The Effects on Virtual Reality Immersion on Retaining Language

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1 INTRODUCTION

To communicate with new people of other cultures, learning a new language is often required. This task requires dedication and patience, usually over multiple years, to become conversational. Traditionally, to learn a language, either classes with a professional teacher, or a more modern approach such as phone applications are often tried. In 2022 alone, over 500 million of people around the world attempted to learn a new language using an application called Duolingo with the most popular languages being English, Spanish, and French [5]. Duolingo and similar apps have grown in popularity due to the ease of access, as well as a typically lower cost of admission (often free), than taking a more structured class. These apps give daily short lessons, in an effort to keep engagement high, and minimize the amount of time that users feel required to use the app. Additionally, this allows users to learn at any time or pace that they choose, such as on the bus to work, or laying in bed before they sleep. With this accessibility, users feel as if they are in control of their learning, and often may study multiple languages at once.

This project explored the effectiveness of high engagement through virtual immersion to increase the retention of foreign language vocabulary. This was done by comparing a traditional flash card style learning program against an interactive Virtual Reality(VR) program. The VR program is designed to increase the engagement and immersion of an individual while they study. VR offers a new medium for foreign language learning, by allowing for physical interaction between the participant and a digital representation of the word they are learning.[18] "VR learning environments represent a promising technology that is now being widely adopted in the educational field." [9] We thought it would be beneficial to further explore this technology in a language learning environment.

Many studies have shown that the effectiveness of retaining the language short term using VR has been unclear but promising. This project's aim was to add to this set of knowledge, by providing a larger sample of participants using a VR language learning tool to compare against traditional flash card learning. The comparison was measured between

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the separate quizzes' results. These quizzes were given to the participants after they had studied with the method they were assigned. Questionnaires were provided before and after the experiment to strengthen the integrity of our results.

2 RELATED WORK

The exploration of Virtual Reality in educational contexts has spanned several decades, revealing both its transformative potential and the challenges it presents. In the 90's, researchers could see the potential for using VR for learning. The studies have shown potential particularly in fostering deep, conceptual understanding and engaging learners in complex, abstract domains. They highlight VR's ability to offer immersive, experiential learning environments that leverage human spatial and perceptual abilities. However, they also acknowledge significant challenges that need to be addressed for VR to be effectively integrated into educational settings. These challenges include cost and accessibility, usability and design, and technological fears and acceptance. The research contributed valuable insights into the ongoing discussion about the role of VR in education, highlighting the need for further research, development, and thoughtful implementation strategies.[26] [6] [22]

In 1991, Bricken wrote "VR offers teachers and students unique experiences that are consistent with successful instructional strategies: hands-on learning, group projects and discussions, field trips, simulations, and concept visualization. Within the limits of system functionality, we can create anything imaginable and then become part of it."[6] This is one of the first papers discussing the future of VR to aid teaching and since then the technology and the research behind it has continued to grow. Bricken's paper researched the downsides of VR at the time and suggests that as we continue to develop technology, the tool of VR will continue to gain importance. In 1999, Salzman et al. said "A critical step towards achieving an informed design of VR learning environments is the investigation of the interplay among VR's affordances and other factors."[26] Their team compared various learning methods including a 2d screen, written instructions, and a VR environment for learning various scientific theories. They were able to determine a potential for increased learning but like Bricken thought that the research was not yet adequate to take advantage of this. In 2012 a paper by Benjamin Change, et al.[8] was written, exploring VR in education right after VR had begun to be noticed by the larger public. They found very high engagement and retention of materials from the participants, however it required the environment to constantly need to be interacted with. This reinforced the idea that the technology still needed to advance further, this time specifically on the software side.

In subsequent years, as VR technology advanced, the focus shifted towards optimizing user interfaces and enhancing educational outcomes. The growth of the development in VR research brought it more attention. In the 2010s the concept of VR for learning grew, encouraging more to continue to add to the field of study. In 2018, Allcoat et al., performed a study comparing VR, video, and written materials in order for individuals to study and then be tested on. While VR was able to provide significant positive results, suggesting that the potential of the technology is real. Jinsil Hwaryoung Seo et al. also developed new insight into this emerging technology by comparing physical and virtual learning of anatomy. They found that despite VR taking longer to interact with, engagement was higher and there were positive improvements in retention. It was theorized that the higher level of engagement was the cause for the improvements. Another difficulty with developing VR for learning was addressed by Saunier et al., in 2016. They proposed that the difficulty for this technology to be adopted was because of the difficulty to create and modify programs to be used in VR. Their proposed solution was to develop a adaptable program to be used by teachers/instructors. Robson Santiago Viol, et al. [25] also found similar results, determining that the materials should be flexible and easy to create as this is what would contribute most to VR as a teaching tool since currently it is very difficult for educators to create the materials themselves. [3] [15][16] [21]

Outside of VR being used as a way to immerse learners in learning a language, researchers studied the use of authentic materials, resources that are created for native speakers, not for language learners, to create immersion. Materials including but not limited to audiovisual materials and academic, literary, and journalistic texts have been shown to underscore the value of authentic materials in enhancing language learning and teaching. Research has shown they make a positive impact on language skills such as reading and cultural awareness as well as speaking skills and confidence. Authentic materials also enhanced motivation and engagement by providing real-world contexts and culturally rich content. These findings suggest that authentic materials can bridge the gap between classroom learning and real-world language use, making them a valuable resource for language educators. In 2021, Ilana Dubovi[9] found that VR increased engagement while in a learning environment. This higher engagement was continually associated with higher performance and the participants wanting to study longer. This may suggest a similar engagement between VR and authentic materials. Qiao Jin, et al.[23] also found potential within a VR learning environment that is collaborative. They suggest that it's possible that VR being used in such a way could be a constructive direction to continue research. In contrast, Rhodora Abadia, et al.[24] found improvements within a non-collaborative environment to educational abilities. More research will need to be done to determine which would be better to prioritize, collaborative or non-collaborative VR learning. [11] [4] [10] [1]

Modern VR technology has been used to enhance language learning such as through a gameified, using a game to learn, experience. Research has found that learning through gameified simulations is effective as students are more amused and willing to learn. This has been studied through a varitey of electronic mediums in classrooms over the decades including CD-ROMS, educational Flash games, mobile games, and now virtual reality. [28] [14] [17]. One research article conducted this and suggested that VR technology can be a more effective method for vocabulary learning, providing a compelling case for integrating VR into educational settings to enhance language acquisition and engagement. There was also an article written that provided a systematic review of augmented reality and virtual reality studies in language learning. It reviewed and analyzed over 80 articles from multiple perspectives. The purpose was to understand how AR is used in language education, who the main users are, how effective AR is for language learning, and implications for future research. AR and VR were found to promote language learning by immersing learners in target language environments, increasing their motivation, allowing them to interact in the target language, and decreasing their language anxiety. The article argues for further explorations of AR within educational settings. A paper by Lan[18] suggests that in order to maximize the efficiency of learning within VR, a program must allow for direct interaction with those who can speak the language. This would help reassure participants that they had learned things correctly or will point out where they need to improve. An article by Legault, et al.[19] also suggested that VR may have greater potential for those who initially performed poorly with retaining foreign vocabulary. [2] [13] [27]

A review of VR language learning research performed by Hua and Wang [12] showed that despite the current growth of VR technology, the amount of research performed recently has declined. Despite this, the overall consensus seems to be that this technology has potential for language learning, however we do not yet have the tools necessary to fully utilize it yet. A research paper by Gunay and Barakat[7] confirms this showing that with current programs using gameification for VR education does not yet fully utilize VR as a tool and can result in worse performance if not utilizing it beyond traditional gameified resources. As Mones[20] has found in their research paper, despite the challenges, educational settings are already beginning to seriously adopt VR. The results thus far are mixed on how much these systems have helped, however my educators trust that this technology has the potential to become very helpful.

This body of work collectively underscores VR's potential as a powerful educational tool, necessitating further research to overcome its implementation challenges. The ongoing development of VR applications and their integration

into educational settings continue to be driven by these foundational studies, which provide crucial insights into both the opportunities and limitations of VR in enhancing learning outcomes.

3 METHODOLOGY

The methodology for this research project involved comparing the effectiveness of virtual reality immersion versus traditional flashcard methods in retaining foreign language vocabulary. The Participants were divided into two groups. One of these groups used a flashcard program with images and translations. The other group was placed in an interactive VR room with labeled objects. They were able to interact with these objects and the labels contained both the English and Nepali words for that object. Participants upon beginning were required to fill out a short survey containing questions regarding their previous experience with languages and VR. This information provided us with a baseline with which to compare different participants progress.

Control variables such as previous language knowledge were accounted for by selecting a language that has a low rate of speakers in the area where participants were selected and by asking preemptively the languages that that individual already knows. After the participants finished their quiz, they were presented with an addition questionnaire that asked about the comfort of the participant regarding the software they used to study. This feedback was used to see if discomfort with a particular program affected results.

The language and vocabulary were deliberately chosen for a few reasons. We wanted the focus of our research to center around the retention of the language and not the introduction of unknown characters and letters. We therefore decided, from the beginning, to use a language that utilizes a Latin-based alphabet. We also wanted to choose a language that wasn't very prevalent in the region which we were conducting the experiment in order to limit the exposure those individuals would have had to it. Our final decision, to use Nepali, was because it met the first two criterion and because one of our group members knows the language which ensured that the translations were as accurate as possible. The use of a virtual room for displaying objects meant that we wanted our vocabulary words to consist of common household nouns, which we had the capability to put within a virtual space in order to interact with.

3.1 Participants

Before conducting experiments, all participants were provide with a survey and consent form. Consent was received verbally. The survey's purpose was to collect information on previous experience with technology, language, and demographics. The participants were 85% age 18-25 and 15% were age 26-35. (Figure 1)

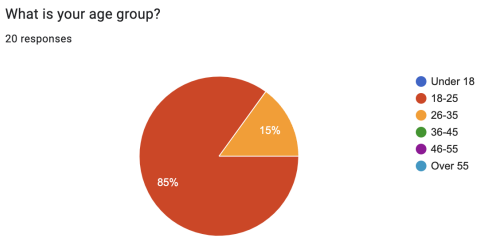

Fig. 1. Age Group Graph

The participant pool also consisted of 65% males, 30% females, and the remaining 5% who chose not to share that information. (Figure 2)

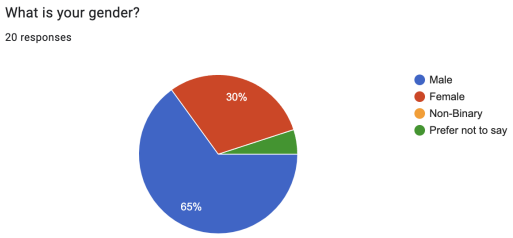

Fig. 2. Gender Graph

Our more technical questions revolved around experience with foreign languages and usage of technology (specifically VR). We found that when asked how many languages participants had experience with the results showed that 65% spoke 1 (English), 25% spoke 2, and 10% spoke 3 languages. (Figure 3)

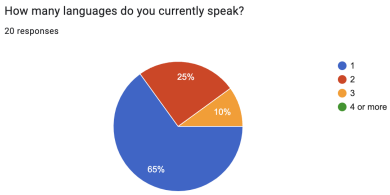

Fig. 3. Languages Spoken by Participants Graph

Continuing to investigate those who spoke more than 1 language it was found that only 10 % of those had any experience with Nepali, Indo-European, Indo-Iranian, or Indo-Aryan Languages and furthermore they only reported that it was only some experience. (Figure 4)

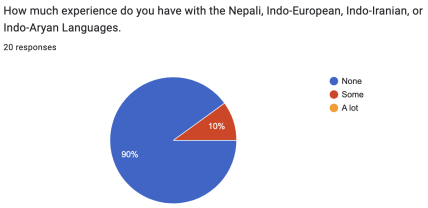

Fig. 4. Previous Nepali Experience

The next area we focused on use of technology and VR. It was found that when asked about how often individuals used VR, 55% responded never, 35% responded rarely, 5% responded occasionally, and 5% responded frequently. (Figure 5)

3.2 Procedure

Both groups were given instructions on how to use their given program. The VR participants were allowed to figure out the controls for a few minutes before the vocabulary words were introduced into the program while the flashcard

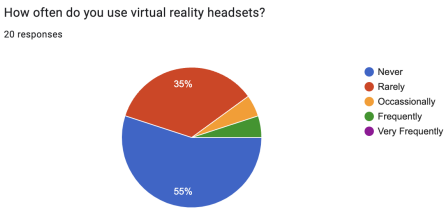

Fig. 5. VR Usage

participants were walked through the controls before given their words. After this, they were given a 7-minute session with their assigned program. The participants then took a vocabulary quiz to assess retention. The vocabulary quiz provided each English word once and required the participant to write the Nepali translation of each word in a text field. Each participant was given a maximum of 5 minutes to take the quiz. The number of correct translations recalled was measured without focusing on spelling accuracy. Spelling was addressed by allowing 2 characters of difference between their answer and the correct answer. The differences were then analyzed.

3.3 Apparatus

The VR program was a classroom environment (Figure 6) where individuals could traverse the room and pick up objects that have translations attached. Traversal of the room was done by allowing the user to press a button to project an arced path through the air. If the location can be teleported to, a circle was projected onto the ground at the location where the projected arc ends (Figure 10). Once the button was released, the participants teleported to the circle. The objects with translations attached could be picked up, moved, and rotated using the VR controller (Figure 9). The grip button was used to attach the object to the controller. The translations attached to the items included both English and Nepali words for the item (Figure 7). The translations constantly orient themselves to face the VR camera in order to maintain ease of readability. A counter presented in the room counts the number of objects that have yet to be interacted with so that the participants did not miss any items while studying (Figure 8).

Fig. 6. VR Application: Design

The flash card program was designed to resemble traditional flashcards by allowing the user to see one side of the the card with an English vocabulary word and be able to click on the card which would flip to the other side and display the Nepali translation. (Figure 11) (Figure 12) In addition to resembling traditional flashcards, buttons were added to the program which would allow the user to cycle both forward and backward through the cards as well as pull a random

Fig. 7. VR Application: Text displayed with English and Nepali

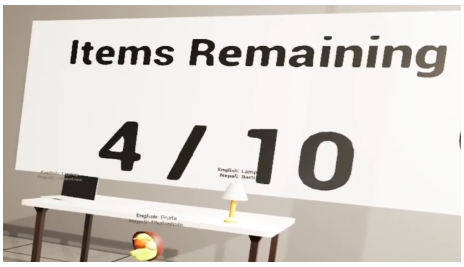

Fig. 8. VR Application: Objects not interacted with

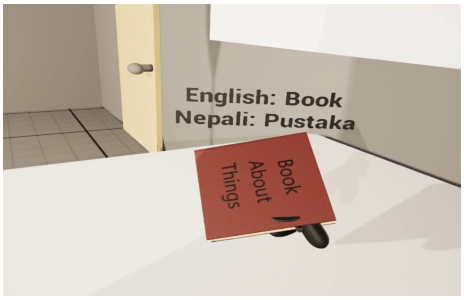

Fig. 9. VR Application: Interaction between participant and an item

card from the vocabulary list. To accomplish the realistic feel of the flashcards, the program was written as a web application which utilized the open-sources front-end JavaScript library, React.

4 RESULTS

Each participant in our study was required to take a 10 question vocabulary test on the materials retained from studying using their given method. In total we had 10 participants whose results are from learning in VR and 10 participants whose results are from learning with a flash card program. Each questions answer, a translated word, was compared against the actual translation. We allowed participants to misspell words by a maximum of 2 characters to be considered correct. Our results are seen below in (Table 1) (Table 2).

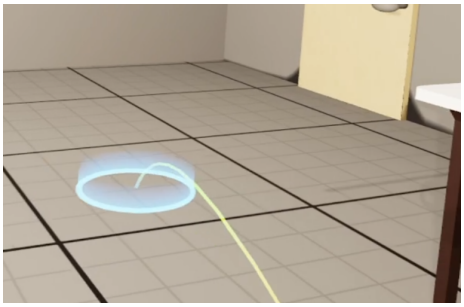

Fig. 10. VR Application: Projected arc with teleport circle

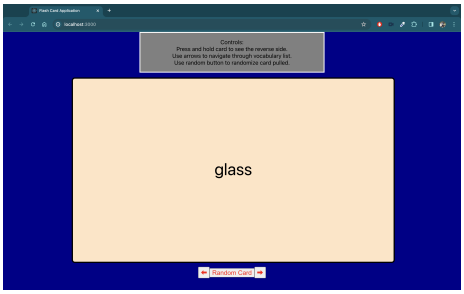

Fig. 11. Flashcard Application: English Side

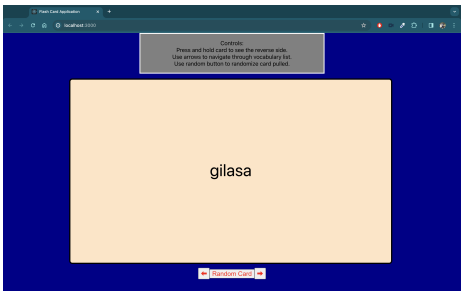

Fig. 12. Flashcard Application: Nepali Side

The grand mean between all participants is 8.3/10 correct answers. The mean score for those participants who used VR to learn was 7.7/10. For those who studied using flash cards, the mean score was 8.9/10. This means that the mean result from the VR learners is a 14% decrease from the flash card learners scores, or an 8% decrease from the grand mean. The flash card learners performed 7% better than the grand mean. An Anova was performed on the results (Figure 3. Our calculated p value was 0.2482 which is greater than 0.05 so our results do not show any significant difference between the scores of the participants who used VR compared to those who used flash cards. All participants who performed the experiment by learning through VR were asked if they felt the VR had made them motion sick or nauseous in order to ensure that was accounted for, however no participants reported any discomfort.

Many different results have been obtained through other studies also researching VR for language learning. Both positive and negative results compared to baseline have been observed with many finding no significant difference. Our results backed up the large amount of data showing no significant difference. [19] .[29] Using a larger pool of participants would have been necessary to see if this stayed constant.

Table 1. Results - Between participants completion scores out of 10

VR Simulation Participant Scores	
Participant	Score
P01	10
P02	9
P03	8
P04	10
P05	10
P06	7
P07	10
P08	8
P09	2
P10	3

Table 2. Results - Between participants completion scores out of 10

Flashcard Participants Scores	
Participant	Score
P11	10
P12	7
P13	10
P14	10
P15	9
P16	8
P17	9
P18	10
P19	9
P20	7

5 DISCUSSIONS AND LIMITATIONS

5.1 Discussions

We originally chose Nepali because we were adamant about choosing a language not common for the region we conducted the experiments. In this case, Northern Colorado. When looking over the survey responses of our participants,

Table 3. ANOVA of results

ANOVA					
Effect	df	SS	MS	F	P
Study Method	1	7.2	7.2	1.424	0.2482

one question we proposed was whether or not the individual had experience with Nepali, Indo-European, Indo-Iranian, or Indo-Aryan Languages. Of the 20 participants in our study, 18 of them responded that they had no experience with these languages while only 2 responded that they had some experience. These were exactly the results we were looking for in order to reduce the potential of an extraneous variable arising through background knowledge.

Our results suggest that while there can be a difference between VR learning and learning via flashcards, the difference is not significant. It is possible however that VR could provide added benefits such as retaining an individual's interest long term. The opposite is also possible, where VR could possibly become tiring to some individuals. We were only able to address short term retention in our experiment, so our results of no significant difference only applies to short term memory.

5.2 Limitations

After analyzing the responses from the pre-experimental quiz, It was found that of the 10 participants that were placed into the VR study, 4 of them responded that they had rarely used VR in the past while the other 6 responded that they had never experienced VR. This creates the potential that they may have had more of a learning curve in their given control group which could have negatively impacted their scores despite our groups' attempt to mitigate that with a training environment before introducing the vocabulary words.

Due to errors within 2 participants tests, their results were not included. More participants were asked to join to compensate for these lost results.

6 CONCLUSION AND FUTURE WORK

6.1 Conclusion

We were able to successfully collect more data in regards to the effectiveness of VR for learning to help further this field of research. We were able to record dat from 20 participants total, with half studying using VR and half using flash cards. Our study was able to contribute to this pool of knowledge by showing no significant difference between VR and flash cards as a method for retaining words from another language short term. VR, as a field of study, will continue to grow and as such more research will always be required because the general population continues to adopt this technology. Language learning will also continue to grow in necessity as these users interact with others online and interact with many people in real life, many of which will speak different languages. Because of this, finding effective ways to help others learn languages will continue to be a high priority and we feel VR as a technology can continue to play an important role.

6.2 Future Work

Based on our experience, future works progressing knowledge about learning languages in VR will need to have a larger pool of participants to collect data from. Because of our low participant count, 20, we were unable to see any significant results despite a large difference in average. We think that increasing the number of participants would fix this problem. Future works could also benefit from using a more limited amount of time to study using the method assigned to them. More sets of words to test would also help improve the accuracy of the results. More words would increase the amount of data that could be collected since participants getting 10/10 words translated correctly have an unknown potential to learn more than 10 that is not being measured.

7 ACKNOWLEDGMENTS

We would like to thank Professor Francisco Ortega for allowing us to perform this experiment and to Colorado State University for supporting Professor Ortega for allowing us to use the library for our experiments.

7.1 Software and Hardware

Unreal Engine - Game engine for VR program

Krita - Used to create textures and edit photos

Blender - Used to create 3D models for the VR program

Occulus - VR headset that was being used and associated drivers.

Steam VR - Used to connect Occulus drivers to our VR program

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