How Spatial Presence in Virtual Reality Affects Memory Retention and Motivation on Second Language Learning

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Abstract

This research examines the efficacy of media effects and memory retention in second language(L2) learning by comparing desktop-based learning and VR-based learning. It is assumed that VR uses latent acquisition when used for learning L2, increasing memory retention by producing spatial presence and a stronger immersion experience. Thus, we investigate whether Virtual Reality Head Mounted Display (VR HMD) with strong spatial presence improves language learning simulation through the use of 'Method of Loci'. If so, the VR method has potential to be an effective novel approach that uses subconscious mechanisms of memory coding to facilitate the L2 acquisition of the new words. Participants played the VR language program to test the effectiveness of learning of Korean vocabulary using interactive objects arrayed around the 3D classroom environment. The results indicated that VR had significant effects on enhancing language learning through the use of spatial memory, spatial presence, enjoyment, and motivation. Lastly, structural equation modeling was used to find the significant path in media effects.

Keywords: Virtual Reality, *Spatial Presence, Language Learning, Spatial Memory, Enjoyment, Motivation*

Introduction

Second Language Acquisition (SLA) is the process of learning an additional language. Acquisition of language is perceived differently than learning. SLA uses subconscious mechanisms for memorizing and learning a language (Krashen, 1981). Ellis (2015) explains the differences by stating, “Acquisition is the incidental process where learners ‘pick up’ a language without making any conscious effort to master it; whereas learning involves an intentional effort to study and learn a language” (p.25). A representative example of SLA is found in the process by which a new-born baby learns a language, that is without explicit explanation of grammar or structure. The baby learns the language by mimicking and following their parent’s sound or gestures. That SLA process is a natural and fast way to learn the language. In this paper, we investigate the method for enhancing SLA through the use of technology.

Implementation of second language (L2) learning has been made easier with rapid technological growth in recent years. Unsurprisingly, with the development of the Internet, various computer-assisted learning language (CALL) systems have become common in the home and school environments (Iandoli, 1990). For instance, it is now possible to acquire L2 learning through video teaching of L2, online communication with a L2 partner or playing language games via a mobile phone.

With the presence of computer technology, CALL has been praised by many researchers as a method that offers suitable tools for increasing language and motivation (Dunkel, 1991; C.-L. C. Kulik, Kulik, & Bangert-Drowns, 1990; J. A. Kulik, Kulik, & Cohen, 1980; Waxman & Huang, 1996). The researchers believed that computers are capable of promoting the acquisition of new languages to people with its capability in provisioning several communicative activities, reducing learning anxieties and stress, and providing repeated lessons (Lai & Kritsonis, 2006).

In addition, there has been an increase of L2 learners in the use of simulation computer games to assist L2 learning. A study by Miller and Hegelheimer (2006) investigated the structural play of the original version of The Sims in combination with support materials specifically designed to allow English L2 learning to make use of the game as well as use it in enhancing their vocabulary and grammar knowledge. Statistically, the researchers found a significant increase of vocabulary words among the participants who played The Sims during their study. K.-w. Lee (2000) argued that the application of computer technology in L2 learning is based on its ability to provide experiential learning practice and the application of multiple resources, such as puzzles, online tutors, simulations or games.

Although there are various benefits of desktop-based L2 learning (C.-L. C. Kulik et al., 1990), researchers indicate limitations (Lai & Kritsonis, 2006) arise with a lack of immersion. Most researchers of CALL intended to focus on learning based on the desktop with the utilization of a monitor to present learning content. Kim, Rosenthal, Zielinski, and Brady (2012) defined the desktop as a system with the lowest level of immersion among other mediums compared with a Virtual Reality Head Mounted Display (VR HMD) or a Cave Automatic Virtual Environment (CAVE). The desktop display may also disrupt concentration and negatively influence the motivation to continue the study due to a lack of immersion.

Considering this, Virtual Reality provides an interesting and viable solution. VR HMD enables a fully immersive, 360-degree environment (Rose & Billinghurst, 1995). Solak and Erdem (2015) assert that a sense of presence can generate a high-immersive environment in VR, where the concept of presence is defined as “being there” (Biocca & Delaney, 1995). This increased immersion is responsible for the motivation and learning performance. For example, Bonde et al. (2014) introduced the VR Labster, which is a virtual chemistry laboratory, with comparisons to lectures and traditional learning. Participants who used the virtual reality laboratory demonstrated a 14% increased performance compared to students who followed a traditional lecture for learning.

Another benefit is that VR may affect memory retention using spatial presence. An experiment conducted by E. A. Johnson (2010) compared various media (non-VR vs. VR) capable of immersion level generation. A shutter glass with tracking sensors was used at the head to create an immersive 3-D environment. A correlation was found between spatial memory and presence due to a higher immersion level offering greater impact on the spatial memory.

In sum, learning based on VR environments offers better chances for L2 learners because of a higher immersion level, higher retention of memory, and enhancement of the motivation for the continuous study by the learners. However, virtual reality is still in the early adoption stages as a technology, so there are few research comparing the medium with media effects for a L2 learning. Thus, the purpose of the paper will seek the media effects and memory retention between desktop-based learning and virtual reality-based learning.

Factors Affecting Memory in VR

Spatial Presence in Simulation

Spatial presence is a form of the ‘presence' dimensions (Shafer, Carbonara, & Popova, 2011). Biocca, Harms, and Burgoon (2003, p. 459) stressed “a spatial presence as the phenomenal sense of ‘being there’ including automatic responses to spatial cues and the mental models of mediated spaces that create the illusion of place.”

Virtual environment is an essential tool in the study of brain activation in the use of spatial navigation (Sanchez-Vives & Slater, 2004). For example, Bliss, Tidwell, and Guest (1997) introduced VR for training firefighters to acquire and display knowledge about spatial navigation in an unfamiliar place. They compared the blueprint, VR, and no training conditions to investigate which approach is the most effective for firefighter training, and hypothesized the VR exploration method would be the best training tool because 3-D displays provide more visual and the top spatial information than 2-D displays. However, opposite to his hypothesis, the blueprint performed best for the task of navigation time as well as for the number of wrong turns. They explained this result because firefighters are more familiar with using a blueprint, and the data was limited due to a low number of test samples with only 10 participants. In this research, they differentiated the implemented tools between paper and a computer monitor. Thus, the immersion level depended on the visual tool and did not affect the result. If they had experimented utilizing VR HMD, the result could have been different due to a higher spatial presence. Thus, this study posits the following hypotheses:

H1. During L2 learning, participants who are assigned to VR-based learning will report higher sense of spatial presence compared to participants who are assigned to desktop-based learning.

Memory of Loci Increases Spatial Memory

Anecdotal evidence for memory recall was provided by journalist Joshua Foer in 2005 while interviewing the “grand master” of memory, Ed Cooke. After making observations, Foer practiced applied these concepts into practice. A year later, Foer attended the 2006 memory championship to become a memory champion. The mnemonic strategy applied is called ‘Memory of Loci,’ which uses subconscious capturing of the space in an image to map objects using relations in sequential order (Foer, 2012). Foer’s experience suggests that Virtual Reality (VR), by using the ‘Method of Loci’ strategy, may have potential for enhancing language learning.

The ‘Method of Loci’ is related to spatiality. For example, comparing only textual information and textual information with the map, a geographic map is supporting to students remembering more textual information (Abel & Kulhavy, 1986; Kulhavy, Stock, Peterson, Pridemore, & Klein, 1992; Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Schwartz & Kulhavy, 1981). Another example is the memorization experiment from a California State University (Bass & Oswald, 2014). They recruited 94 participants and divided two groups to memorize five lists of five fruits: one group using the 'Method of Loci' and another group using without any other particular method strategy. The results presented that the group used the 'Method of Loci' showed high memory retention than another group that did not use 'Method of Loci'. It is because the 'Method of Loci' supports to recall the serial order of the images based on the location and spatiality. Bass and Oswald (2014) concluded that sequential and visual techniques like the 'Method of Loci' may reduce forgetfulness and aid in retention.

In addition, spatial memory is related to VR since VR presents a visual framework with spatiality (Järvinen, Bernardet, & Verschure, 2011). Pantelidis (2010) also supports the argument as mentioning that VR improves spatial memory. Another supportive research is measure level of immersion and spatial memory by E. A. Johnson (2010). The research focused on the question, "when navigating a complex virtual 3-D environment, does the user's spatial memory improve with an increased level of immersion?". Depending on the level of immersion, it may affect to the user's short-term spatial memory. The work analyzed two virtual environment contexts (the Muscatatuck Virtual Tour and the 21st Century World Future City) and used shutter glass with a tracking sensor immersive environment in 3-D. The results presented that a higher level of immersion significantly affects to spatial memory. This suggests VR techniques impacts mediated experiences on cognition, which helps to improve spatial memory (Järvinen et al., 2011). Thus, the following hypothesis is also considered:

H2. During L2 learning, participants assigned to VR-based learning will experience increased memory retention *compared to participants who are assigned desktop-based learning.*

Correlation Between Spatial Presence and Spatial Memory

People may memorize things by their physical location (Patel & Vij, 2010) or sequential order by location. If a feeling of presence exists, then virtual objects related to the location will encode in the brain (Järvinen et al., 2011). Thus, VR has the advantage of convincing its user because they feel as if they are in a real physical environment, such as on a road, in a city or hotel, while learning a new language in that environment or situation. Thus, enhancing memory through immersion is shown in research as being important to the success of maintaining learning.

According to Bailey, Bailenson, Won, Flora, and Armel (2012), to measure the immersion level, researchers observe the presence level, and to measure presence, researchers use memory tasks or tests of recall because memory retention in the virtual environment is associated with levels of presence (Bailey et al., 2012). The greater level of presence users' experience, the more they remember the details of the virtual environment, such as virtual objects, spatial layouts, and message content (Lin, Duh, Parker, Abi-Rached, & Furness, 2002; Mania & Chalmers, 2001). For example, researchers at The Computer Museum developed an VR HMD application designed to teach children about the structure and function of cells (Gay & Greschler, 1994). Comparing non-immersive and immersive treatment groups, they found that the group in the immersive environment had better memory retention of information and more interest in the class. Thus, in this research, the following hypothesis posits:

H 3. A positive correlation exists between spatial presence and spatial memory.

Educational Benefits of Using VR

Fostering and Enjoyable Environment

Many scholars argued that a game is an enjoyable and useful means to develop communicative competence (Baltra, 1990; Peterson, 2009; Ryan, Rigby, & Przybylski, 2006). Lai and Kritsonis (2006) asserted that the computer provides many fun games and communicative activities in simulation learning. Since the scope of gaming is broad, in this paper, the game refers to a simulation game. There are a few reasons why playing computer games can be enjoyable for players: (1) they allow players autonomy of controlling the game, which may make the players more active (Ho & Crookall, 1995), (2) computer-based learning offers to learn through repetition (Lai & Kritsonis, 2006) and anonymity (Ortega, 1997) with elements of simulation learning that reduces stress and anxiety while enhancing confidence through practicing skills without fear (W. L. Johnson & Wu, 2008; Ortega, 1997), and (3) an authentic environment through a simulation provides a more immersive environment to visualize the virtual world as it the real world (Scoresby & Shelton, 2010).

These advantages of using a simulation game can be expanded to help language learning. SZABÓ (2011, p. 67) stated, "language learning environments and language teaching materials are the facet on retention of language learning". Since the task of langue learning requires repeated learning, it should be performed through a routine. Thus, incorporating enjoyment into the routing can be a crucial element for successful language learning.

There is a great deal of research to support this recommendation. Wehner, Gump, and Downey (2011) conducted a comparison experiment while teaching undergraduate students taking a Spanish course through a traditional curriculum or by utilizing a simulation game in Second Life. They used the Attitude/Motivation Test Battery (Gardner, 1985) to measure anxiety and motivation. They reported 75% showed more positive results in favor of the Second Life scenario group due to having a sense of anonymity in the simulation game makes learners less anxious and more comfortable to interact with each other. However, we need to prove whether different medium (e.g., computer, mobile, and VR) may cause different results.

H4. During L2 learning, participants who are assigned to VR-based learning will report higher enjoyment compared to participants who are assigned to desktop-based learning.

Motivation as Active Learning

Motivation has an important role in the success of language learning (Klein, 1986) because language learners need to maintain motivation through the repetition of the language until mastery (Brown, 1980). VR is designed in a manner that keep the motivation (Kreylos, Bethel, Ligocki, & Hamann, 2003) because fully immersive environment can block distractions, in order to make the environment where the students can focus on for their learning objectives. Several VR studies revealed that students who used VR HMD show better concentration (Hussein & Nätterdal, 2015) because VR provides the opportunity for learning and developing an idea in an environment similar to reality.

Furthermore, the interactivity by using VR can transform students from passive learning to active learning (Pantelidis, 2010). For example, Merchant (2012) analyzed the learning of chemistry concepts in a 3-D VR environment through spatial instruction where learners could break apart a molecule or bond atoms to form a molecule enabling them to examine its bond angles virtually. He found that the students with 3-D molecule seemed better understanding of chemistry concepts and became more active learner.

Evidence exists to indicate the advantages of VR include keeping students motivated, playing an active role in the learning process, and providing an experience with learning autonomy and high immersion (Bricken & Byrne, 1993; Loftin, Engleberg, & Benedetti, 1993; Regian, Shebilske, & Monk, 1992). So, VR may be considered an efficient language learning tool, and the following hypothesis will help elicit if this is the case:

H5. During L2 learning, participants assigned to VR-based learning will report higher motivation compared to participants who are assigned to desktop-based learning.

Correlation Between Spatial Presence, Enjoyment, and Motivation

First, there may be a correlation between spatial presence and enjoyment. Skalski and Tamborini (2007) stated, “spatial presence is a driving component of media enjoyment.” Shafer et al. (2011) also stressed that the feeling of spatial presence is an important factor in enjoyment. They researched to measure spatial presence and enjoyment by comparing the three gaming systems, Wii, Move, and Kinect, with 160 university students randomly assigned to one of the platforms to report their experience. The result revealed a positive impact of spatial presence on enjoyment as the more the respondents felt a sense of presence within the game, the more enjoyment was experienced. The research of Lombard, Reich, Grabe, Bracken, and Ditton (2000) found the different displays affect presence and enjoyment. Thus, in this paper, the relation between spatial presence and enjoyment via different displays (i.e., desktop monitor versus VR HMD) is analyzed.

Second, spatial presence is associated with motivation. Research by Mikropoulos, Chalkidis, Katsikis, and Emvalotis (1998) on the motivation of students towards VR as a tool in the educational process as well as towards virtual learning environments in specific disciplines, examined students had a positive attitude towards VR in the educational process. In this sense, people prefer VR over other electronic mediums for education (Pantelidis, 2010). Emotions are also important when dealing with virtual teachers in distance and learning contexts. The presence of a realistic character proved to have a positive impact on students' perception of the learning experience (Lester et al., 1997). Virvou, Katsionis, and Manos (2005) found increasing motivation while playing an educational VR game (i.e., VR-ENGAGE) which requires navigation feature in the virtual worlds.

Third, enjoyment has a strong relationship with motivation. Teo, Lim, and Lai (1999) expressed in their research how perceived enjoyment is a form of intrinsic motivation. They were curious in the purpose of how the Internet was used, so they investigated the reasons through the two lenses of intrinsic and extrinsic motivation. In this research, they suggested intrinsic motivation is tantamount to a perceived enjoyment, and extrinsic motivation refers to perceived usefulness. Other research showed that interest in an activity, inherent satisfaction with an activity, and enjoyment of an activity could increase intrinsic motivations (Ryan & Deci, 2000). They expressed that enjoyment is the primary motivating factor of satisfaction (Frederick & Ryan, 1995), which can be generated when people play a video game or recreational activity through entertainment media (Ryan et al., 2006) as they fall within the realm of activities that are intrinsically rewarding. Thus, based on the past literature review, enjoyment can be a trigger for increasing motivation.

Prior studies noted the importance of correlations between spatial presence, enjoyment, and motivation. As the goal of this paper is to investigate how different media affect L2 learning along with the advantages of using VR, the following hypothesis must be considered:

H6. Positive correlations exist between spatial presence, enjoyment, and motivation during L2 learning.

Research Model

Based on the past literature reviews, the research is overviewed on how it will take a look at these relationships in L2 learning and investigate if VR is a good language learning tool. There are likely associations between media, memory, and motivation, such as (1) spatial presence may affect spatial memory, (2) spatial presence may affect motivation. Considering both the above literature studies, research model is proposed as seen figure 2.

First, spatial presence is apparently an essential feature for L2 learning in VR and is related to spatial reasoning ability (Taylor, 1997). Taylor found the correlation between the presence and spatial memory. A high level of immersion may have a high spatial memory. Also, the spatial presence may be a mediator connecting memory, enjoyment, and motivation. Hartmann et al. (2015) states, “if spatial presence is understood as a cognitive feeling, then it can be entirely based on unconscious processes even though users consciously experience the sensation.” In fact, people can perceive the spatial presence unconsciously and recall it from the subconscious. Thus, since VR has a high spatial presence, it may help increase spatial memory unconsciously and to remember the L2 better.

Second, to claim VR as a latent language learning tool, the media’s learning effects must be proved. Many scholars researched the correlations between spatial presence, enjoyment, and motivation as in the relationships explained above of (1) spatial presence affects enjoyment and (2) enjoyment affects motivation.

The unparalleled experience of presence is the most significant motivation for using VR. Research by Mikropoulos et al. (1998) on the motivation of students towards VR as a tool in the educational process, and towards virtual learning environments on specific disciplines, incurred students had a positive attitude towards VR in the educational process. In that sense, people prefer VR over another electronic medium of education (Pantelidis, 2010).

As aforementioned the media effects, it is important to examine the correlation of the variables (i.e., media, spatial presence, spatial memory, enjoyment, and motivation) by comparing the medium (i.e., desktop monitor and VR HMD). Thus, to prove whether VR is a good language learning tool or not, based on results of the two studies, the following research question should be answered:

RQ 1. Does the VR have a latent L2 acquisition feature?

Method

Stimuli and Apparatus

A 3D language learning environment was created using Unity 3D design and several designed virtual objects. The simulated classroom environment was created. The first, which we call the spatial language environment, a set of hat, chair, bookshelf, drawer, map, calendar, lecture desk, blackboard, clock, light, heater, earth, desk, Notebook, follow Jar, bag, picture, pencil, window. The objects were randomly displayed around the virtual classroom. When the participant was near a target object, a Korean cue card appeared over the object with the Korean work and phonetic spelling. The cue card disappeared when the participant stepped away from the object (Figure 2)

Participants experienced the virtual environment using either a (1) 17-inch PC monitor or (2) Oculus Rift device (Figure 3).

Participants

A total 64 participants were in the experiment and were equally balanced across conditions. The participants had no prior knowledge of the Korean language. Although none spoke Korean the majority of the participants were multilingual (multilingual, N = 47; unilingual, N = 17). The gender of participants (M = 32, F = 32) balanced across conditions in order to prevent gender effects. The range of age was between 18 and 65 years old; the average age of participants was 27.28 (SD = 8.02). The participants were compensated five dollars for their involvement.

Procedure

The experiment included a (1) pre-memory test, the (2) experimental treatment, a (3) post-memory test, and a (4) questionnaire. First, all participants completed a paper-based pre-memory test during which they memorize the 20 items and match the images and Korean words. Second, the participants are randomly assigned to either the desktop monitor or VR HMD experimental setup. Third, after experiencing the language learning content, they complete a spatial memory test. Finally, all participants complete a questionnaire to measure perceived interactivity, spatial presence, enjoyment, and motivation (Figure 4).

The pre-memory test provided an initial stage to check how many Korean words the participants knew. They were provided information on 20 items they could find in a classroom (Figure 5), and the participants were asked to memorize the items for three minutes, which is a period identified based on the pilot test. The memorization was evaluated for image recognition through matching the images and words by drawing lines, which was adopted from the Griffin and Robinson (2000) experiment comparing images listed in a row and images in a location map.

Before starting the experiment, the baseline was contacted to all participants in order to (1) eliminate the novelty effect and (2) to make them comfortable to use the medium. After practicing with the tutorial, if the participant was randomly selected for the desktop condition, then they used the mouse and keyboard to watch and interact with the virtual module through a computer monitor. The participants assigned to the VR condition wore the HMD goggle to watch and interact with the module and used a controller to move around in the environment (Figure 6).

After the experiment, the participants were given five minutes to perform a spatial memory test to identify how many items they could memorize based on location. The testing tool was a classroom map sheet on which the participants were provided with the same classroom map previously experienced during the experiment. Also, numbers were included on each item, and the participants were asked to write the corresponding number for where the item was located in the virtual classroom. After completing the experiment and tests, the participants completed a set of questionnaires measuring: spatial memory, spatial presence, enjoyment, and motivation.

Measurements

Image Recognition was measured from an image recognition test (M = 5.90, SD = 2.87) used to match the images and Korean words, and the participants drew lines to match 20 classroom items.

Spatial Memory was measured from a spatial memory test (M = 12.09, SD = 5.76) that consisted of a map of the classroom and a list of 20 numbered objects' image, and the participants were required to match the correct location to the number (each object had a uniquely assigned number) based only on memory recall.

Memory was calculated from the post-test (i.e., the spatial memory test) less the pre-test (i.e., the image recognition test) values from which we determine the memory retention.

Spatial presence (α=.75, M = 5.17, SD = .92) was measured using seven questions related to spatial cognition allowing for physical aspects to be considered (Biocca, 1997). For example, questions were introduced as “The classroom seems to be more like,” “The module that I participated seems to be spatially immersive,” “I can feel the space,” and required participants to respond on a 7-point Likert scale (1=Strongly disagree; 7= Strongly agree).

Enjoyment (α=.91, M= 5.58, SD =.93) consisted of six adjectives representing enjoyment: “entertaining,” “interesting,” “enjoyable,” “fun,” “exciting,” and “satisfying.” These options were based on the enjoyment subscale (Tamborini, Bowman, Eden, Grizzard, & Organ, 2010) and modified for a language learning context. Participants were asked to indicate how much they enjoyed the module based on their experience by rating their statements on a 7-point Likert scale (1=Not at all; 7= Extremely).

Motivation (α=.85, *M*= 4.83, *SD* = 1.16) consisted of six questions such as "After interacting with the program, I want to learn Korean more," "After interacting with the program, I am confident in learning Korean vocabulary," "I think the module enhanced my efficiency of learning a language (e.g., vocabulary)," using a 7-point Likert scale (1=Strongly disagree; 7= Strongly agree). These questions mixed with intrinsic and extrinsic motivation (Teo et al., 1999).

Results

For analysis of the quantitative data, SPSS (version 21) and AMOS (version 21) were used. Among 64 people who participated in the experiment, six responded with a minimum of 4 for the question, "How much do you know Korean?" These participants were excluded from the data analysis leaving only 58 participants for data analysis, N = 30 of which were deployed to the desktop condition and N = 28 to the VR condition. Also, based on proposed research model, each hypotheses and research question are shown (Figure 7).

Media Effects in VR: Test of H1, H4, H5

H1 tested the effects of the media on spatial presence through a one-way ANOVA to compare the desktop monitor and VR HMD. H1 predicted that the participants assigned to the VR-based learning condition would have a higher sense of spatial presence than the participants assigned to the desktop-based learning condition. The results showed that there are significant differences in the spatial presence F (1, 56) = 5.65 ($p <.05$, η_p^2 =.09) between the participants who used the desktop monitor and those who used the VR HMD (see Table 1). Therefore, H1 is supported.

H4 was a test of the effects of the media on enjoyment through a one-way ANOVA to compare the enjoyment of the desktop and VR medium. H4 predicted that the participants assigned to the VR-based learning condition would perceive a higher enjoyment than the participants assigned to the desktop-based learning condition. The results showed significant differences in enjoyment F (1, 56) = 6.85 ($p < .05$, $\eta_p^2 = .11$) between the participants who used the desktop monitor and those who used the VR HMD (Table 5). Therefore, H4 is supported.

H5 was a test of the effects of media on motivation through a one-way ANOVA to compare the motivation expressed from the desktop and VR. H5 predicted that the participants assigned to the VR-based learning condition would feel a higher motivation than the participants assigned to the desktop-based learning condition. The results showed significant differences in motivation F (1, 56) = 4.48 ($p < .05$, $\eta_p^2 = .07$) between the participants who used the desktop monitor and those who used the VR HMD (Table 5). Therefore, H5 is supported.

Memory Retention in VR: Test of H2

H2 measured how memory is changed from pre-test to post-test scores on the media through an analysis of covariance (ANCOVA) with the pre-test scores as covariates. Effect sizes were computed by using Cohen's *d* by dividing the post-test mean differences between the two groups by the pooled standard deviation in the between-subject design. Effect sizes of 0.20 reflected a small or minimal effect, 0.50 as a medium or moderate effect, and 0.80 or higher as a large or meaningful effect (Olejnik & Algina, 2000). In this memory test, the effect size of medium is small (0.10). This value is explained dependent variable by independent variable (10%).

The means of the pre-test and post-test scores for the desktop and VR condition are presented in Table 2 and show there is an increase in both conditions (Figure 8). Levene's test and normality checks were performed and the assumptions met. Table 3 outlines the results of ANCOVA. When the covariate pre-test was controlled, the effect of media on the post-test was significant, $F(1, 56) = 4.57$, $p < .05$. Therefore, H2 is supported.

Spatial Presence and Memory: Test of H3

H3 was a test between the spatial presence and memory by calculating a simple linear regression to predict the memory based on spatial presence. First, the dependent variable, memory, was calculated as the mean values from the formula of pre-test minus post-test scores. Spatial presence significantly predicted memory, B = .26, t (2, 56) = -.43, p = .67 as well as explained a significant proportion of the variance in memory, R^2= .07, F (1, 56) = 4.07, p < .05. Thus, H3 is supported.

Spatial Presence, Enjoyment, and Motivation: Test of H6

H6 predicted that spatial presence, enjoyment, and motivation are positively correlated depending on the media. Among these correlations, the relations of spatial presence and enjoyment (Skalski & Tamborini, 2007) and enjoyment and motivation (Ryan & Deci, 2000) must be explained in detail, which is presented in the graphs showing the relationships in Figure 9. The means, standard deviations, and correlations were calculated for the spatial presence, enjoyment, and motivation (Table 4), and Pearson correlation was used for this analysis of H6. As Evans (1939) suggested for the absolute value of r, there was a strong positive relationship between spatial presence and enjoyment, r (56) = 0.51, p < 0.01. In addition, the Pearson correlation identified the correlation between enjoyment and motivation and showed a strong positive correlation, r (56) = 0.58, p < 0.01. Last, Pearson's r data analysis revealed a strong positive correlation between spatial presence and motivation, r (56) = 0.57, p < 0.01. Therefore, strong correlations between spatial presence, enjoyment and motivation are corroborated.

Spatial Presence as Mediator: RQ1

To corroborate RQ1, a structural equation model (SEM) was conducted using the

AMOS 21 software. Before starting the path analysis, each path needs to verify validity by regression, and the results revealed they are significantly different as seen in Table 5.

In the next step, a model-fit was assessed using the most common goodness-of-fit (GOF) indices (Hair, Black, Babin, Anderson, & Tatham, 1998). The most frequently reported indexes include CFI > 0.90 (Bentler, 1990), GFI > 0.90 (Joreskog and Sorbom, 1984), RMSEA < 0.08 (Browne and Cudeck, 1993), and Chi-square/df < 3.0 (Marsh and Hocevar, 1985). According to this level of acceptance, the model fit statistics applied to this research indicated an acceptable fit of the model (Normed χ^2 = 1.219, CFI= .982, GFI= .961, RMSEA = 0.63, Chisq/df =1.219, TLI= .946) (Table 6). Although the model fit is not fully satisfied (e.g., AGFI > 0.90), it remains an acceptable fit of the model.

The two groups, desktop monitor condition(N=30) and VR HMD condition (N=28), were next analyzed in the multigroup SEM. At the structural level, the test yields the standardized path coefficients, which indicate the positive and negative relationships between the constructs as well as their statistical significance. 5000 bootstrap samples at 95% bias-corrected confidence intervals were used to analyze the path model. As seen in Table 7, the test of the path coefficients for the two samples was compared to identify possible interaction effects between the medium and the constructs.

There are several paths for which the critical ratio of differences showed significant variation. In the desktop condition, two significantly different paths existed in Spatial presence →Motivation (C. R.= 2.34) and Enjoyment → Motivation (C. R.= 2.14). In terms of the VR HMD, two paths also proved to be significantly different in Spatial presence → Enjoyment (C.R.= 5.34) and Enjoyment → Motivation (C.R.= 2.35). Figures 12 and 13 contain the schematic representation of the final model with the standardized estimates for each sample studied.

As the next step, Figure 10 and 11 presents the comparison of the multigroup analysis in the structural model to find if there are significant differences between the structural models for the two investigated samples. The z-score was calculated for each path using the regression weights in two samples and the critical ratios matrix. If both samples are together, then the only path of spatial presence → enjoyment is significantly different (Table 7). Therefore, RQ 1 is partially supported.

Discussion

VR Increases Memory

The study investigated correlations between media and memory. Results of H1 indicated that VR offers higher spatial presence than desktop. Considering the spatial presence theory, this was an expected result as a large amount of research has supported that spatial presence is high if the immersion level is high (Bricken, 1991; Dede, Salzman, & Loftin, 1996; E. A. Johnson, 2010; Katz & Halpern, 2015). Out of the several factors that increased immersion levels, the delivery device was found to be most significant. VR HMD provides a 360-degree environment, which generates high immersion levels.

Kim et al. (2012) facilitated a fully immersive environment with the following factors. First, the simulation must be interactive. The participants interact with Korean cue cards with corresponding 3-D objects, such as a hat, pencil, desk or shoes. Second, the simulation must have familiarity (Mania & Chalmers, 2001). The background stimulus environment is the classroom, which is familiar context for most participants. Third, the first-person perspective must be used to increase immersion levels.

H3 assumed that an increase of spatial presence affects memory retention. The result of a linear regression test between the spatial presence and memory in the medium of the desktop and VR conditions together verified a positive correlation and significant difference. However, when the path analysis was conducted for the VR condition, there were no differences. It is argued that spatial presence affects memory retention, but in unpredictable ways in the use of VR (Groom, Bailenson, & Nass, 2009). Unsurprisingly, the study by Mania and Chalmers (2001) revealed a significant negative association between physical presence and memory, concluding that memorization is associated with individual differences, including the participants' ability to remember certain types of information, limited cognitive capacity, and mediated arousal. Thus, presence is not always associated with memory retention. The following section will explain how spatial presence with arousal affects memory retention.

The question remains if VR affects memory retention. H2 examined the memory test in desktop and VR. The results indicate that memory score in VR is 7.64 greater than desktop from pre-test to post-test. These findings suggest that VR has potential for enhancing memory retention though spatial presence does not directly affect memory retention in VR condition.

The purpose of this study is to identify how the mechanism of the 'Method of Loci' can be applied in VR and positively affect language learning outcomes. However, the remembering and memorizing process are different. The "remember" awareness state is linked with episodic memory (Tulving, 1985). "Remembering" is defined as a state in which "images" relating to a past event or space come to mind during the process of recall. Alternatively, "memorization" is intentionally attempting to remember a cognitive process. The 'Method of Loci' is a process of memorization rather than remembering. In this experiment, the differences between these two processes were not explained to participants. Thus, we suspect that participants may have recalled objects in such a way that resembles the remembering process.

Results found by Mania and Chalmers (2001) agreed with our findings. Comparing real environment, desktop, VR HMD, and audio-only conditions, VR HMD resulted in the highest recall in remembering. This research supports that HMD is effective for remembering objects. In sum, VR HMD is an effective tool for increasing memory retention, but additional research is required to study the relationship between spatial presence and memory.

VR Increases Motivation

An advantage to using VR in education is that it increases motivation for learners (Bricken & Byrne, 1993; Kreylos et al., 2003; Loftin et al., 1993; Merchant, 2012; Regian et al., 1992). H1, H4, and H5 were conducted to verify the media effects of spatial presence, enjoyment, and motivation by comparing desktop and VR. These three factors in VR were revealed to be higher than those in desktop. K. M. Lee (2004) asserted that the more spatial cues the medium offers, the more attentive and motivated users would be. As suggested by the strong positive correlation between spatial presence and motivation found in H6, spatial presence may affect motivation.

Enjoyment has been found to be essential for learning due to its strong association with motivation in the learning process (E. A.-L. Lee, Wong, & Fung, 2010). Enjoyment reduces stress or fear when practicing a language. Motivation is increased when people enjoy a task (Deci, 1972). Among the correlations between dependent variables, correlation between enjoyment and motivation was the highest (r = .58). Even in the multigroup SEM model, the path spatial presence to enjoyment and enjoyment to motivation were significantly different. This suggests that enjoyment is moderating the spatial presence to the motivation path. Enjoyment can help reduce stress or anxiety to study (W. L. Johnson & Wu, 2008), which is why many game-based learning systems use this strategy to enhance confidence and motivation without a negative response. Therefore, since VR showed a significant difference in the path analysis of spatial presence to motivation, enjoyment factors should be considered for increasing motivation.

Furthermore, H6 and RQ1 showed a strong correlation between spatial presence and motivation. The spatial presence is high in VR as verified in H1, and with this increased spatial presence, VR facilitates motivation. For example, a participant commented that VR was fun because of the freedom they felt when controlling their virtual arm in the environment. With a high immersive environment, autonomy for learners can increase motivation (Ho & Crookall, 1995), which was similar to results found by Merchant (2012), who reported VR enhances learning of molecular 3-D structures or atomic bonds giving more agency to students as active learners, promoting self-study. Therefore, from the path analysis and result, VR-based learning can increase learner motivation.

VR is a Good Language Learning Tool

VR is a useful language learning tool as it has a latent language acquisition based on the results. From H1 to H6, VR demonstrated superior results compared to desktop, including higher memory scores, spatial presence, enjoyment, and motivation. The participants who used VR showed a higher satisfaction as seen in the survey question, “Do you think this language learning program was effective for learning a language?” receiving 5.79 for VR and 4.97 for desktop out of 7 on the Likert scale. Most of the participants expressed satisfaction with the VR language learning tool.

However, VR could not adequately explain what makes the ‘Method of Loci’ possible because spatial presence failed to show an impact on memory retention. Although the memory retention in VR was higher than that in desktop, and media effects such as spatial presence, enjoyment, and motivation were also higher in VR, the exact mechanism for increasing memory retention could not be concluded. Thus, additional research is needed for identifying factors affecting memory retention.

The current study contributes to the current literature on VR-based learning as there has been very little work in this area. Comparisons between two different interfaces and measured media effects have been rare in the literature. Additionally, this study deepens the current research literature on creating new language content. VR-based learning is currently in its nascent stages. Thus, there has been a need for further verification using novel VR methods for learning. In terms of language content, this paper offers a guide on how to leverage the advantages of VR HMD in language learning.

Limitations and Future Research

The current study aimed to measure the media and language learning effects as a communication lens. As a language learning purpose, however, it requires more work for implications from a language learning perspective. Learning words cannot be referred to as a full language learning activity as learning a language requires many processes, such as memorization, learning grammar, speaking practice, and situationally relevant drills. According to by Richards (2002) covering the theories of methodology in language teaching, he emphasized that language learning is a process to memorize, and learning occurs through dialogs and drills. As such, while memorizing words is a core feature, speaking and listening to language is also important. Thus, learning words alone is not enough to thoroughly verify language learning effects. For further research, a broader variety of learning contents need to be compared such as conversation simulation content.

Secondly, the memory test conducted in the experiment was measuring short-term memory exclusively. Information stored in short-term memory decays completely and is lost in approximately 30 seconds. Long-term memory is a permanent repository. The brain localizes the information in long-term or short-term memory (Atkinson & Shiffrin, 1968). For future work into verifying external validity, both short-term and long-term memory should be measured to support the argument that language learning in VR is effective.

Conclusion

This study tested media and educational effects in VR for language learning. From the perspective of 'Memory of Loci', VR impacts language learning using spatial memory, which facilitates memory retainment and acquisition of vocabulary as the process is related to L2 acquisition via unconscious mechanisms.

From the perspective of communication, this research contributed to the literature on how to find the right medium for the right content. Biocca and Delaney (1995) implied, "the computer is a protean technology; VR is a protean medium" (p. 118), which may be interpreted that VR could be widely used as a messenger in a variety of fields. In this case, VR is used as a medium to learn a language. Thus, this study provides an approach to verify the media effects of VR in language learning. If learners use VR in language learning, they can have a high sense of spatial presence which may potentially lead to positive learning outcomes.

From the technology perspective, the effectiveness of using VR learning environments should be further explored. It is essential to measure the user's performance when engaging in such an innovative technology. Although much research has been done on VR, investigations for practical application purposes is still limited (Tinianow, 1997). Thus, this study aids in finding ways to improve VR design for practical purposes, such as language learning. Also, the results showed that people are inclined to use VR rather than a computer. It can be argued that if VR technology is used appropriately, media effects such as enjoyment will be increased. In that point of view, this research provides positive influences for VR educators considering VR technology in their classrooms. Therefore, this study contributes insight into evaluating the most suitable candidates for learning through VR use.

From the language learning perspective, the study focused on the effectiveness of VR technology as well as language learning. Through the study, it was concluded that VR increases memorization via simulation, and this innovative approach can be beneficial for L2 learners. Due to a sense of presence, if learners replicate language study in VR simulation, it can help them remember words more efficiently. Thus, VR can be a valuable language tool for simulating real-world situations and increase language learning.

VR-based learning has potential as an effective form of pedagogy for teaching L2 based on the three perspectives outlined above. This study offers meaningful implications as a first feasibility test regarding spatial memory and language learning. Thus, this study bridges the utilization of VR and L2 learning. In the future, VR content creators can consider the following factors as a guide for designing VR language learning content in the future. (1) Using a high spatial presence through VR will increase memory retention, and by following the strategy of the 'Method of Loci', a memory game in VR could support enhanced language memory. (2) Spatial presence is the most important factor for increasing enjoyment and motivation via VR. Thus, when creating VR content, presence factors, such as high resolution, spatiality, and interaction should be considered in the design of the VR language learning content. Finally, despite the research finding some interesting results on how spatial presence mediate media effects to increase language learning in VR, more empirical studies of VR must be conducted to create better VR language learning content.

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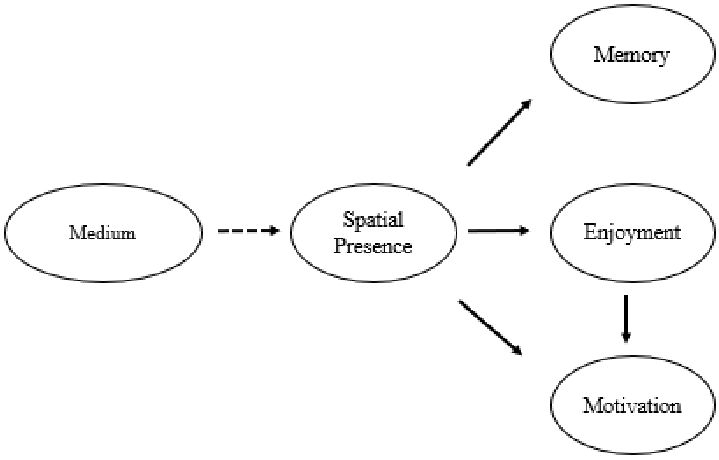


Figure 1. Proposed Research Model

Figure 2. Appearance of Stimuli

Figure 3. Medium Used to Present the Virtual Environment (Left: Desktop Computer Equipment, Right: VR Apparatus)

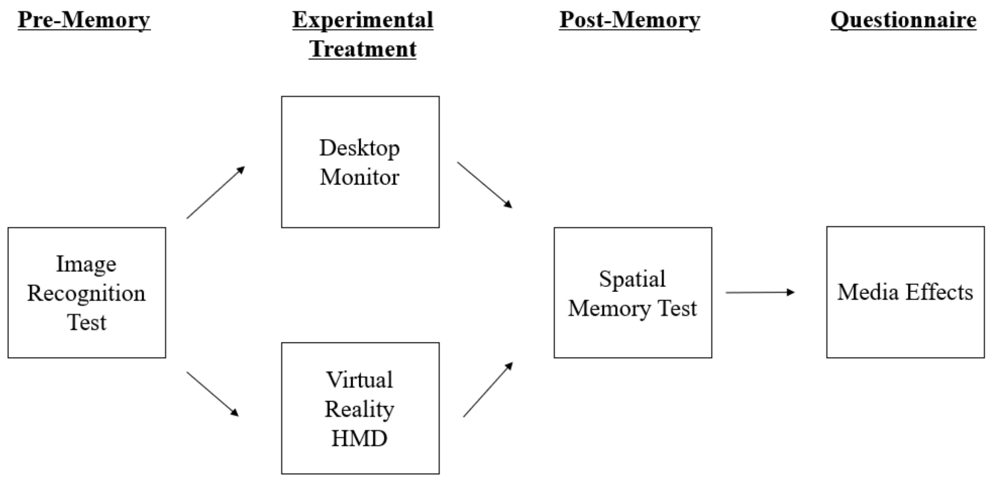


Figure 4. The Experimental Procedure

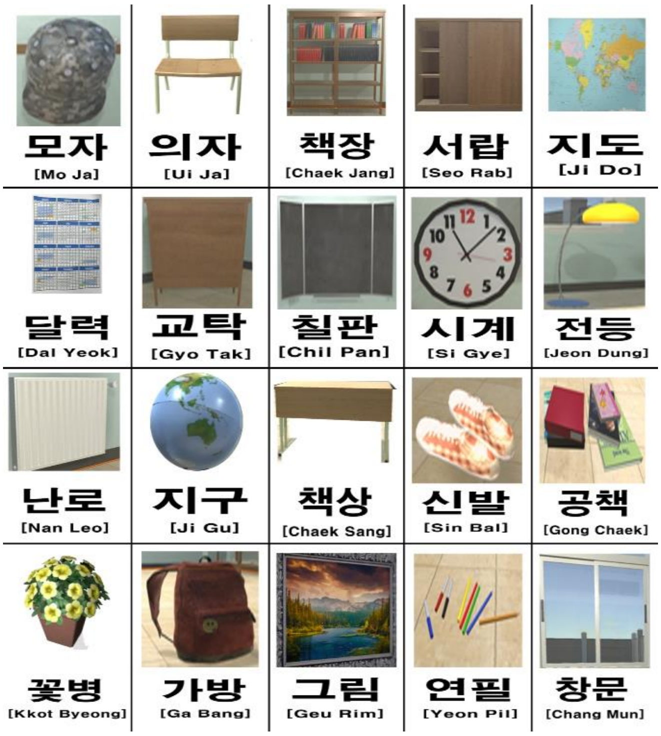


Figure 5. Korean Words of 20 Classroom Objects

Figure 6. Experimental Setup with Participants Interacting with the Virtual Environment (Left: Desktop Condition, Right: VR Condition)

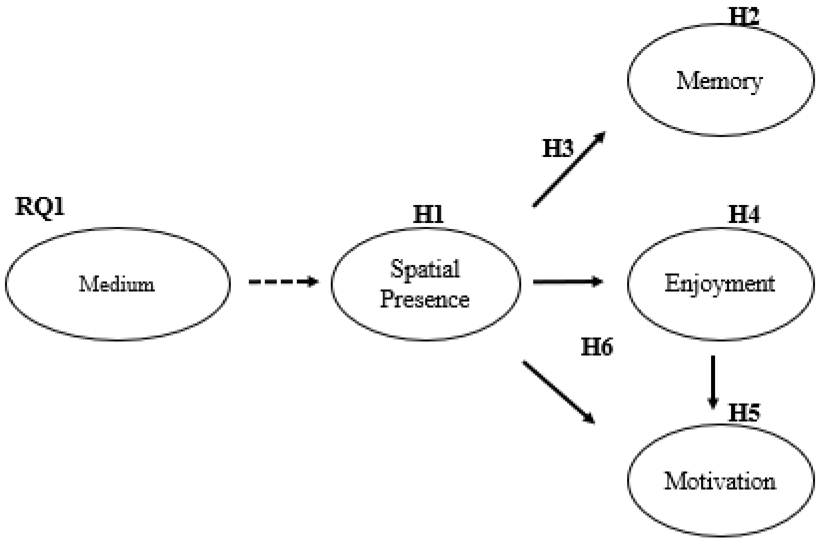


Figure 7. Hypothesized Relations Between the Constructs

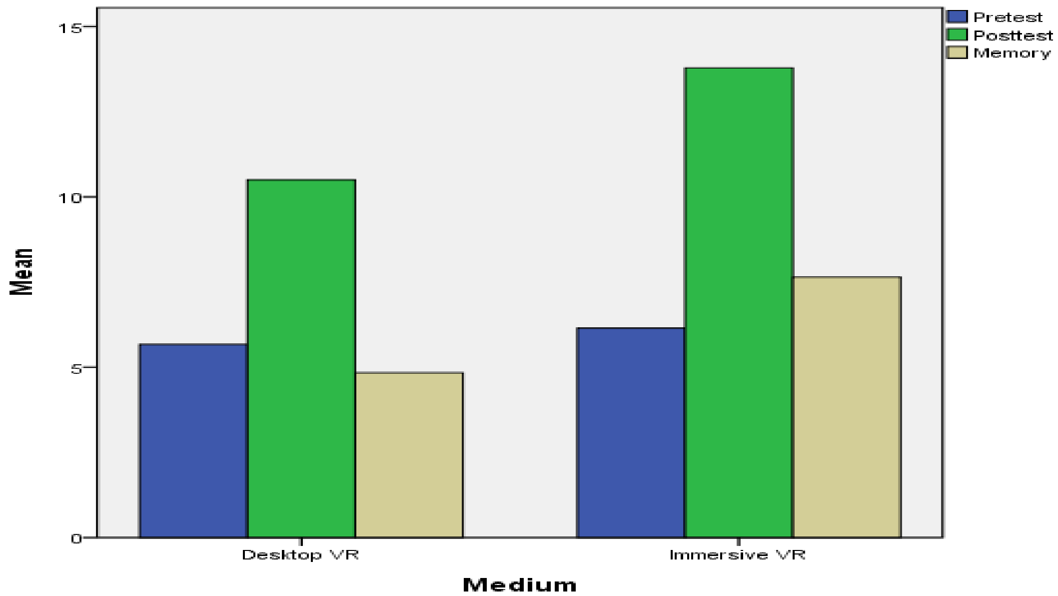


Figure 8. A comparison of the means of memory for the two independent variables

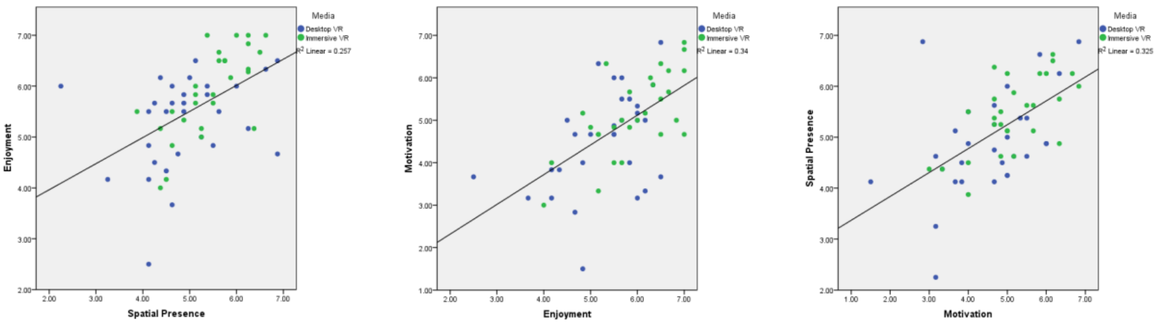
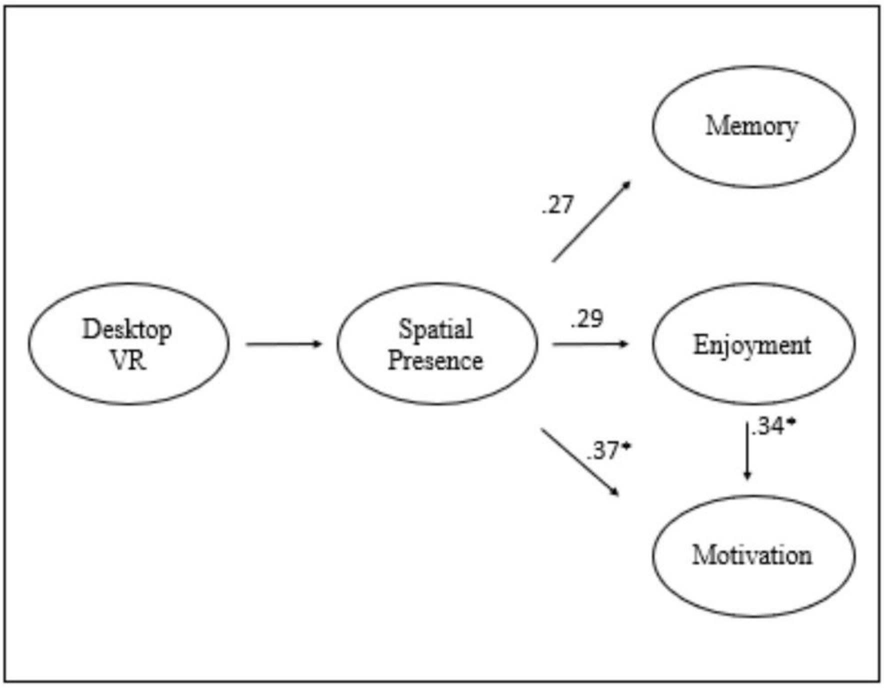
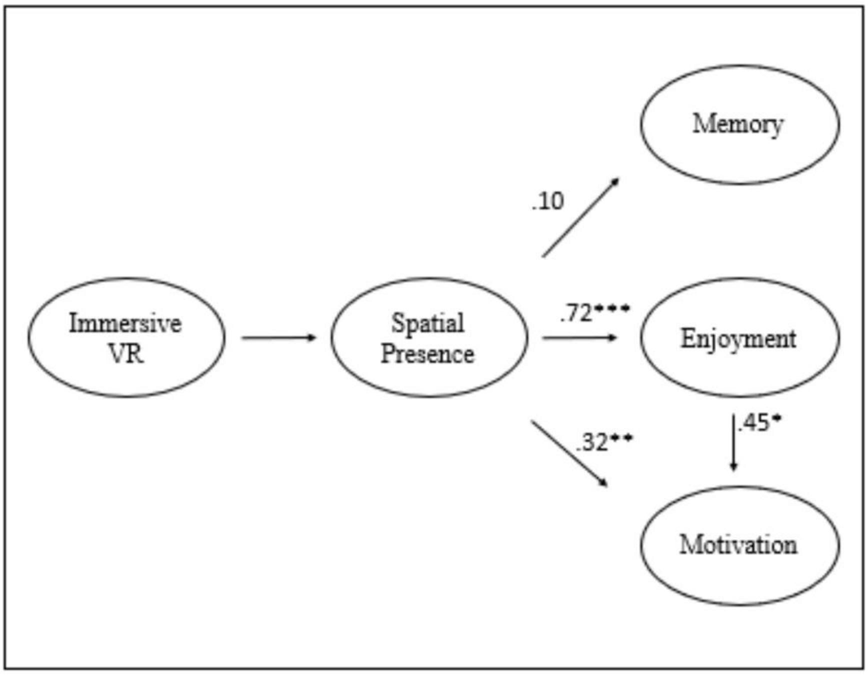


Figure 9. Correlations between Each Variable



Note. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Figure 10. The Final Model for the Desktop-based Learning with Standardized Estimates.



Note. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Figure 11. The Final Model for the VR-based Learning with Standardized Estimates.

Table 1.

ANOVA of Dependent Variables: Test of H1, H4, H5

	Desktop-based learning		VR-based learning				
DVs	M	SD	M	SD	F (1, 56)	η_p^2	*P*
Spatial Presence	4.90	1.00	5.45	.73	5.65*	.09	.02
Enjoyment	5.29	.92	5.90	.85	6.85*	.11	.01
Motivation	4.54	1.18	5.14	.96	4.48*	.07	.04

Note2. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$ two-tailed.

Table 2.

Memory Test Scores.

	Desktop-based learning		VR-based learning		
DVs	M	SD	M	SD	P
Pre-test	5.67	3.48	6.14	2.10	.53
Post-test	10.50	6.04	13.78	5.02	.03
Memory	4.83	5.09	7.64	5.42	.05

Table 3.

ANCOVA Results of the Post-test with Controlled the Pre-test

Source	*SS*	*df*	*F*	η^2	*p*
Pretest	235.27	1	8.60**	.14	.01
Condition	125.00	1	4.57*	.08	.04
Error	1504.94	55			
Total	10369.00	58			
Corrected total	1896.57	57			

Note2. $*p < 0.05$, $**p < 0.01$, $***\ p < 0.001$, $R^2 = .18$

Table 4.

Correlations Among Recognition Test and Measured Variables: Test of H6

	M	SD	1	2	3
1. Spatial Presence	5.17	.92	1		
2. Enjoyment	5.59	.93	.51**	1	
3. Motivation	4.83	1.12	.57**	.58**	1

Note1. **p* < 0.05, ***p* < 0.01, ****p* < 0.001, two-tailed.

Table 5.

Unstandardized and Standardized Regression Coefficients by the Medium

Path	b	S.E.	B
Spatial presence → Memory	1.53	.76	.26*
Spatial presence → Enjoyment	.51	.12	.51***
Spatial presence → Motivation	.69	.13	.57***
Enjoyment → Motivation	.70	.13	.58***

Note2. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Table 6.

Goodness-of-fit Indices for This Research

Name of category	Name of index	Measured model fit	Threshold
1. Absolute fit	Chi-Square	.300	P-value > 0.05
	RMSEA	.063	**RMSEA < 0.08**
	GFI	.961	**GFI > 0.90**
2. Incremental fit	AGFI	.805	AGFI > 0.90
	CFI	.982	**CFI > 0.90**
	TLI	.946	TLL > 0.90
	NFI	.919	NFI > 0.90
3. Parsimonious fit	Chisq/df	1.219	**Chi-square/df < 3.0**

***The indexes in bold are recommended since they are frequently reported in the literature

Table 7.

Standardized Coefficient and Z-score in Both Environment Interfaces

Path	Desktop-based learning		VR-based learning		z-score
	Standardized coefficient	C.R.	Standardized coefficient	C.R.	
Spatial presence → Memory	1.376	2.34	.755	.532	-0.368
Spatial presence → Motivation	**.440***	2.34	.420	1.66	-0.061
Spatial presence → Enjoyment	.268	1.65	**.829*****	5.34	**2.491***
Enjoyment → Motivation	**.438***	2.14	**.515***	2.35	0.256

Note2. $*p < 0.05$, $**p < 0.01$, $*** p < 0.001$