ASSESSING THE EFFECT OF INTERACTIVITY ON VIRTUAL REALITY SECOND LANGUAGE LEARNING

by
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Acknowledgments

First and foremost, I hope that my research can contribute to the study and development of educational Virtual Reality Language Learning content. Language learning is a global endeavor that can connect us to one another. As an old proverb says "To learn a language is to have one more window from which to look at the world."

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Abstract

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Virtual Reality (VR) being used as a helpful tool in language education is widely supported by the current literature. It can provide a variety of stimulating scenarios that keep learner engagement high. The use of VR for language learning is a research area that has shown promise in recent years. This makes it necessary for further research to be conducted in the field to determine ways to maximize its potential. This thesis aims to determine if the level of interactivity present in a VR Language Learning Application is a factor that will impact a user's capability to successfully learn a second language. Also, to discover an optimal level of interactivity needed to foster successful language learning in VR can be identified when dealing with subjects with different age, gender, and previous VR experience. To satisfy these aims, 3 versions of a VR Language Learning Application were created with varying levels of interactivity. Data collected from participants of this study were used to test efficiency of the VR language learning application. Results of this analysis determine that the level of interactivity present in a VR Language Learning Application is a factor that will impact a user's capability to successfully learn a second language. Also, according to the results, all interactivity levels are useful but no interactivity is the most optimal for successful language learning in VR.

Table of Contents

Table of Contents (Continued)

List of Figures

List of Tables

Chapter 1
Introduction

The way that people learn has not changed much over the course of history. The traditional method of teachers lecturing while students passively receive information has remained as the most reliable and widely used method. Improving education has steadily been an important topic in our society. The United States alone spends billions of dollars each year on the advancement of human knowledge (National Center for Education Statistics, 2018). New methods of knowledge acquisition have come and gone over the years, but the introduction of Virtual Reality into Education has captured the attention of teachers, students, and researchers alike. Although Virtual Reality's inception was in the early 1960's, it wasn't until the release of the Oculus Rift headset in 2012 that it became widely available and provided an affordable, high-quality Head-Mounted Display (HMD) to the public, including educators and students (Anthes, Christoph & García Hernandez, Rubén & Wiedemann, Markus & Kranzlmüller, Dieter, 2016). As the technologies and the availability of Virtual Reality continue to grow and evolve, so do the many possibilities of ways to enhance the learning experience.

1.1 What is Virtual Reality

Virtual Reality (VR) has been notoriously difficult to define since how it is defined can vary based on the specific type of VR being referenced. By the Oxford dictionary definition, Virtual Reality is "the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person." (Oxford Dictionary, n.d.). VR has created a shift in the way that people experience the digital world. The very first example of VR in history was the creation of the Sensorama in 1962 by Morton Heilig. The Sensorama was what Heilig described as a “multi-sensory theater”. It simulated the immersive experience of a bike ride through New York City by incorporating four senses, sight, sound, smell, and touch to create a realistic experience. (Stanford University Computer Science Department, 2011). Heilig’s ideas for creating a virtual world experience were never properly funded but they did inspire future works. The Sensorama was the inception of what would become Virtual Reality as it is known today.

There are hardware and software components that are necessary for creating and experiencing VR. Software components that are used to develop a virtual experience include 3D modeling software, 2D and 3D graphics software, sound editing and creating software, and VR simulation software. These softwares used together create everything a user sees and hears during a VR experience (Schmidt, 2011).

Some hardware components that are key to building a successful virtual experience include a computer workstation, sensory displays, tracking systems, and input devices (Schmidt, 2011). A VR computer workstation refers to a high-performance laptop or desktop computer. Most VR technologies cannot stand alone and must be connected to a computer workstation to function fully. A computer workstation with a high-quality CPU, graphics card, and memory is usually preferred for running VR in order to optimize the visualizations. A sensory display is what is used to show the virtual world to the users. The most widely known sensory display is the Head Mounted Display (HMD) which is probably the first thing that comes to mind when you think of VR (see Figure 1). A HMD is put on the head and has a screen that sits inches away from the eyes. This screen presents the 3D visuals directly to the eyes and spans the entire field of view to make the sights more realistic (V. R. S., 2017). Head Mounted Displays use head tracking technology to mimic the movement and turns of the user's head to aid in feelings of immersion. Again, most HMDs need to be connected to a computer workstation in order to work but HMDs such as the Oculus can stand alone as their own VR device.

Figure 1

Head Mounted Display, by (n.d.) www.htc.com/blog

Input devices are needed for the user to interact with the virtual environment. The most common VR input devices are handheld controllers. VR controllers have a combination of buttons, triggers, trackpads, or a thumb joystick that allow the user to grab, throw, and move virtual objects and allows users to move themselves around the virtual world (see Figure 2). These wireless handheld devices can register a user's physical hand and finger movements in the real world and translate them into digital hand and object movements within the virtual world. For example, users can grab a virtual object by pressing the trigger button on a controller and they can walk in a virtual world by using the trackpad.

Figure 2

VR Handheld Controllers, by (n.d.) www.htc.com/blog

The integration of these hardware and software technologies makes VR possible and together they produce a powerful experience for delivering 3D media that can be manipulated as if it were the real world. Emerging advances in these technologies and products will only further enhance the virtual experience.

1.2 Virtual Reality Applications

Today, VR is widely used to advance the fields of healthcare, entertainment, automotive, architecture, marketing, education and so much more. In healthcare, professionals are using VR medical training to better prepare for the real-world scenarios they are likely to face. Entertainment seeking VR users can use the technology to immerse themselves into virtual video game worlds without leaving the comfort of their homes. In the field of architecture, using VR, architects can create realistic 3D models of their plans to share with clients and other professionals. The military uses VR simulations to train for intense combat situations which they otherwise wouldn't be able to prepare for. In education, VR is used in classrooms to expose students to new learning methods and to appeal to students with learning difficulties. Today's VR applications allow humans to blur the boundaries between what is 'real' and what is virtual.

1.3 Statement of Problem

The idea that VR is a helpful tool in language education is widely supported by the current literature. Because VR can provide a variety of stimulating scenarios that keep the users engagement high its use has increased rapidly. Though untested, there were claims that since high degree of interaction and immersion were key factors often included in Virtual Reality Language Learning Applications, they may be factors that lead to effective second language learning (Legault et al., 2019). The aim of this paper will be to consider the key factor of interaction and assess its correlation to effective second language learning.

A Non-immersive VR environment is defined as one that is presented on a monitor and can be manipulated using a keyboard and mouse (Robertson et. al.,1993). An immersive VR environment is one that involves the use of a Head-Mounted Display (HMD). The current VR-related literature about second language learning mostly involves non-immersive Virtual Environments (Lan, 2020). Literature regarding second language learning in an immersive VR environment is still growing and new research is needed.

1.4 Purpose of the Study

New knowledge of the factors that are involved in successful immersive VR second language learning will allow for the design of new and more efficient immersive language learning software applications. For educators, this research could result in creative and modern ways to teach and engage students in the language classroom. For language learners, this research could result in a more beneficial and favorable learning experience. The aim of this thesis is to assess if the level of interactivity provided in a VR Language Learning Application plays a role in the users' ability to successfully learn a second language. Also, to determine if factors such as the users age, gender, and previous VR experience affect the learning outcome.

Chapter 2

Literature Review

2.1 Virtual Reality in Education

Education and training are pointed out as promising fields of VR implementation (Philippe, Souchet, Lameras, et al., 2020) It has become increasingly popular to incorporate VR into learning and training programs across a variety of fields of study. The use of multimedia resources such as images, videos, recorded presentations, interactive images, discussion forums, and audio recordings, offers learners the possibility to have content represented in a number of ways. This learning through multimedia has been incorporated into teaching and training due to its ability to encourage learners to develop a more flexible learning approach. But, in more recent years VR has been incorporated into education to take this flexible learning approach a step further. VR technologies push the limits of education and training by creating effective learning visualizations to represent teaching content and creating interactive and immersive environments for learners. Interaction and immersion are traits that can promote a learner's active learning (Saunders & Wong, 2020). These interactive and immersive environments are called Virtual Reality Learning Environments (VRLEs) VRLEs allow the learner more control than a traditional classroom teaching setting by giving them the ability to interact with the class material and virtual environment and manipulate characters or objects in the virtual environment. These environments are sharable learning spaces that have the ability to be accessed by all types of learners all over the world. Many organizations have already begun using VRLEs regularly for training and learning purposes. For example, within the healthcare industry there are

VRLEs created with the purpose of training incoming healthcare professionals on how to correctly perform their job tasks. Within the social sciences, there has been development of immersive VRLEs that teach psychiatrists and psychologists how to properly diagnose and treat common mental disorders (Gonzalez, Martin-Gorriz, Berrocal, Morales, Salcedo, Hernandez, 2017). In the agricultural sector, VRLEs are being used to decrease the likelihood of tractor related injuries and fatalities through realistic tractor driving simulations (Berger, Völkle, 2013). The benefits of VRLEs are also being explored in Second Language Learning scenarios.

2.2 Second Language Learning

While learning any new topic is already difficult for most people, the difficulties are multiplied when it is a new language that is being learned. The learning and teachings of new languages has been carried out for hundreds of thousands of years. Styles of language teachings continually change with the times. Developments of new principles, procedures, and approaches flood into the world of language learning as this field attempts to adjust to the shifts in the educational and social environment in which it is conducted (Anthes, Christoph & García-Hernandez, Rubén & Wiedemann, Markus & Kranzlmüller, Dieter, 2016). Second language learning (SLL) is defined as the process and study of how people acquire a second language (Rieder-Bünemann, 1970). The term second language, also known as L2 or target language, refers to any language learned in addition to a person's native language. In this context, second language learning can also be referencing a third or fourth learned language (Rieder-Bünemann, 1970). In any educational setting, second languages are typically taught based on the teacher's personal preference of methods. How it is taught can also vary based on the individual teacher's experience level with the language they're teaching. For example, whether or not the teacher is a native speaker of that language will surely have an effect on how they present it to students learning it as a second language. A difficulty that arises in regards to second language learning is that it involves pupils who vary in age, gender, intelligence, previous linguistic experience, motivation, and many other characteristics (Zafar & Meenakshi, 2012). This is why second language learning in a traditional classroom setting can be extremely difficult for people who struggle with the teaching approach being used. One single approach may not be the most effective for every student based on these defining characteristics. Clinical experience tests with university students suggests that students learning a second language can experience extreme anxiety. Some symptoms they could face include worry, dread, forgetfulness, struggles concentrating, avoidance behaviors, sweat, and even palpitations (Horwitz, Horwitz, Cope, 1986) while focusing on this area of study. But, despite the difficulties and challenges that are faced when it comes to learning a second language, it is a knowledge that is still sought out by many and oftentimes VR is used to make it happen.

Chapter 3

Methodology

3.1 Description of Research Design and Defining Interactivity Levels

Since this thesis aims to determine if the level of interactivity present in a Virtual Reality language learning application affects the user's ability to learn a second language, the study developed to investigate this included varying levels of interactivity. For this study, a No Interactivity, Low Interactivity, and High Interactivity version of an immersive VR language learning application was created to teach 15 Spanish vocabulary words to non-Spanish speakers. Each non-Spanish speaking participant of this study was assigned to complete one of the three interactivity levels of the VR language learning application. All three levels of the application were identical other than the level of interactivity provided. In each level, participants would explore the VR environment that was modeled after a busy city. The 15 Spanish vocabulary words were taught to the participant while they navigated through the city environment. Before the VR study takes place, participants completed a pre-study evaluation and immediately after the VR study takes place, participants completed the post-study evaluation. A questionnaire was conducted after the VR study was complete. All of the collected data was analyzed.

In order to examine the effectiveness of the three levels., High Interactivity, Low Interactivity, and No Interactivity, it is necessary to clearly define interactivity. Interactivity in VR is defined as the ability of the user to navigate the VR world, the power of the user to modify or interact with the virtual environment, and the capability of the virtual environment to respond to the user's actions (Ryan,1999). This definition of interactivity was used to create each varying interactivity level for this study.

The High Interactivity level of the VR language learning application for this study is the level of interactivity that allows the participants the most control over the virtual environment. In the High Interactivity level of the VR language learning application, participants were able to freely move around the environment, were able to interact with the virtual characters and objects in the environment using the hand-held controllers, and the environment relayed auditory feedback to the participants triggered by their actions within the virtual environment and based on the objects within the virtual environment.

The Low Interactivity level of the VR language learning application created for the study allowed the participant minimal control over the virtual environment. In the Low Interactivity level, the participant was able to interact with objects in the environment using the hand-held controllers but was not able to interact with the virtual characters. The participant's ability to move around the environment was limited as they could only move in the direction that was explicitly shown. There is auditory feedback based on the objects in the scene but none that is triggered by the participant's actions.

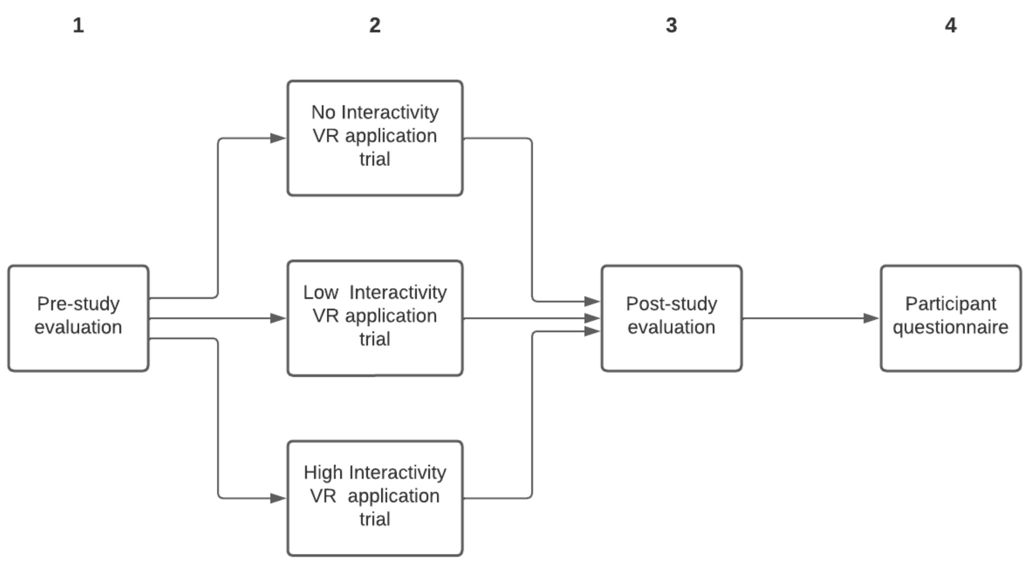
In the No Interactivity level of the VR language learning application created for the study, the participant had no control over the virtual environment. Their movements throughout the environment were automated. The participant was able to turn their heads and the headset would follow but they had no ability to use the hand-held controllers to move to other areas or interact with objects and characters in the scene. There was also no auditory feedback triggered by the participant's automated movements.

3.2 Procedures

This research study included a (1) pre-study evaluation, a (2) VR language learning application trial, a (3) post-study evaluation, and a (4) participant questionnaire (see Figure 3).

Figure 3

Experiment Procedures

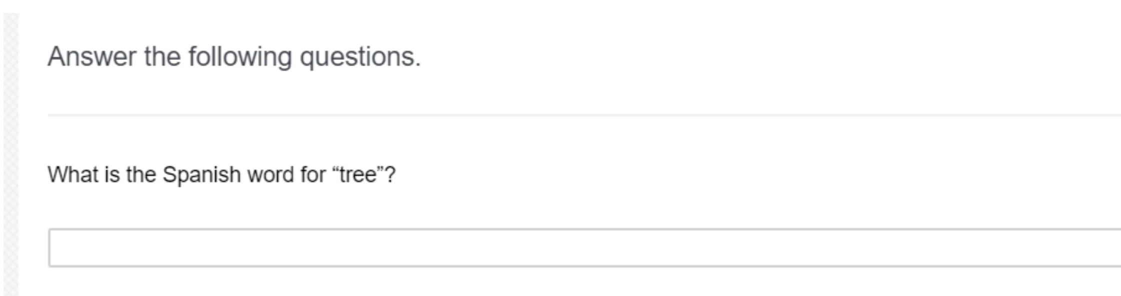


3.2.1 Pre-Study Evaluation

The pre-study evaluation was created to determine the number of the 15 Spanish vocabulary words that each participant already knows before the VR language learning application trial. On the pre-study evaluation, participants were first asked their personal information such as name and gender, and they were asked information that would be used for analysis such as their age range, and if they had any previous experience using VR technologies. The evaluation consisted of fill-in-the-blank type questions for the vocabulary words. Participants were given a word bank of the English translation of each word and were to fill in the blank beside each Spanish word with the correct translation. Next, participants were asked to answer text entry questions about the 15 Spanish vocabulary words. An example of these questions is “What is the Spanish word for “tree”?” and “What is the English translation for the Spanish word "autobus"?” where “tree” and “autobus” are the Spanish vocabulary words. For this pre-study evaluation, participants were told to leave unknown questions blank. They were asked not to guess any answers that they weren't sure of. Participants were not allowed to seek help from any outside resources. Figure 4 below displays an example of what participants would see on their screen.

Figure 4

Example of Pre-Study Evaluation Questions


Answer the following questions.

What is the Spanish word for “tree”?

3.2.2 VR Application Trial

After completing the pre-study evaluation, participants would complete the VR application trial. Participants were assigned to complete the VR application trial in one of the three interactivity levels, High, Low, or No Interactivity.

All three interactivity levels of the VR language learning application created for the VR application trial were developed with the Unity Game Engine version 2019.2. A combination of custom-made and downloaded assets were used to design the virtual environment. As previously mentioned, the environment created for all 3 interactivity level trials was a busy city scene. Within the city environment there was a plethora of city-related objects and artificially intelligent virtual characters to increase the immersive experience. The environment was identical in all three interactivity level versions. Figures 5 and 6 show the virtual environment busy city scene that is used for the VR application trial.

Figure 5

Virtual Environment for this Research Study

Figure 6

Virtual Environment for this Research Study

3.2.2.1 Creating an Intelligent Virtual Reality Learning Environment. Unity's software includes a navigation system that allows you to create Artificial Intelligent (AI) characters that can intelligently move around your virtual world. These characters are called agents. This navigation system is Unity's NavMesh system which consists of 3 major pieces:

- NavMesh: a data structure which defines the 'walkable' surfaces of the environment. This data structure must be manually created.
- NavMesh Agents: intelligent characters that try to avoid each other while moving towards their goal location. Their goal location must be manually specified.
- NavMesh Obstacles: obstacles the agents should avoid while navigating the world. These obstacles must be manually specified

When you want to intelligently move characters in a Unity scene, there are two problems that must be considered by the AI: how to find the destination and then how to move there. The problem of finding the destination is a global and static problem since it considers the whole scene. Moving to the destination is a local and dynamic problem because it only considers the direction to move and how to prevent collisions with other moving characters.

In order to define the area of the scene where the agent can move, it is necessary to create a NavMesh. The NavMesh will store the moveable areas of the virtual environment. This system uses a common AI algorithm to find the path from the agent's start position to the agent's goal destination. Once the start position and goal destination locations are mapped, the algorithm searches for the best path to move the character from start to finish.

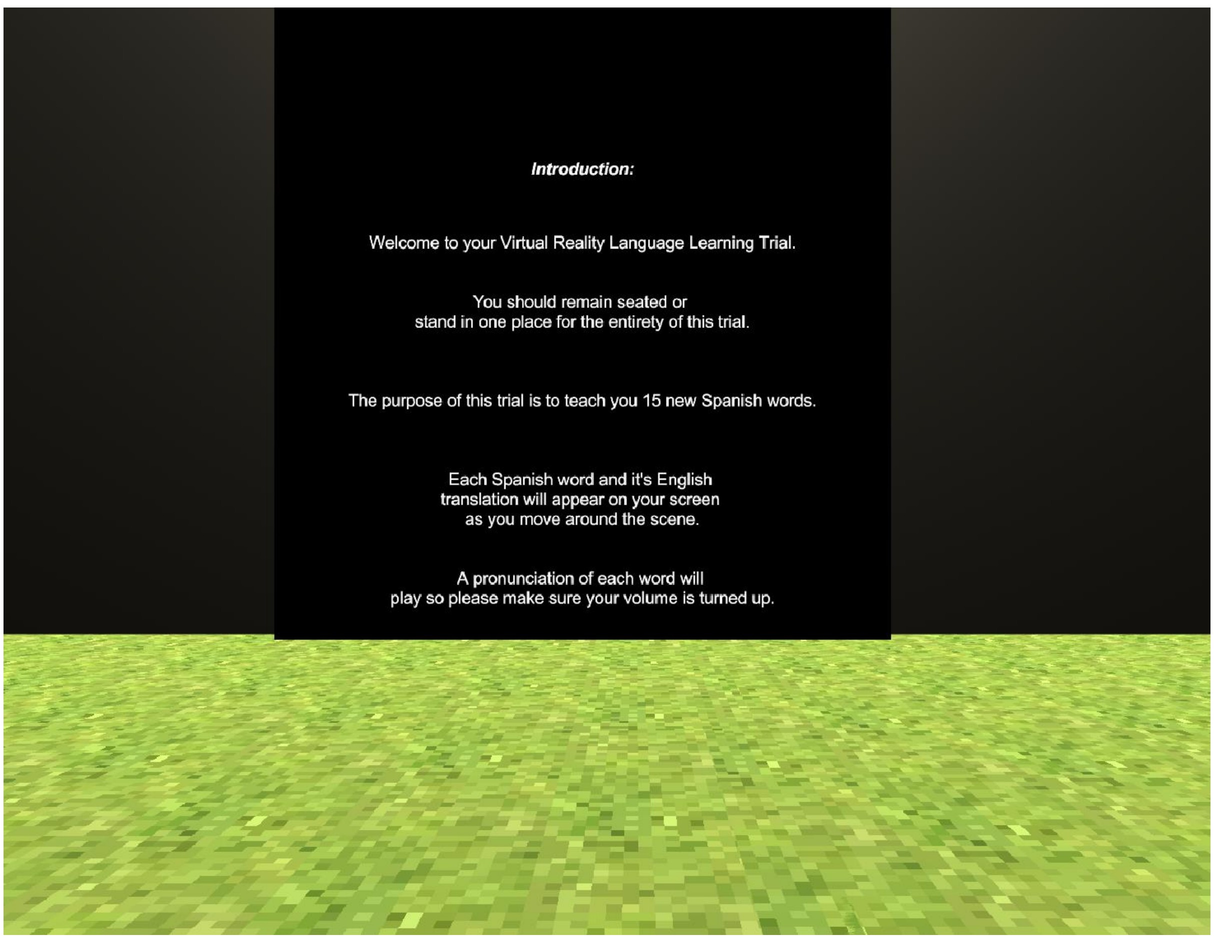
Once a character or object is assigned as an agent in Unity, its speed, acceleration, braking distance and other navigation related parameters such as obstacle avoidance can be customized and specified as well. Obstacle avoidance prevents characters from colliding with objects in the environment that are deemed obstacles. It can automatically choose a new direction or speed that ensures the agent has a clear path to its goal destination.

Artificially Intelligent characters and agents were included in the VR language learning application used for this study. The purpose of the inclusion of the AI agents was to increase the participants' feelings of immersion and to make each interactivity level have aspects that make it feel realistic.

3.2.2.2 No Interactivity Tutorial and Trial. Each interactivity level included an introduction and tutorial to introduce participants to VR and give them the opportunity to practice using the headset and hand-held controllers. After experiencing the tutorial, participants would complete the VR application trial. Figure 7 shows what is displayed in the participants VR headset during the introduction.

Figure 7

VR Experimental Trial Introduction



In the No Interactivity tutorial, participants had no control over the virtual environment and their movements throughout the environment were automated. Once wearing the headset, participants could see a screen that displayed the introduction and explained what would take place during the trial and how they would navigate through the virtual environment.

After the introduction was complete, character movement throughout the environment was automated and the No Interactivity application trial would automatically begin.

3.2.2.3 Low Interactivity Tutorial and Trial. During the Low-Interactivity tutorial, the participant had minimal control over the virtual environment. After the introduction was complete, participants received a brief tutorial on how to use the hand-held controllers to move. As defined previously, movement of participants in this interactivity level was limited and they could only move in the explicitly shown direction. After the tutorial, participants needed to use the hand-held controllers to start the Low Interactivity application trial.

3.2.2.4 High Interactivity Tutorial and Trial. In the High Interactivity tutorial participants were able to freely move around the environment. After the introduction participants received a brief tutorial on how to use the hand-held controllers to move and participants were prompted to use the hand-held controllers to move to a specified area. At this specified area, participants received a brief tutorial on how to interact with the virtual characters in the scene and were then prompted to interact with the character in the scene. After both tutorials were completed, participants would move to a specified area to begin the High Interactivity application trial.

3.2.3 Post-Study Evaluation

The post-study evaluation was identical to the pre-study evaluation. Participants were again given a word bank of the English translation of each of the 15 Spanish vocabulary words and were to fill in the blank beside each Spanish word with the correct translation. And they were asked to answer text entry questions about the 15 Spanish vocabulary words such as “What is the Spanish word for “tree”?” and “What is the English translation for the Spanish word "autobus"?”, where “tree” and “autobus” are the Spanish vocabulary words. For the post-study evaluation, participants were told to answer all questions to the best of their ability. They were encouraged to guess any answers that they believed they knew but were to leave any unknown questions blank. Again, participants were not allowed to seek help from any outside resources.

3.2.4 Questionnaire

After completing the pre-study evaluation, the VR application trial, and the post-study evaluation, participants lastly completed a questionnaire regarding their feelings, perceptions, and their overall experience of the VR experiment. The questionnaire consisted of 10 statements about the experiment and participants were expected to rate the truthfulness of each statement from “strongly disagree” all the way to “strongly agree”. Figure 8 shows a questionnaire question as the participant would see it.

Figure 8

Example of Questionnaire Question

It was easier to focus when using the Head-Mounted Display (vs. focusing during traditional classroom learning)

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

3.3 User Case Studies

A total of 56 participants took part in this research study. 21 participants were assigned to the No Interactivity level, 19 participants were assigned to the Low Interactivity level, and 16 participants were assigned to the High Interactivity level. Each user was assigned an individual appointment to complete all aspects of the study defined in Fig. 3. No time limits were in place and participants were encouraged to take as much time as they needed on all aspects of the study. On occasion, people report experiencing motion sickness or dizziness when using a VR Headset (Coles,2021). Participants were encouraged to remove the headset if they experienced this slight discomfort during their trial and were given the option to withdraw from the study if discomfort lasted.

3.3.1 Participants Demographics

Participants were asked three demographic questions to determine which interactivity level trial they would be completing. The three demographic questions were age, gender, and previous VR experience.

Each participant was asked to choose which age category they fit in. The three age categories were 18-24, 25-30 and 30+. Out of the 56 participants, 31 were in the 18-24 age range, 5 were in the 25-30 age range, and 19 were in the 30+ age range.

Each participant selected their gender identity. The three gender options were Male, Female, or Non-Binary/Third Gender. Out of the 56 participants, 25 identified as Female and 26 identified as Male. None of the participants identified as Non-Binary or a Third Gender.

Each participant was asked to indicate whether or not they have had any experience using VR software or hardware. The two options they were asked to choose from were ‘No Previous Experience’ or ‘Have Previous Experience’. Out of the 56 participants, 28 participants indicated having no previous experience using VR. The other 28 indicated that they had some previous experience.

The participants' answers to the 3 demographic questions were used to determine which interactivity level trial they would be participating in. The previous experience level and gender was aimed to be balanced as well as possible between the three interactivity level groups so that the effects of these factors could be measured.

3.4 Data Collection and Analysis

Participant data was collected from the pre-study evaluation, the post-study evaluation, and the questionnaire. The pre- and post-study evaluations consisted of 30 questions. Each participant received a score out of 30 based on the number of questions they answered correctly. No half or partial points were given when scoring these evaluations. Any participant that received a score of 15 or above on the pre-study evaluation was excluded from taking part in the rest of the study because a score over 15 indicates that the individual already had good knowledge of the Spanish vocabulary words present in this study. The data collected from these individuals was discarded. Participants scoring less than 15 were able to continue on to complete the rest of the study. Any individual that requested to stop the study due experiencing motion sickness or dizziness when using the VR was also excluded from taking part in the rest of the study. Their previously collected data was discarded as well.

For analysis of quantitative data, analysis focused on word gain. Each participants' 'word gain' was determined by how many more words they knew on the post-evaluation compared with the pre-evaluation. The equation used to calculate each participants word gain is ((Post-evaluation score / 2) - (pre-evaluation score/2) = Word Gain)

For example, a participant scoring 8 out of 30 on the pre-test indicates that before the study they know 4 out of the 15 Spanish vocabulary words. If that same participant scores 22 out of 30 on the post-test then that indicates that after the study they know 11 out of the 15 Spanish words. In this case the participant has a word gain of 7 meaning they successfully learned 7 new words through the completion of this study.

Each participant received a word gain score based on their results. Analysis was done to determine the trend between the word gain of the participants in each interactivity level of the study.

Chapter 4

Results

4.1 Statement and Result of Hypotheses

H1. Participants that use the High Interactivity level of the VR language learning application will learn more of the Spanish vocabulary than those participating in the Low and No Interactivity versions of the VR language learning application.

H2. A positive correlation exists between the level of interactivity and language learning outcome.

H3. Participants taking part in the High Interactivity level trial will report enjoying this VR based language learning more than those participants taking part in the Low and No interactivity trials.

H4. Participants that had previous experience using VR technology will learn more Spanish Vocabulary from a VR language learning application than those with no previous experience using VR technologies.

H1 hypothesizes that the participants testing the High Interactivity Level of the VR language learning application would learn more Spanish vocabulary words when participating in this experiment than the participants testing the Low and No Interactivity levels. To test this hypothesis the overall word gain and the average word gain of the participants in each interactivity level group was compared.

Table 1

Total and Average Word Gain

Interactivity Level of Participants	*Total Words Gain*	*Average Word Gain*
No Interactivity	178	8.47
Low Interactivity	150	7.89
High Interactivity	114	7.12

As the results in Table 1 suggest, the High Interactivity level had the lowest total word gain and the lowest average word gain of the 3 levels. The participants that tested the No Interactivity level of the VR language learning experimental application learned the most Spanish vocabulary words during this study.

H2 states that there would be a positive correlation between the level of interactivity and language learning outcome. To assess this hypothesis, average word gain for each interactivity level was evaluated. The average word gain of the No Interactivity level was 8.47, the average word gain of the Low Interactivity level was 7.89 and the average word gain of the High Interactivity level was 7.12. There is not a positive correlation between the level of interactivity and the language learning outcome of this study. To be a positive correlation between the level of interactivity and the language learning outcome of this study, the number of words learned would need to be the highest from the highest interactivity level and the number of words learned would need to be the lowest within the lowest level of interactivity. Again, this is not true for the results of this study. Instead, the results of this study indicate a negative correlation between the level of interactivity and the learning outcome. The lower the interactivity level of the VR language learning application, the higher the participants' learning outcome is. The lowest level of interactivity which in this case is the No Interactivity trial, has the greatest learning outcome with the greatest word gain. The highest level of interactivity, which is the High Interactivity trial, has the weaker learning outcome with the smallest word gain. The middle level of interactivity which is the Low Interactivity trial has a learning outcome that falls in the middle of the other two levels.

H3 states that participants taking part in the High Interactivity trial will report enjoying this VR based language learning more than those participants taking part in the No and Low Interactivity trials. Participants' questionnaire responses were analyzed. Questionnaire statement number 1 said "This Virtual Language Learning Experience was enjoyable overall." Figures 9-11 display the responses of participants from each interactivity level.

Figure 9

No Interactivity Responses to Questionnaire Statement 1

#	Field	Strongly agree
1	The Virtual Learning Experience was enjoyable overall.	50.00%

Figure 10

Low Interactivity Responses to Questionnaire Statement 1

#	Field	Strongly agree	
1	The Virtual Learning Experience was enjoyable overall.	57.89%	1

Figure 11

High Interactivity Responses to Questionnaire Statement 1

#	Field	Strongly agree	
1	The Virtual Learning Experience was enjoyable overall.	62.50%	1

50% of the No Interactivity respondents indicated they strongly agree that they found this VR language learning experience to be enjoyable (see Figure 9). 57.89% of the Low Interactivity respondents indicated they strongly agree that they found this VR language learning to be enjoyable (see Figure 10). And 62.50% of the High Interactivity respondents indicated they strongly agree that they found this VR language learning to be enjoyable (see Figure 11). According to these responses, participants taking part in this VR language learning application within the High Interactivity trial reported strongly agreeing to enjoying the trial at a higher percentage than participants taking part in the Low and No interactivity levels.

4.2 Statement and Result of Research Question

RQ1. Does the level of interactivity provided in an VR language learning application play a role in a users' ability to successfully learn a second language?

To corroborate RQ1, the analyses done when attempting to verify the validity of H1 and H2 can be reviewed. As shown in table 1, the total number of words learned by all participants varies for each interactivity level. The High Interactivity participants learned the lowest number of Spanish vocabulary words compared to the Low Interactivity participants that learned more of the Spanish vocabulary words, and compared to the No Interactivity participants that learned the highest number of Spanish vocabulary words. This pattern is also true when the average word gain and mean value of each interactivity level is analyzed. The mean word gain for the High Interactivity level participants is the lowest. The mean word gain for the No Interactivity level participants is the highest. And the mean word gain for the Low Interactivity level participants falls in the middle. These results suggest that RQ1 is supported. The level of interactivity provided in an VR language learning application does play a role in a users' ability to successfully learn a second language. In this case, when there is immersion but No Interactivity provided in a VR language learning application, a user has the greatest chance to successfully learn a second language.

4.3 Other Results

Analysis of the results was also performed based on the participant demographics mentioned previously. The effects of age, gender, and previous VR experience on word gain were examined to determine if these factors also play a role in a users' ability to successfully learn a second language within a VR language learning application.

Figure 12

Demographic Breakdown of All Participants

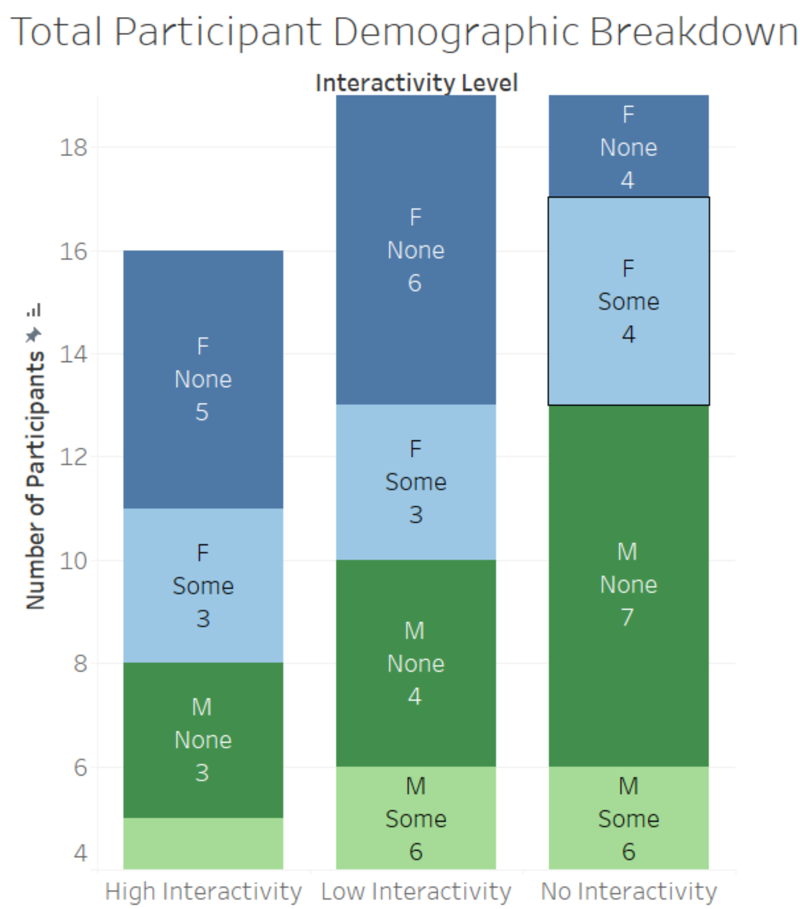


Figure 12 above displays the demographic breakdown of all of the participants that took part in this study. In the High Interactivity level, there are 5 female participants with none indicated as their previous VR experience, 3 female participants with some indicated as their previous VR experience, 3 males with no previous VR experience, and 5 males with some previous VR experience. In the Low Interactivity level, there are 6 female participants with none indicated as their previous VR experience, 3 female participants with some indicated as their previous VR experience, 4 males with no previous VR experience, and 6 males with some previous VR experience. In the No Interactivity level, there are 4 female participants with none indicated as their previous VR experience, 4 female participants with some indicated as their previous VR experience, 7 males with no previous VR experience, and 6 males with some previous VR experience.

Figure 13

Average Word Gain of Participants Based on Demographics

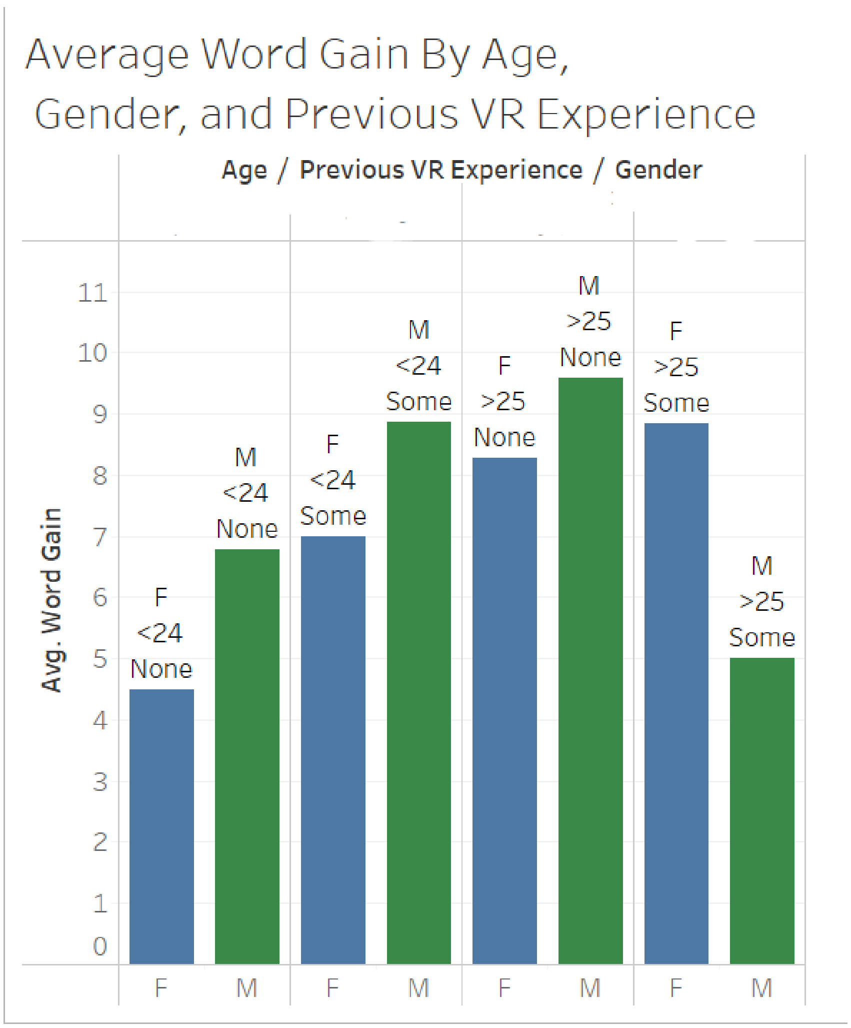


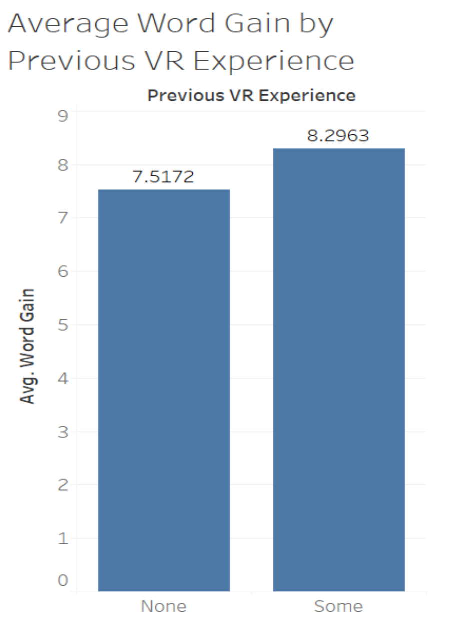
Figure 13 above displays the average word gain of participants in each demographic category. Males of all age and previous experience groups averaged a higher word gain than their female counterparts except for males that are age 25 and older with some previous VR experience. Female and male participants aged 25 and older scored higher than their aged 24 and younger previous VR experience counterparts males that are age 25 and older with some previous VR experience.

4.3.1 Previous VR Experience Results

H4 hypothesizes that participants with previous experience using VR technology will learn more Spanish Vocabulary from a VR language learning application than those with no previous experience using VR technologies. As seen in Fig. 14, the results showed that H4 is supported. Participants in this study with some previous VR experience have a greater average word gain than the participants without any previous VR experience.

Figure 14

Average Word Gain by Previous VR Experience

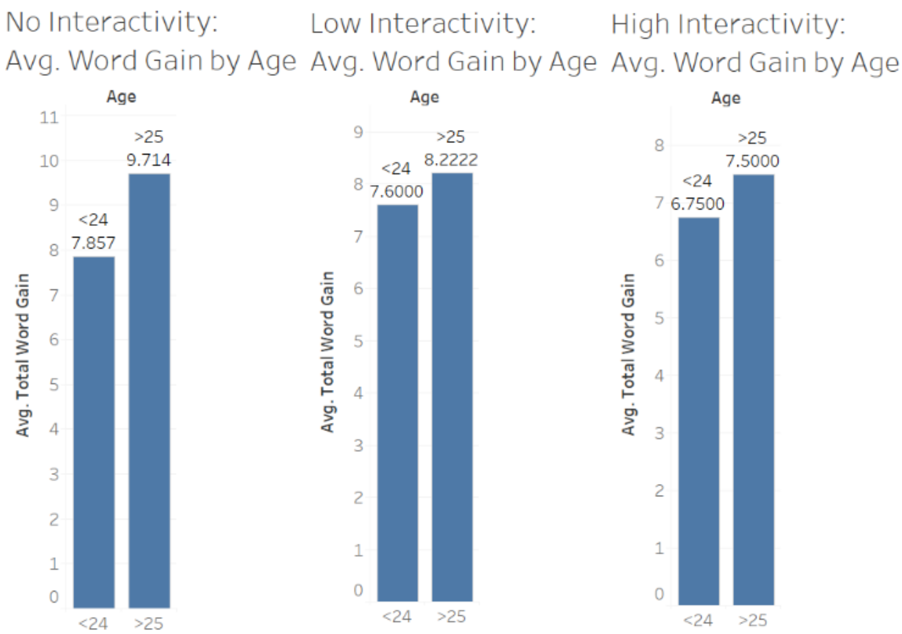


4.3.2 Age Results

In each interactivity level, results show that participants aged 25 and older had a greater average word gain than the participants aged 24 and under (see Figure 15). In the No Interactivity level >25 participants averaged 9.71 words gain and <24 participants only averaged a 7.85 word gain. In the Low Interactivity level >25 participants had an average word gain of 8.22 while <24 participants had an average word gain of 7.60. In the High Interactivity level >25 participants had an average of 7.50 words gain and <24 participants only had an average of 6.75 words gain. Participants over the age of 25 benefited more from this.

Figure 15

Average Word Gain by Age and Interactivity Level

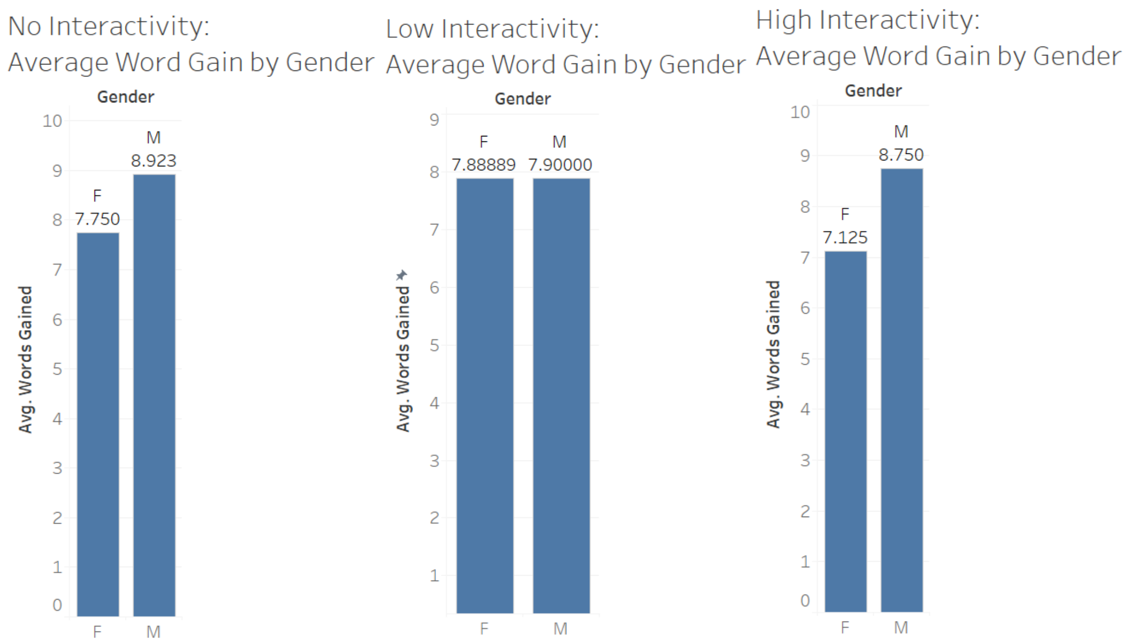


4.3.3 Gender Results

In each interactivity level, male participants averaged a higher word gain than female participants (see Figure 16). Results show that men had an average word gain of 8.92 in the No Interactivity level, 7.90, in the Low Interactivity level, and 8.75 in the High Interactivity level. This is greater than the average word gain of women in each level which is 7.75 in the No Interactivity level, 7.88 in the Low Interactivity level, and 7.12 in the High Interactivity level. According to the results, men benefited more from this VR language learning application.

Figure 16

Average Word Gain by Gender and Interactivity Level



4.3.4 Statistical Analysis of Results

In order to determine if the difference between the results from each interactivity level were statistically significant, a t-test was performed on the data. The t-test was first performed to determine if the results between the No Interactivity level and the Low Interactivity Level were statistically significant. There was no significant effect, t = 0.72, p = 0.23, despite the mean word gain of the No Interactivity participants (M = 8.47, SD = 2.44) being higher than the Low Interactivity participant word gain (M = 7.89, SD = 2.66). Next, the t-test was performed to determine the statistical significance between the results of the Low Interactivity level and the High Interactivity Level. The participant results of the Low Interactivity level (M = 7.89, SD = 2.66) compared to the participant results of the High Interactivity level (M = 7.12, SD =1.96) did not pan out to have a significant difference, t=0.95, p = 0.17. Lastly, the t-test was performed to determine the statistical significance between the results of the No Interactivity level and the High Interactivity Level. The word gain of participants in the No Interactivity level (M = 8.47, SD = 2.44) compared to the word gain of participants in the High Interactivity level (M = 7.12, SD = 1.96) demonstrated to be significantly better, t=1.81, p = .039. In the first two cases, the null hypothesis (H0) is accepted. H0 affirms that there is no significant difference between the means of the two groups. But, in the third case, the null hypothesis (H0) can be rejected and the alternative hypothesis (Ha) can be accepted instead. Ha affirms that there is a statistically significant difference between the mean word gain of the No Interactivity level and the High Interactivity level. Therefore, the results of this study regarding these two interactivity levels can be regarded as true with a high degree of confidence.

4.4 Primary Findings

Primary Finding 1- Interactivity level affects language learning in VR

Previous literature related to language learning in VR language learning application suggests that the degree of interactivity in VR could be a key factor that leads to effective second language learning (Legault et al., 2019). Results of H1, H2, and the data collected in this study determines that this suggestion is accurate. Degree or level of interactivity is a factor that affects language learning in VR. Results of this study indicate that lower levels of interactivity are more useful for effective VR language learning. It is clear that the potential for a successful language learning outcome in VR can be linked to the interactivity level.

Primary Finding 2- A user's personal factors can *affect language learning in VR*

Age, gender, and previous VR experience results suggest that a user's personal factors (such as these) have an effect on the user's ability to learn a language. Although this research study was not designed in such a way to thoroughly test the effects of these factors, the data shows correlations between these factors and a successful language learning outcome in VR.

Chapter 5

Conclusions and Future Work

5.1 Conclusions

This study investigated if the level of interactivity provided in a Virtual Reality Language Learning Application plays a role in a users' ability to successfully learn a second language from the application. The VR-based language learning application for this experiment was developed with varying levels of interactivity so that the effects of No Interactivity, Low Interactivity, and High Interactivity application design could be clearly analyzed. It was hypothesized that the level of interactivity present in the application would play a role in a user's ability to successfully learn a second-language. More specifically, it was hypothesized that participants of this study that tested the High Interactivity level would benefit the most and show the most language gain over those participating in the Low and No Interactivity Virtual Reality Language Learning Application levels. The results of this study are promising. There is a clear variance in the learning outcome for each interactivity level which is evidence that interactivity is indeed a factor within Virtual Reality Language Learning that can be manipulated to lead to more effective second language learning.

5.2 Limitations and Future Research

While the current study measured the effects of multiple interactivity levels on language learning, this study is unsurprisingly limited by its scope. Language learning is a global endeavor. To truly understand the effect VR interactivity level has on language learning it would be necessary to conduct a study with a much wider global population of research participants. The reliable results of this study allow a conclusion to be drawn on the research question at hand, however, future work in this research area should consider recruiting a broader population of subjects. Because this study took place on a university campus, all of the subjects were either students or faculty of the university. Results may differ for subjects who are not in academia and subjects from different backgrounds. The area of language learning involves pupils who vary in age, gender, intelligence, previous linguistic experience, motivation, and many other characteristics. [3] Some of these characteristics are considered and investigated in this study but there are more whose effects must be investigated further in future research.

This research taught Spanish as a second language to non-native Spanish speakers which is also a limitation. Spanish is not the only language being learned and taught around the world. Teaching other foreign languages through a Virtual Reality Language Learning Application may require different techniques. Subjects learning a language other than Spanish may reap greater benefits from a different interactivity level. The results of this study must be compared with results from potential future work to determine if H1 and H2 are still supported when tested against different languages.

Learning foreign vocabulary words is a valid form of language learning. This study assesses each participants' gained knowledge of the vocabulary words to determine if they have learned the foreign language from participation in this study. But, there is more to acquiring a new language than learning vocabulary. In 1990, Oxford defined a classification of language learning strategies. Oxford's (1990) classification of foreign language learning strategies is one of the most widely used classifications in teaching, practice, and research on language learning (Berger, Völkle, 2013). Oxford states that there are direct strategies including memory, cognitive, and compensation strategies, and there are indirect strategies including metacognitive, affective, and social strategies. This study solely employs direct strategies to teach the Spanish language to participants. The indirect strategies are those which "go beyond purely cognitive devices, consider learners' emotions, attitudes, motivation and values, and place emphasis on social communication in the target language" (Gholamali-Lavasani, Faryadres, 2011). Future researchers on this topic may choose to use indirect strategies as well when teaching a language to assess if they have an impact on learning outcome.

Future works in this research could advance this study further by considering time as a factor as well. This study did not place time constraints on the participants while they were exploring the Virtual Reality Language Learning Application to learn the Spanish vocabulary words. Participants were allowed as much time as they needed to navigate the VR environment and to learn all 15 words. The length of time that each participant took to complete the task was not recorded as a factor. It is possible that taking a longer or shorter amount of time to complete this study could contribute to the results. While the time length of the No Interactivity trial was exactly the same for all participants in that level due to it being automated, the length of Low Interactivity and High Interactivity trials was completely dependent on the speed of the participants. Taking a shorter longer length of time to learn the words in the Low Interactivity level and High Interactivity levels may be a factor that contributes to the participants learning outcome of the VR Language Learning Application.

Overall, this research contributes new knowledge of the factors that are involved in successful immersive VR second language learning. The findings can encourage the design of more efficient immersive language learning VR software that includes the optimal level of interactivity in order to facilitate the greatest possible learning outcome and a more engaging and favorable learning experience for users.

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