire area, so it [HMD] definitely felt more in-person versus the [flat-screen] video just kind of being on the TV and you know where you are. (participant N. 108)

It [HMD VR experience] changed my perception of what was going on, so I felt a little bit of responsibility to figure out what was going on. (participant N. 110)

Also, participant N. 110 linked increased empathy with social presence experience; participants N. 114 and 412 linked the increased MTL with their immersion; and participant N. 114 linked the increased emotional flow with social realism. These examples show the psychological associations behind the reconstruction of schematics (Dewey, 1938; Mezirow, 1997) that can drive transformative learning.
**Research question 5b: Presence in international issues content**

Ten of eighteen participants who described spatial presence in their experiences (participant N. 202, 206, 208, 210, 214, 302, 304, 310, 312, and 314) watched the content about international issues in Syria: “The Displaced” (Solomon & Ismail, 2017). They watched the content with the HMD and they described it helped them to feel connected, as participant N. 204 explained: “Because it feels more real it feels like you're there so we get more of a connection.” Participant N. 110 already described these as “in-your-face” in when they were in the HMD condition despite the physically far distance where it’s been happening in the global warming condition.

Nine of seventeen participants who described social presence in their experiences (participant N. 202, 204, 210, 214, 304, 306, 308, 310, and 312) watched the content about the international issues with the HMD and they described it was helpful for them to understand more about the struggles of others clearly, as participant N. 214 explained, and because of the increased level of social presence, as participant N. 308 explained:

People that were right there and you could actually like to see their struggle and learn about it. In the first one [flat-screen] I thought it was also as powerful, but it was, I guess just slightly harder to engage. (participant N. 214)

I like the VR [HMD] because it felt like so real and especially with the sounds and just everything looked so real and I feel like they are looking right at you and walking towards you. (participant N. 308)

Eleven of fifteen participants who described immersion in their experiences (participant N. 202, 204, 206, 208, 210, 212, 214, 302, 308, 310, and 314) watched the content about international issues with the HMD. They described it was helpful for them
to be focused and resonate with the issues in the content. As participants N. 202 and 206 explained, HMD was better than the flat-screen condition:

It [flat-screen] kind of did but it didn’t resonate quite as well because I felt like I was watching TV instead of being immersed in it [like HMD].
(participant N. 202)

Immersion is really intense with the headset [HMD] and rather than using a mouse [flat-screen] to you to control your sight really being able to turn your head and then that really draws you into the environment as the sounds as well. (participant N. 206)

Four of five participants who described social realism in their experiences (participant N. 206, 210, 310, and 314) watched the content about international issues with the HMD. The participant described it was helpful for them to realize the problem more clearly than they knew before. As participant N. 210 described, it is because of the more realistic experience that the words could not capture:

[When an airplane] dropped the food, because I even didn’t know it. So that is something new to me, that was very weird to see because it was like feeding animals to watch. And then, like all of them chased after it [the dropped bags of food] was a pretty like I just didn't know that happened.
(participant N. 210)

The sense of spatial presence, social presence, immersion, and social realism first helped these participants to have a more direct, clearer, and shared experience. Participant N. 110 already described it as an “in-your-face” experience in the HMD condition with the global warming content. Similar to the participants who watched the global warming content, the increased level of presence that accompanies with a wider bandwidth of the channels for sensory and perceptual systems in psychological processes
somewhere helped them to have a more direct, clearer, and shared experience, as participant N. 214, 308, 202, 206 & 210 described above.

A similar pattern was also identified here that the increased bandwidth of the channels for sensory and perceptual systems in visual processing seems to help them to reconstruct their cognitive structure about the topic and content that they experienced through the bottom-up cognitive process (Vetter & Newen, 2014). Especially for this topic, participants reported more mixed presence related descriptions with emotional responses than with the global warming topic. For example, participants N. 202 and 208 felt a stronger emotional connection with the person in a distant location:

The second experience [HMD] was much better, it actually made you feel like you were there and it definitely it triggered a little more empathy. (participant N. 202)

I mean yes, like just to see and I really feel like I was in there in Syria. It was pretty like emotional. (participant N. 208)

Participant N. 304 reported a more sympathetic response linked to spatial and social presence:

Put yourself in the people’s shoes that are affected by this [Syrian war], especially because you’re able to scale it to. It really does feel like you’re there just [it] gives you a better understand [about] what’s going on into what scope it’s happening in. Like just a picture probably wouldn’t [do]. (participant N. 304)

Also, the participants reported more emotional responses with social presence than for the global warming issues topic. Participants N. 110, 202, 304, and 308 linked increased empathy with social presence experience; participant N. 312 linked the sense of
being part of the community with social presence, and also linked the increased care about the people and the sense of being part of the community with social presence:

Feels like you are part of like their community. Yes, I think definitely like I will look into them more cause seeing like the effects [of it] that it could have on someone. Like, [it’s] not something just [I] only care about it, I feel like I look more into. Not just like problems with our countries but with problems with others. (participant N. 312)

Participant N. 202 linked their disturbing emotion with knowing more about the story in the VR of the people who suffer from the Syria war:

I don’t know why kids have to get kicked out of their homes. Like, it's extremely disturbing. I just can't really wrap my head around to say how to fix it. (participant N. 202)

Participant N. 308 also linked their sadness with having more immersive experiences in VR than just seeing photos and reading stories of people; pointing out specific scenes and moments:

I mean it was pretty upsetting just seeing how that their entire lives were like uprooted and displaced because of like the wars that were going on in the separate areas, and like especially just with the [HMD] VR being able to see like the scope of the destruction around them was pretty upset. Especially cause when they talk about it. It’s kind of just, oh, that’s so sad. Like OK, even when you see a picture but [it’s] just a picture. But when you like to see it [HMD VR] it’s just like when it’s like the food was dropping and I was sad. (participant N. 308)

Participant N. 302 linked the increased care about the topic with their immersion and spatial presence; participant N. 210 and 304 linked the humanistic point of view towards the people documented in the content with social realism:

Cuz you’re more immersed and what’s going on. and I feel like if you feel like you're actually there then you'll care more about it. (participant N. 302)
So you kind of get more information out of the first one [flat-screen] but the second one [HMD] I feel like it kinda hits someone like feels more real……this seems more real than something on the screen like it feels because you feel there that you feel like okay these are actually people as opposed to just words in a book. (participant N. 210)

I mean, like that kinds open my eyes to the facts that this is something affecting even younger people, like kids who were younger than me, so that was pretty alarming. I just like the immersive experience with that kind of was alarming too. (participant N. 304)

In addition to those for RQ 5a, these are examples demonstrating the psychological associations that can drive transformative learning (Dewey, 1938; Mezirow, 1997).

**Research question 6: MTL and transformative learning**

To explore the relationship between Motivation To Learn (MTL) and transformative learning, RQ6 asked: “How do people describe their motivation to learn and transformative learning in different VR display-type conditions?” This research question guided exploring how to understand the effects of having immersive experiences with technology on effective learning.

Participants N. 408 and 412 came to have an increased level of MTL about both topics that were presented and were willing to go further to know more about the topic because they are more interested and felt it is more relevant to know more about the topic.
Participants were able to report the increased level of their MTL because they find both topics more interesting and engaging than before when they only have a general understanding about global warming, for example:

I think the second [HMD] experience was definitely more like engaging and it made me like want to learn more about what it talked about [global warming]. I’m like more interested in anyway. But I also think that it’s because it’s like being talked about more, in general, like I already know more about it [than others], but yeah, I definitely feel like the second thing kind of made me more interested in. (participant N. 412)

Also, having more immersive experiences in the HMD VR increased the level of MTL. Even in the case when VR experiences did not add additional knowledge or information, participants found the topic more interesting and engaging to learn about, and they found the HMD worked better than the flat-screen, for example:

Because there’s a little new to me, I mean, I used [HMD] VR before but not in that setting like a learning setting. So it’s definitely interesting and engaging. I still enjoyed the TV one [flat-screen] because it was still a topic that was relevant and I enjoyed even like mousing. I don’t think that would have been an issue [using mouse] but it would have been cool to see that one [the content in the flat-screen] in [HMD]VR. (participant N. 408)

Their increased levels of MTL seem to reflect the change of the participants’ “frames of reference” that were restructured (Mezirow, 1997, p. 7). That explains why they felt learning more about the topic is enjoyable, engaging, and important, and that the change seems larger with the HMD VR experiences. Although the specific level of these higher cognitions is not precise, it is possible that they can compare their psychological state in the result of the restructured “frames,” similar to how participant N. 110 explained:
I think like there’s more of a level of like empathy and engagement compared to just like reading a textbook. What I see with it [HMD VR] instead of just like kind of going through a book. Like, I’m not as much [through books] unless I’m really interested in these issues. They [books] probably not going to be as engaged. (participant N. 110)

Similar to participant N. 408 mentioned earlier, although most of the participants already had some prior knowledge about these topics, they felt more interested and a need to know more about the topic in both flat-screen and HMD conditions. Further, sometimes with the restructured frame they even evaluated their level of knowledge and participation about the issues that were presented in VR and criticized themselves, similar to participant N. 206, and this pattern was consistently observed while exploring RQ4 and RQ5, for example: “I don’t even have the basics on, I know how so ignorant, so this is what I’m going to do, what would I spend more time (participant N. 206)

When the restructured frames, with a more immersive experience, meet with the right prior knowledge, it can give students a chance to experience the consequences of their social status and behaviors. This can significantly help students for advancing their learning a further level, for example:

I just think [it’s like] looking at regions that were affected by, like Western imperialism overtime on, seeing like the remnants of that. I like how they’re struggling to overcome it. It’s very important for someone who was in western civilization. (participant N. 104)

Chapter summary

This chapter presented qualitative analysis and results to research questions in the previous Chapter 4. The results also supported the effects of HMD VR on MTL via
presence in the quantitative analysis. The results of this chapter further suggested how having immersive experiences can contribute to transformative learning. Next, Chapter 8 will present discussions about the results in chapters 6 and 7.
CHAPTER 8

DISCUSSION

This study examined whether or not deploying HMD VR in higher education enhances learning. Although some prior studies examined the effectiveness and limitation of VR’s educational effectiveness, there is little empirical evidence that examined students’ Motivation To Learn (MTL) as another form of transformative learning. Further, most of the prior studies were unclear about the psychological processes evoked in immersive VR experiences and because none of them applied presence in the theoretical frameworks of SCT, and RISP.

In response to these gaps in our knowledge, an experiment and in-depth interviews in a mixed method approach were conducted as described in chapter 5. This last chapter will discuss the implications and future studies based on the results presented in Chapters 6 and 7, suggesting helpful guides to create and use educational VR systems effectively as well as limitations and future studies.

Theoretical Contributions

To explore the educational effectiveness of advanced communication technology, this study compared HMD and flat-screen display-types that presented the same spherical VR video content. Applying the framework of presence, SCT, and RIPS provided useful guides to understand how HMD VR can increase the level of students’ MTL. The results based on these theoretic frameworks supported the studies that suggested the association between interactive experiences and enhanced learning outcomes (Ang & Rao, 2008; Hew & Cheung, 2010; Kaufmann et al., 2000; Martín-Gutiérrez et al., 2017; Moreno et
al., 2001; Steinberg, 2000); studies that shown media technology could enhance the
deeper processing of people (Gardner, 1993; Hew & Cheung, 2010; Jensen & Konradsen,
2018; McLellan, 1994; Merchant et al., 2014), and studies that more immersive media
technology could help people to perceive events through media technology better
(Bracken & Lombard, 2004; Lombard et al., 2015; Lombard et al., 1997; Lombard et al.,
2017; Lombard et al., 2000).

As H1 predicted, HMD VR increased students’ MTL significantly. The increased
level of MTL in the HMD condition also was observed in the in-depth interviews. The
results of subsequent SEM analyses applying presence, SCT, and RIPS frameworks and
in-depth interviews explained the increased presence of students psychologically help to
increase students’ MTL. This explains why HMD VR was effective for some of the prior
studies. The in-depth interviews further explained this increased MTL shows signs of the
transformative learning of participants.

The results also contribute to the theories explaining human motivation. The
following sections will explain how and why RISP provided a useful theoretic framework
to understand changes in MTL caused by technological differences but it needs some
modification, and how and why presence and SCT were worked well together to provide
a good theoretic framework.

**RISP to Understand MTL**

Testing H2 provided limited support for the “risk” avoidance behaviors in the
Risk Information Seeking and Processing (RISP) framework (Kahlor, 2007; Stern &
Fineberg, 1996). The relationship between information insufficiency (current knowledge
and sufficiency threshold) and MTL was not strong enough to support and explain the effects of HMD VR on MTL. Compared to the reasoned action part of the RISP model (information insufficiency) that was not supported, the results do support the heuristic and emotional parts of the model (affective response and informational subjective norm).

This study was the first attempt to deploy RISP for testing effects of technological differences on motivation, and the results for H2 suggest that motivation has a broader spectrum and RISP needs a more comprehensive framework or a restructuring of its elements. This is because the results are more consistent with the argument that the motivations are constantly changing through specific experiences and status changes (Lam & McNaught, 2006; Simmering et al., 2009). Therefore, it makes sense to consider MTL as another dimension of the more general motivation in the RISP model, as described in Figure 30.

**Figure 30.**
A Motivational Model of RISP
The proposed model is consistent with the subsequent post-hoc analysis results of the H2.1 – a, b, c, and d that suggests interesting interaction effects of storytelling and communication technology. The way of delivering information in the content about international issues, whereas it is difficult to specify the way in the experiment, tends to reduce the perceived level of current knowledge and the flat-screen was more effective than the HMD VR. These results suggest the nature of self-reflection that is constantly changing based on the reference points. For example, the level of current knowledge in the post-test can be lower than the level in the pre-test could be because they realized there are more areas that they should know compared to before watching VR contents in this study.

Also, regarding the way of delivering information in the content about global warming, whereas it is difficult to specify the way in the experiment, it tends to increase the perceived level of current knowledge and the HMD VR was more effective than the flat-screen. Because, in the flat-screen condition, the level of reported current knowledge about international issues was significantly decreased from its baseline compared to the slight increase in the global warming condition’s level. The level of reported current knowledge about global warming was, in the HMD condition, significantly increased from its baseline compared to the slight decrease in the international issues condition.

While the results did not support H2.2 & H3 that tested the effects of the information insufficiency on MTL, the post-hoc analysis results for H2.1-c and H2.1-d suggest VR experiences with HMD are more effective than the flat-screen for increasing the level of affective response and informational subjective norms via the heuristic
routes, in the RISP model (Griffin et al., 1999). Because participants reported the increased level of affective response and informational subjective norms with HMD, compared to its level of baseline and flat-screen condition.

**Presence and SCT to Understand MTL**

The results also support the effectiveness of creating more immersive learning environments under the Social Cognitive Theory (SCT) framework (Bandura, 1977; Miltiadou & Savenye, 2003; Rotter, 1990). H1 and 2 compared HMD VR and flat-screen display-types to see if advanced communication technology can help to increase MTL. As predicted, HMD VR increased students’ MTL significantly and this study is the first attempt to explore this effect by evaluating the role of presence. H3, H4, RQ 1, RQ 2, and RQ3 were designed for this purpose.

As H3 predicted, HMD VR was effective in increasing the level of a) spatial presence, b) social presence, c) immersion, and d) social realism than a flat-screen. These results are consistent with the idea of “parasocial interaction” (Lombard & Ditton, 1997; Rubin et al., 1985), and the effects of the increased bandwidth of the channels for sensory and perceptual systems (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000). The in-depth interview results also identified a sense of more “being (am, was, are, were) there” (International Society for Presence Research, 2000; Lombard et al., 1997; Minsky, 1980) and the reduced awareness of the role of technology (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000) in the HMD condition.

This study was the first attempt to examine how the dimensions of presence mediate the effects of technological differences on MTL under the SCT framework.
The set of mediation analyses in SEM controlled for self-efficacy to apply the SCT framework to explore RQ 1, which revealed that spatial presence, social presence, immersion, and social realism all significantly increased MTL, as described in Figure 31.

**Figure 31.**
*Indirect Effects of HMD VR via Presence*

Spatial presence, social presence, and immersion are suppressor variables that significantly increase the ability to predict MTL when estimate effects of HMD VR experience. The results of RQ 2 also supported that the dimensions of presence mediate the effects of HMD VR. Further, the results indicated that spatial presence made the most influential difference. Because only the effects of spatial presence on MTL between the flat-screen and HMD conditions were significantly different.

Social realism’s indirect effect was also close to the significant level ($p = .064$), but the results also can be interpreted as a “complete mediation” considering the effect size (Rucker, Preacher, Tormala, & Petty, 2011, p. 369), but this needs further investigation with the study that can use a larger scale mediation analysis (MacKinnon, Krull, & Lockwood, 2000; Rucker et al., 2011).
Transformative learning and MTL

By considering the transformative learning and progressive education as a key goal of enhanced higher education (Dewey, 1938; Hullender, Hinck, Wood-Nartker, Burton, & Bowlby, 2015; Ravitch, 2010), the ongoing debate between Clark (1994) and Kozma (1994) about the learning benefits from media (Collins & Halverson, 2018; Fedorov & Levitskaya, 2015) might find a new direction. MTL with a sociocultural perspective of motivation in this study played an important role in contributing to theories explaining the relationship between human motivation and transformative learning (Dewey, 1938; Mezirow, 1997; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007). In addition, the results further suggest there are motivational benefits of adopting advanced media technology in higher education because having immersive experiences with advanced media technology can help students to be motivated to deeper information processing.

Although MTL cannot unfold the full spectrum of motivation, MTL provided a good index of students’ status of motivation and how it helped participants to reflect on their transformative learning experiences as part of a holistic and integrated mixed-method design (Cameron, 2009; Creswell, 1994). This approach contributed to find comprehensive results about students’ motivation (Creswell, 1994; Lawrenz & Huffman, 2002). Quantitatively measuring restructured “frames of reference” (Mezirow, 1997, p. 7) is extremely difficult (Hullender et al., 2015). Because motivation is a very broad psychological concept and state, it is difficult to capture the entire spectrum of a student’s motivation. In addition to RISP (Kahlor, 2007; Stern & Fineberg, 1996) and SCT
(Bandura, 1977; Miltiadou & Savenye, 2003; Rotter, 1990) in this study, the contemporary perspectives of motivation focused more on the reasons to be motivated (Kaplan et al., 2012; Levy et al., 2004). On the other hand, in-depth interview results showed that the increased MTL reflects the transformative learning of students, supporting a sociocultural perspective of motivation in the quantitative results too (Dewey, 1938; Hullender et al., 2015; Mezirow, 1997; Middleton, 2014; Provident et al., 2015; Stipek, 2002; Taylor, 2007)

**Implications and Future Studies**

Previous sections focused on theoretical discussions about the results. This section suggests specific implications concerning adopting HMD VR technology in higher education. These implications suggest it is important to use immersive experiences with advanced communication technology, providing suggestions and insights to create and use educational HMD VR content to foster transformative learning experiences for students.

There are some practical suggestions based on the results. First, higher education institutions need to have diverse educational materials in HMD VR. Second, higher education institutions should focus on the importance of students’ motivation to learn toward their goals of higher education. Third, content creators and instructors need to consider the most effective story-telling techniques of educational materials in HMD VR. These will be further discussed in the following sections.

Future studies should consider some limitations of this study. This study’s experiment design controlled pedagogical influences, such as how to incorporate in-class
tasks, the structure of curricula, teaching style, and teaching philosophy (Becker & Ravitz, 1999); the participants were all undergraduate students (Anderson & Adams, 1992); the study used two specific topics about global warming and international issues.

Considering the limitations, future studies will benefit by considering pedagogical practices, student learning styles, classroom settings with more diverse populations, and more topics than those in this study (Anderson & Adams, 1992; Becker & Ravitz, 1999; North, Sessum, & Zakalev, 2004). Also, studies will benefit by exploring types of the psychological processes of the reconstruction of schematics with parasocial interactions; discovering quantifiable variables that are involved with this process (Dewey, 1938; Lombard & Ditton, 1997; Mezirow, 1997; Rubin et al., 1985); and mapping out these psychological associations in cognition to categorize types of para-reality interaction (Lombard & Ditton, 1997; Rubin et al., 1985); investigating specific storytelling practices or communication technologies that can moderate elaboration and heuristic routes when having more immersive experiences (Chaiken, 1980; Dancyger, 2011; Griffin et al., 1999; Klotz & Lombard, 2006). These will be further discussed in the following sections.

Presence and Transformative Learning

The first implication of this study is that higher education institutions need to invest more in creating diverse educational materials in HMD VR, because these materials are useful to increase students’ motivation to learn. Most of the participants reported, in their in-depth interview responses, that the HMD VR was more effective for having more immersive experiences and educational outcomes than the flat-screen. The increased MTL with the HMD VR also suggests the educational effectiveness of using
advanced communication and media technology. These results are consistent with what Boyer et al. (2006) and Provident.et al. (2015) observed in their work, further supporting the idea that HMD VR can help to create transformative learning experiences.

Most of the participants further explained they thought the HMD VR experience was better because it was more realistic, engaging, emotional, focused, impactful, personal, connected, enjoyable, and involved with having a more caring mind toward people and the environment, similar to what participants N. 214, 302, and 402 described. HMD VR made them be motivated and focused to learn more about what they experienced, especially for those who are visual learners (Ambrose et al., 2010). Also, with the help of HMD VR, participants’ reflections suggest they felt increased and strengthened MTL and showed intention to follow up on the issue more actively regardless of their prior knowledge, though the depth of understanding was different depending on their prior education and knowledge (Ambrose et al., 2010).

Also, in the pattern of describing presence in the in-depth interviews, results revealed the psychological processes of the reconstruction of schematics (Dewey, 1938; Mezirow, 1997) to explain the relationship between having immersive experiences and transformative learning. This is consistent with “parasocial interaction” (Lombard & Ditton, 1997; Rubin et al., 1985). In the process of feeling less aware of the role of technology (Bracken & Skalski, 2009; IJsselsteijn et al., 2001; Usoh et al., 2000), participants had a more direct, clearer, and shared experience, similar to what participant N. 110 described as the “in-your-face” experience in the HMD condition.
To create diverse educational materials in HMD VR, future study will benefit by exploring the types, styles, and patterns of individual differences in the psychological processes of the reconstruction of schematics with parasocial interactions. The psychological processes of the reconstruction of schematics with parasocial interactions (Dewey, 1938; Lombard & Ditton, 1997; Mezirow, 1997; Rubin et al., 1985) in the in-depth interview results could have more detailed structure and mechanisms that this study could not capture. Discovering quantifiable variables involved with this phenomenon will be beneficial to have more reliable and generalizable findings.

**Presence and Para-reality Interaction**

The second implication of this study is that higher education institutions should focus on the importance of students’ motivation to learn toward their goals of higher education with their major. Because the increased motivation to learn to the specific material can also stimulate the motivation to learn toward broader subject matters in their major. This influence can help students to have more motivation to ask challenging and difficult questions. The increased level of presence that accompanied the increased bandwidth of the channels for sensory and perceptual systems seemed to help participants to reconstruct their cognitive structure schematics through the bottom-up cognitive process (Vetter & Newen, 2014). This process seems to reflect the change of the participants’ “frames of reference” that were restructured (Mezirow, 1997, p. 7); it also suggests *para-reality interaction* (i.e. presence as perceptual and social realism) that overarches both spatial presence and social presence.
The researcher used the new term for this phenomenon, *para-reality interaction.* The term resonates with parasocial interaction (Lombard & Ditton, 1997; Rubin et al., 1985) and it applies to the broader interactions in VR. In addition to having parasocial interactions with people through VR, people also changed their perception of reality through VR. That is para-reality interaction and that elucidates why participants felt learning more about the topic is enjoyable, engaging, and important without the other types of reasons to be motivated that were identified studies about intrinsic and extrinsic motivations, for example, achieving higher grades and finding better jobs than others.

To help students to have more motivation to ask challenging and difficult questions, future studies should map out these psychological associations in cognition, categorize types of para-reality interaction, and develop ethical considerations of having para-reality interaction. The psychological associations in cognition need further examination because they need more robust support and a detailed understanding of their mechanisms.

*Educational Storytelling with HMD VR*

The third implication of this study is that content creators and instructors need to consider the use of effective story-telling techniques of educational materials in HMD VR. Story-telling is important to deliver immersive experiences effectively in addition to providing technologically advanced tools. Similarly, the results of this study suggest that HMD VR’s enhanced level of presence increased MTL more than the flat-screen display, but they also suggest there are certain educational contexts and storytelling techniques for which HMD VR is more educationally effective.
**Spatial presence and immersion.** According to the results for RQ2, spatial presence was the most important psychological impact of using the HMD compared to using the flat-screen. RQ2’s results revealed that the dimensions of presence play different roles in affecting MTL between display-types. The multi-group SEM analysis results showed immersion was important to increase MTL with the flat-screen; spatial presence and social presence were important to increase MTL with the HMD VR. Also, it was the effects of spatial presence on MTL that showed significantly different effect sizes between the flat-screen and HMD conditions when the effects of content-type and self-efficacy were controlled for. Also, as participant N. 114 explained, the increased spatial presence and immersion in VR seems to help students’ learning:

> What they want you to look at and see differences in like they made you aware about what they wanted you to observe and you could also observe what you wanted to go with it. (participant N. 114)

The experiment in this study was not designed to identify specific technological elements in the HMD or flat-screen that were particularly associated with the level of spatial presence. But the results suggest that follow up studies should focus on the more specific technical elements of HMDs, such as resolution, field of view, color depth, responsiveness, and frame-rate, which could change the level of spatial presence. That also includes testing the effectiveness of interactive content designs that allow students to navigate and select contents inside VR. Also, a few participants in this study reported that the HMD was not physically natural or easy to use to find more information, which merits more study.
**Social presence and social realism.** Although it is difficult to identify specific differences in the techniques of storytelling from the experiment results, the in-depth interview results suggest a few distinct differences. First, as participant N. 102 pointed out, the content about international issues, “The Displaced” (Solomon & Ismail, 2017), introduced stories of three children with their own voices. Participants reported more social presence responses to these children, such as having “felt [a] more intimate” relationship:

> And with the storytelling and like the specific people. It just felt more intimate and I feel like that’s something [because] we might not have done right. (participant N. 102)

As shown in participant N. 102’s reflection, participants reported they felt the increased level of social presence with the characters in “The Displaced” (Solomon & Ismail, 2017) when they told their story to viewers. This storytelling was similar to a documentary in which a director and cameraperson listen to the interview subject’s story and provide additional visuals.

Based on the participants’ reflections, this documentary-like storytelling with interviewing people who are suffering was effective to evoke the sense of social presence, and further social realism, that increased the awareness of the problems that the content showed. In the end, the increased social presence and social realism helped participant N. 102 to realize people could suffer because of “something we might not have done right.” With this concern in mind, the participant also wanted to know more about problems that are making these people suffer.
Compared to spatial presence and immersion, social presence and social realism produced interaction effects between VR content-type topics and display types. First, the way of telling the story about international issues was more effective to increase the level of social presence and social realism than the way of telling the story in the global warming video. Participants reported a significantly higher level of social presence toward international issues than global warming in the flat-screen condition. Also, in the HMD condition, participants reported a slightly higher level of social presence toward international issues than global warming. Similar to social presence, participants reported a slightly higher level of social realism toward international issues than global warming. Also, in the HMD condition, participants reported a significantly higher level of social realism toward international issues than global warming. As participants N. 214 and 308 described, putting a VR user next to the characters in VR seems to help increase social presence and students’ learning.

People that were right there and you could actually like to see their struggle and learn about it. (participant N. 214)

I feel like they are looking right at you and walking towards you. (participant N. 308)

Future studies should investigate more about the features of the characters in VR experiences. This could include comparing artificial vs real characters, 3D imaging vs captured characters, and the ability to see both user and characters vs seeing only characters in VR.

**Dual processing model.** The post-hoc analysis results for H2.1-b suggest there are more complex interactions behind the concept of “information insufficiency.” The
gap between the perceived level of current knowledge and sufficiency thresholds (Griffin et al., 1999) was largest when participants watched the content about international issues with the flat-screen. After viewing the VR clip with the flat-screen, the level of perceived sufficiency threshold significantly increased and the level of current knowledge decreased. On the other hand, the gap between the perceived level of current knowledge and the sufficiency threshold was smallest when participants watched content about global warming with the HMD.

The results of tests for H2.1-a and b may suggest the flat-screen and the way of telling a story in “The Displaced” (Solomon & Ismail, 2017) worked better in the RISP model for increasing the level of “information insufficiency” through the elaboration route rather than the heuristic route (Griffin et al., 1999). It is also possible that an increased level of affective response and informational subjective norms with the HMD contributed to the increased elaboration process. But these arguments need further investigations to confirm if there are specific storytelling practices or communication technology attributes that can moderate the effects on the elaboration and heuristic routes for processing information.

**Visual discomfort.** There was a direct effect of HMD VR on visual discomfort in this study, as H4 predicted. Nevertheless, considering the statistical flooring distortion and the in-depth interview result that none of the participants reported visual discomfort, it had borderline influence with the contents with 5 min screening times. Follow up studies need to examine the conditions with a higher level of visual discomfort than this study, considering increased visual discomfort with longer screening time, poorer image
quality, fast visual movement, poor tracking, longer tracking lag, and the increased complexity of visual elements and interfaces. This is because the results of this study could be influenced by the stimuluses in this study’s unusually low amount of visual discomfort than the amount of other types of HMD VR titles produce.

Even with the marginal visual discomfort, the results for RQ3 showed that HMD VR increased the level of visual discomfort, and the visual discomfort significantly decreased MTL, especially with the social presence model. But it could be applied to other models for spatial presence, immersion, and social realism when the HMD VR experiences have more visual discomfort. Follow up studies need to examine the same effects when the level of visual discomfort is higher than this study.

Conclusion

To provide meaningful insight to know the benefits of deploying HMD VR in higher education, this study provided empirical evidence of using HMD VR to increase students’ MTL as a form of transformative learning. This study also explored the psychological processes behind the transformative learning with the HMD VR applying presence with SCT and RISP frameworks in with parasocial interaction (Lombard & Ditton, 1997; Rubin et al., 1985) demonstrating the relationships between presence and MTL. It further identified how cultural experiences trigger or attenuate social responses when people make associations in their higher-order cognitive processes suggesting para-reality interaction.

This study, in the end, could be considered as one of the efforts to discover whether and how people have the motivation to increase the depth of humanistic
inquiries, in addition to the apparent reasons to be motivated that contemporary psychology’s view of motivation (Bandura, 1977; Cook & Artino Jr, 2016; Lam & McNaught, 2006; Noe & Schmitt, 1986; Yamashita et al., 2019). Further, this study explored whether and how having more immersive experiences with advanced communication technology enhances motivation. Philosophically, it is promising and notable that the psychologically immersive experiences encourage motivation to learn in a way of altruistic concerns, instead of taking advantage of people and environments that are in danger. This is in line with the sociocultural perspective (Taylor, 2014; Vygotsky, 1980) that the participants’ altruistic schema stems from their prior education and the results of Milgram’s obedience experiment in 1965. Because it showed the increased sense of proximity of HMD VR helped people to think or care more about the consequences of their actions than when the consequences are less perceivable. Although the outcome of this study is not about disobeying/obeying behaviors to authority and this study is rather than about having more motivation to know more about the results of the actions of people as well as themselves, it shares the same element that exploring the effects of mediated experiences that change levels of sensory proximity.

The immersive experiences in this study seem to enhance the altruistic schema of motivation to know more about the complications that people need to solve together. Therefore, the results of this study emphasize the increased importance of educational institutions and teachers with advanced communication technology that can create immersive experiences. Because they can benefit students to create the self-directed transformative learning environment of higher education that is full of realistic, engaging,
emotional, focused, impactful, personal, connected, enjoyable, and involving experiences via evolving their “frames of reference” (Boyer et al., 2006; Dewey, 1938; Mezirow, 1997; Provident et al., 2015). Considering the cost-efficiency, it is still and never will be more efficient than the current classroom settings. But when we place the effectiveness first in higher education, we should implement, reinvent, and create more immersive educational technology and content.
REFERENCES


Retrieved from


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10.1207/s1532785xme0601_2


John Wiley & Sons (published in conjunction with the International Communication Association).


APPENDICES

APPENDIX A: QUANTITATIVE MEASURES

<table>
<thead>
<tr>
<th>SN</th>
<th>Question</th>
<th>Answer choices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Pretest: Below questions will be asked once, at the beginning of experiment</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>What is your age?</td>
</tr>
</tbody>
</table>
|    | Sex      | What is your sex?   | 1. Female  
            |                       | 2. Male  
            |                       | 3. Other  
            |                       | 4. Do not want to answer |
|    | HMD1     | Have you used a HMD device before today?  
            | (For example, Oculus Rift and Google Cardboard) | 1. Yes  
            |                       | 2. No  |
|    | HMD2     | Do you have access to your own HMD device? | 1. Google Cardboard  
            |                       | 2. Oculus Rift  
            |                       | 3. PlayStation VR  
            |                       | 4. Gear VR  
            |                       | 5. VIVE VR  
            |                       | 6. Others  
            |                       | 7. Do not own HMD display |

**Self-efficacy: Course** from College Self-Efficacy Inventory (CSEI) of Gore, P. A., Leuwerke, W. C., & Turley, S. E. (2005)

<table>
<thead>
<tr>
<th>CSEI Course</th>
<th>Please indicate how confident you are as a student at TEMPLE University that you can successfully -</th>
<th>Not at all Confident</th>
<th>Extremely Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manage time effectively</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research a term paper</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do well on your exams</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Take good class notes</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understand your textbooks</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Keep up to date with your schoolwork</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Write course papers</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
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<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Information insufficiency (Current knowledge/Sufficiency threshold)</strong>  from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II.ck</td>
<td>Please rate your current knowledge about <strong>global warming</strong> on a scale of 0 to 100, where zero means knowing nothing and 100 means knowing everything you could possibly know about this topic.</td>
<td>Please type _________(0-100)</td>
<td></td>
</tr>
<tr>
<td>II.st</td>
<td>Think of that same scale again. This time, we would like you to estimate how much knowledge you would need in order to achieve a comfortable understanding of <strong>global warming</strong>. You might feel you need the same, more, or possibly even less information about this topic. Using a scale of zero to 100, how much information would be sufficient for you?</td>
<td>Please type _________(0-100)</td>
<td></td>
</tr>
<tr>
<td>II.ck</td>
<td>Rate your current knowledge about <strong>international issues</strong> on a scale of 0 to 100, where zero means knowing nothing and 100 means knowing everything you could possibly know about this topic.</td>
<td>Please type _________(0-100)</td>
<td></td>
</tr>
<tr>
<td>II.st</td>
<td>Think of that same scale again. This time, we would like you to estimate how much knowledge you would need in order to achieve a comfortable understanding of <strong>international issues</strong>. You might feel you need the same, more, or possibly even less information about international issues. Using a scale of zero to 100, how much information would be sufficient for you?</td>
<td>Please type _________(0-100)</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
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<tr>
<td></td>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Affective Response</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR.gw</td>
<td>When you think about concerns about global warming, how much worry do you feel?</td>
<td>Not Worried at all</td>
<td>Very worried</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1   2   3   4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Informational subjective Norms</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISN.gw</td>
<td>People who are important to me would expect me to stay on top of information about global warming.</td>
<td>Strongly Disagree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1   2   3   4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Affective Response</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR.ia</td>
<td>When you think about the concerns from international issues, how much worry do you feel? Please use a number from one to seven, where one means you have “none of this feeling” and seven means you have “a lot of this feeling.”</td>
<td>Not Worried at all</td>
<td>Very worried</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1   2   3   4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Informational subjective Norms</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISN.ia</td>
<td>People who are important to me would expect me to stay on top of information about international issues.</td>
<td>Strongly Disagree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1   2   3   4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td></td>
<td><strong>PostTest: Below questions will be asked after watching each stimulus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Spatial Presence</strong> from Temple Presence Inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPI.sp1</td>
<td>How much did it seem as if the objects and people you saw/heard had come to the place you were?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.sp2</td>
<td>How much did it seem as if you could reach out and touch the objects or people you saw/heard?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.sp3</td>
<td>How often when an object seemed to be headed toward you did you want to move to get out of its way?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Social Presence</strong> from Temple Presence Inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPI.so1</td>
<td>How often did you have the sensation that people you saw/heard could also see/hear you?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.so2</td>
<td>To what extent did you feel you could interact with the person or people you saw/heard?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.so3</td>
<td>How much did it seem as if you and the people you saw/heard left the places where you were and went to a new place?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Immersion</strong> from Temple Presence Inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPI.en1</td>
<td>To what extent did you feel mentally immersed in the experience?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.en2</td>
<td>How involving was the experience?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TPI.en3</td>
<td>How completely were your senses engaged?</td>
<td>Not at all</td>
<td>Very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
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<td>----------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td><strong>Social Realism</strong> from Temple Presence Inventory**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPI.sr1</td>
<td>The events I saw/heard would occur in the real world.</td>
<td><strong>Strongly Disagree</strong></td>
<td><strong>Strongly Agree</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>TPI.sr2</td>
<td>The events I saw/heard could occur in the real world.</td>
<td><strong>Strongly Disagree</strong></td>
<td><strong>Strongly Agree</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>TPI.sr3</td>
<td>The way in which the events I saw/heard occurred is a lot like the way they occur in the real world.</td>
<td><strong>Strongly Disagree</strong></td>
<td><strong>Strongly Agree</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Motivation To Learn from</strong> Noe &amp; Schmitt (1986) and Simmering, Posey, &amp; Piccoli (2009)</td>
<td>:** Strongly Disagree**</td>
<td><strong>Strongly Agree</strong></td>
</tr>
<tr>
<td>MTL.1</td>
<td>I will try to learn as much as I can about this topic.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>MTL.2</td>
<td>I will exert considerable effort to learn about this topic.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>MTL.3</td>
<td>I will learn as much as I can about this topic.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
<td></td>
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<td>----</td>
<td>--------------------------------------------------------------------------</td>
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<tr>
<td></td>
<td><strong>Motivation To Learn in Media (MTLM)</strong> devised by Matthew Lombard and Hocheol Yang for this dissertation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please indicate how likely it is that you will make an effort to learn about the topic using each of the following</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Text books</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>News articles</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Journal articles</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Wikipedia</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Social media (Facebook, Instagram, YouTube &amp; Twitter etc.)</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Podcasts</td>
<td>1 2 3 4 5 6 7</td>
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<td>7</td>
<td>Movies</td>
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<tr>
<td>8</td>
<td>TV Programs</td>
<td>1 2 3 4 5 6 7</td>
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</tr>
<tr>
<td>9</td>
<td>Virtual reality experiences</td>
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<td></td>
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<tr>
<td>10</td>
<td>Augmented Reality experiences</td>
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<td></td>
</tr>
<tr>
<td>11</td>
<td>University courses</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SSQ.1</th>
<th>During your viewing, did you experience discomfort with your head?</th>
<th>None</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SSQ.2</th>
<th>During your viewing, did you experience discomfort with your eyes?</th>
<th>None</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SSQ.3</th>
<th>During your viewing, did you experience discomfort with your body?</th>
<th>None</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SSQ.4</th>
<th>During your viewing, did you experience discomfort with your mind?</th>
<th>None</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Question</td>
<td>Answer choices</td>
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<tr>
<td></td>
<td><strong>Posttest</strong></td>
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<tr>
<td></td>
<td><strong>Affective Response</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR.po</td>
<td>When you think about the concerns about this topic, how much worry do you feel? Please use a number from one to seven, where one means you have “none of this feeling” and seven means you have “a lot of this feeling.”</td>
<td>Not Worried at all</td>
<td>Very worried</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Posttest</strong></td>
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<td><strong>Informational subjective Norms</strong> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
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<tr>
<td>ISN.po</td>
<td>People who are important to me would expect me to stay on top of information about this topic.</td>
<td>Strongly Disagree</td>
<td>Strongly Agree</td>
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<td><strong>Posttest</strong></td>
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<td><strong>Information insufficiency</strong> <em>(Current knowledge/Sufficiency threshold)</em> from RISP model (Robert J. Griffin, Kurt Neuwirth, Sharon Dunwoody &amp; James Giese, 2004)</td>
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<td>II.ck</td>
<td>Rate your current knowledge about this topic on a scale of 0 to 100, where zero means knowing nothing and 100 means knowing everything you could possibly know about this topic.</td>
<td>Please type</td>
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<td>__________(0-100)</td>
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<td>II.st</td>
<td>Think of that same scale again. This time, we would like you to estimate how much knowledge you would need in order to achieve a comfortable understanding of this topic. You might feel you need the same, more, or possibly even less information about this topic. Using a scale of zero to 100, how much information would be sufficient for you?</td>
<td>Please type</td>
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<td>__________(0-100)</td>
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APPENDIX B: QUESTIONS FOR THE IN-DEPTH INTERVIEW.

1 Questions for the in-depth interview.

1. Technological elements making a more immersive experience

- You have used both flat-screen TV and a VR headset. Could you explain the differences?

- If you have felt being in a different place or being with a person in the experience, what technology gave you more of the feeling? Could you explain why?

- In the questionnaires that you completed, have you found anything particular in your experience or mind that you have not been asked about?

2. Presence and motivation to learn

- If you have a limited time to study the environmental issue or international issue, which topic would you like to spend more time on? Could you explain why?

- Assuming you are taking an undergraduate course that is about environmental issues or international issues and an instructor watched these in the classes, which types of technology would you think is more helpful and why?

- Can you suggest any ideas for more effectively using these technologies for undergraduate or graduate courses?

3. Catch up and supplementary questions

- Could you identify the most impressive moment, scene, place, event or person in these experiences?

- Have you ever used VR with a headset before? What do you think of it?

- Do you have any final thoughts about problems, benefits, confusion, or concerns about using these technologies for learning in higher education courses?
APPENDIX C: IRB APPROVAL

Protocol Number: 23658
Pt. LOMBARD, MATTHEW
Review Type: EXEMPT
Approved On: 11-Mar-2019
Committee: A1
School/College: MEDIA AND COMMUNICATION (1700)
Department: KLEIN MEDIA STUDIES AND PRODUCTION (17040)
Sponsor: NO EXTERNAL SPONSOR
Project Title: Presence and education in VR

The IRB approved the protocol 23658.

The study was approved under Exempt or Expedited review. The IRB determined that the research does not require a continuing review; consequently there is not an IRB approval period.

If applicable to your study, you can access your IRB-approved stamped consent document or consent script through E.R.A. Open the Attachments tab and open the stamped documents by clicking the Latest link next to each document. The stamped documents are labeled as such. Copies of the IRB-approved stamped consent document or consent script must be used in obtaining consent.

Note that all applicable Institutional approvals must also be secured before study implementation. These approvals include, but are not limited to, Medical Radiation Committee ("MRC"), Radiation Safety Committee ("RSC"), Institutional Biosafety Committee ("IBC"), and Temple University Survey Coordinating Committee ("TUSCC"). Please visit these Committees' websites for further information.

Finally, in conducting this research, you are obligated to submit the following:

- Amendment requests - All changes to the research must be reviewed and approved by the IRB. Changes requiring approval include, but are not limited to, changes in the design or focus of the research project, revisions to the information sheet for participants, addition of new measures or instruments, increasing the subject number, and changes to the research funding. Changes made to eliminate apparent immediate hazards to subjects and implemented prior to IRB approval must be promptly reported to the IRB.
- Reportable New Information - using the Reportable New Information e-form, report any information items such as those described in IRB - 071 Policy - Prompt Reporting Requirements to the IRB within 5 days.
- Closure report - using a closure e-form, submit when the study is permanently closed to enrollment; all subjects have completed all protocol related interventions and interactions; collection of private identifiable
information is complete; and analysis of private identifiable information is complete.

For the complete list of investigator responsibilities, please see the HRP – 070 Policy – Investigator Obligations, the Investigator Manual (HRP-910), and other Policies and Procedures found on the Temple University IRB website: https://research.temple.edu/irb-forms-standard-operating-procedures.

Please contact the IRB at (215) 707-3390 if you have any questions.