The Impact of Immersive Virtual Reality Flashcard on L2 Vocabulary Acquisition on Logographic Language

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***Abstract*—The impact of Virtual Reality (VR) on language learning has been demonstrated in much research. However, a great deal of research focuses on the social effect or the subjective impact of the method rather than the quantitative result. A lot of previous research neglects to mention the relationship between the result observed and language learning theory. This research aimed to provide quantitative research on the impact of virtual reality on vocabulary acquisition by measuring VR flashcards in second language (L2) language learning. The research used a sample of 30 students, randomly divided into two groups: a control and an experimental group. The control group used traditional physical flashcards, while the experimental group used VR-assisted learning. Data collection involved pre-tests and post-tests to assess vocabulary knowledge, as well as recording reaction speed, number of guesses, and correct/incorrect answers. The research concludes that VR speeds up vocabulary acquisition while also increasing the student's motivation and interest in the subject. This finding is subsequently examined through the lens of language acquisition theory for further discourse. Future research should involve larger samples and more complex vocabulary. The study further emphasizes the significance of integrating innovative technologies, such as VR, into language learning pedagogy to augment student engagement and retention. This research indicates that VR possesses the capacity to transform language acquisition by offering a more immersive and interactive experience for learners. It further underscores the necessity for educators to modify their pedagogical approaches to harness technology, thereby fostering more effective and engaging learning environments.**

***Keywords*—computer assisted, education technology, language learning, Virtual Reality (VR)**

I. Introduction

Even in this age of artificial intelligence where translation between languages has been somewhat trivialized, second language (L2) language acquisition has been stable research for many years. A large number of research is dedicated to understanding and enhancing our ability to learn/acquire a new language.

Out of the many aspects of learning a language, vocabulary is one fundamental part that is crucial to language learning, a building block of the language [1, 2]. Vocabulary is defined as a lexical unit that conveys a particular meaning [3]. Without sufficient vocabulary, a student cannot convey any meaning in a language. To acquire/learn vocabulary thus becomes a subject of research that resulted in multiple theories on vocabulary acquisition. Among those theories mentioned is the use of mnemonics, repetition, and other methods of training. These theories are then translated into approaches that we use within the classroom context or in personal learning.

Vocabulary knowledge is usually divided into 9 components of "work knowledge" which is spoken word, written word, word parts, form and meaning, concept and referent, associations, grammatical functions, collocations, and constraint of use [1]. From these components word form, concept, and association is what this research focused on. Traditional approaches to vocabulary acquisition includes a lot of exercise that is repetitive in nature [4, 5]. Memorizing vocabulary by flashcards, reciting words, or writing words in repetitive manners are some of the methods that are being used. Although much research has proven the effectiveness of these approaches, many students struggled to learn L2 language because they find it be tedious, and since it is repetitive in nature it dampens students' engagement [6]. Not to mention that traditional approaches do not usually address the affective aspect of language learning such as the feeling of unease, stress, or fear that might hinder a student's progress.

Therefore, much research has tried to increase student engagement using different methods. One of the methods to increase student engagement while maintaining learning effectiveness is using gamification. Gamification can be described as the use of game components in a non-gaming context [7]. Gamification in language learning helps students in several ways. The first and by far the most important part is the increase in vocabulary acquisition/learning [8–10]. Another aspect of learning that gamification provides is the ability to alleviate the fear and stress that students encounter in L2 language learning. Language anxiety defined as a phenomenon that is subjective to the individual and by recognizing it and addressing it properly student may achieve greater effectiveness in language acquisition [11]. Another big part of gamification success in language learning is student engagement. Engagement can be referred to as a state of heightened attention and involvement in cognition, social, behavioral, and affective dimension [12].

The medium choice for gamification can also be an important factor to consider. The use of mobile devices for language learning has been increasingly favorable due to their wide availability. In a systematic review by Burston and Giannakou [13] 2021, it is mentioned that since 1994 more than 3800 studies have been conducted on Mobile-Assisted Language Learning (MALL) implementation, a number that surely has gone up by 2024. These studies have also shown that MALL implementation has been advantageous to students in several ways.

Another medium that's been gaining attention is virtual reality. Immersive virtual reality research in specifics has been gaining traction in the last few years ever since the covid pandemic and the announcement of Meta's metaverse. One of the key difference between this medium and other type of

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digital medium is that within virtual spaces, a student can be involved in real scenarios, environment, or just isolated with the current world [14, 15]. These conditions are beneficial to learning as it adds beneficial aspects to learning or removes unfavorable aspects/distractions. The combination of gamification aspects and immersive virtual reality is then proven in quite a bit of research to be fruitful for learning [16–21]. But a lot of these research focuses on English as Foreign Language (EFL), and not enough research is being done on other types of language that have a significantly different characteristic from a lot of other language. Logograms/logographic language are written language in which each character corresponds to a word [22]. Another definition would be a language that is represented as visual organization of smaller graphemic units with words meaning that changed through compositional variations of these units [23]. Chinese, Japanese, Egyptian hieroglyphs are examples of logographic language.

Learning a logographic language presents its own challenges to alphabetical language user, since a new writing system that is vastly different needs to be studied [24]. Logographic language uses symbols that have little or no correspondence with spoken syllable [25] which in turn complicates the usual sound-symbol learning process in non logographic languages. This makes logographic language harder to learn when considering that vocabulary learning is easier for phonologically accessible language [26]. Not to mention, logographic language vocabulary learning requires a student to memorize thousands of different characters. When the world second largest language is using logographic language [27], research towards learning that type of language can certainly be beneficial. This research aims to analyze the impact of immersive virtual reality in vocabulary acquisition on logographic language with the Japanese language as a sample language.

1) How effective a virtual reality vocabulary acquisition technique compared to traditional approaches in logographic language.
2) How effective is Virtual Reality (VR) assisted vocabulary acquisition on retaining knowledge.
3) What is the level of student engagement on VR-assisted vocabulary acquisition?

This research offers a novel approach to L2 vocabulary acquisition by examining the effectiveness of immersive virtual reality flashcards for learning logographic languages, specifically Japanese Kanji. This focus on Immersive Virtual Reality (IVR) for logographic languages fills a gap in existing research, which predominantly explores VR applications for alphabetic languages like English. This study goes beyond simply demonstrating the benefits of VR and delves into the quantitative impact of IVR on vocabulary acquisition, providing a direct comparison with traditional flashcard methods. This quantitative analysis, coupled with an examination of the results through established language acquisition theories, strengthens the contribution of this research to the field

II. Literature Review

Virtual reality technology has been around since the founding of the first head-mounted design in 1968 till today's era of metaverse and extended reality. What started as a medium for entertainment has made it way to the education field. Definitions of virtual reality varies, but generally a virtual reality is a simulation of a three dimensional virtual environment where user can interact and receive feedback from that environment [28, 29].

Virtual reality can also be categorized into three: Immersive, semi-immersive and non-immersive [30]. Immersive VR means that the user is put through a generated 360-degree virtual space that can be perceived as being spatially realistic [31]. It includes full immersion, perception of physical presence, utilization of avatars, and interaction [32]. This immersive part of VR turns out to be very beneficial to language learning. While being immersed in virtual reality, a student is "isolated" from the outside world reducing distractions and focusing the student to learn/play. Other aspect to note on immersive reality is that it also reduce anxiety for many students learning language [14, 33, 34]. Not to mention the gamification aspects that are prevalent in virtual reality apps for language learning that engage the students and keep the students motivated throughout their learning sessions.

The use of immersive VR for language learning offers an interactive world in which students can interact and learn which can be advantageous to students in many ways. In effectiveness, some research on VR for language learning has shown an increase in student motivation and engagement [35]. An increase in performance has also been recorded in IVR research for language learning in different domain such as speaking [33], writing [36], listening [37], vocabulary acquisition [16, 38, 39], pronunciation [40] and more. IVR has also been shown to alleviate students anxiety when learning language learning [34].

Vocabulary acquisition is one of the largest topic to be researched in IVR [33, 41]. One of the research being done to assess the impact of virtual reality on vocabulary acquisition is done by Alfadil [16] in 2020. In this research it is concluded that using VR as a vocabulary acquisition tool is beneficial. However, this work is conducted with EFL in mind. While the work being done can be a representation of what VR can do, it does not take into consideration other types of foreign languages that might have some different characteristics. In 2020, Hartfil *et al*. [42] conducts a research on IVR vocabulary acquisition with VR game that is similar to the commercial game beat saber. But instead of symbols, students would have to cut objects corresponding to a word given. However, this study reports that this method is inferior to learning vocabulary with flashcards. Other researchers have also reported a negative effect when using IVR for vocabulary learning even though retention are lower with IVR and engagements are higher [43, 44]. These studies were designed as a one-time intervention with VR for about 5 to 45 minutes. And as such, these studies may report negative results due to their limited interaction.

This research intends to experiment with language that has symbols as an alphabet (logographic language), as the added complexity of symbols might change the outcome of the experiment. As an example, the Japanese kanji is chosen. The Japanese language has mainly 3 types of alphabets which is kanji, katakana, and hiragana.

Table 1 shows the difference example between those types of character. This research will focus on the kanji symbol.

This is chosen because katakana and hiragana work similar to an alphabet in another language. By choosing kanji words as the target vocabulary, it is believed that the research might reveal more insight to vocabulary acquisition, especially on logographic language. Several research has been conducted on logographic language learning with VR but some of them are not directed at vocabulary acquisition. Research by Luo *et al.* [45] focused on writing calligraphy and Kim *et al.* [46] also focused on writing letters although they also measures some vocabulary acquisition. VR for vocabulary acquisitions research by Legault *et al.* [47] show increase performance and its connection to context shown in VR, however this research does not show retention on learned skills. In 2023, Chen and Yuan [48] conducted a research on VR for the Chinese language as the target language. This research showed an improvement in engagement and vocabulary; however, it does not compare traditional approach to VR based learning.

Table 1. Japanese words comparison

Word	Hiragana	Katakana	Kanji
Cat	ねこ	ネコ	猫
Car	くるま	カー	車

This research aims to compare traditional approaches to VR based learning on logographic language and measure the impact on vocabulary acquisition and retention as a novelty research factor.

III. Materials and Methods

This research employed an experimental study design to investigate the impact of immersive virtual reality flashcards on L2 vocabulary acquisition of logographic languages. To analyze the effectiveness of VR-assisted vocabulary acquisitions a group of 30 random students was taken as a sample population. This student group consists of 17–24 years old male and female that are randomly sampled from the community around the university. The group is then randomly separated into two groups, control and experimental each group consist of 15 persons. Control groups are given a traditional approach using physical flashcards for vocabulary learning while the experimental group is given VR assisted training. The experiment is then conducted five times to assess retention with each experiment given a seven day off periods.

Before any experiment is executed, each participant went through a pre-test to assess participant pre-knowledge of the vocabulary. The pre-test consisted of multiple-choice questions presented through a Google Form. Each question displayed a Kanji character, and participants were asked to select its meaning from five possible answers.

After five experiments are conducted each participant is given a post-test to assess the vocabulary growth.

Traditional experiments are conducted with 5 minutes of learning via physical flashcard or written notes. After 5 minutes of learning. Each participant is then given a test. In each test 3 base metrics are recorded.

Reaction speed is the speed at which the user answers the test question. This metric is chosen to specify familiarity between participant and a word.

The number of guesses is recorded to separate participants that answer randomly or participant that answer based on knowledge.

The number of correct answers within a time frame is also recorded to indicate user mastery over vocabulary. The number of wrong guesses and accuracy can then be derived from these metrics.

The VR application is split into 2 different scenes with each scene corresponding to a specific group of words. The first scene consists of numbers, and the second scene focuses on colors. In each scene there are two boards. The first part is the learning board. The Learning board are boards with the vocabulary that are intended to be learned. These boards act as a sort of digital VR flashcard. Students can then interact with any of these flashcards to show their translation and meaning. Students may choose to learn these words in whatever order they choose arbitrarily. The other boards are test boards. These boards are intended to test the student's vocabulary acquisition. To increase students' interest, engagement, and fun factor, Fig. 1 shows the first scene, on the right side of the scene is the learning board, and on the center of the screen is the test board the boards in the two rooms contain different tests that is akin to a game.

Fig. 1. Sample VR scene.

The number test will list a number in the form of a label that the participant needs to write using kanji characters that are available. The color test will show 3 ducks in random color that the user needs to guess using kanji character in the test boards. Though each test is different, the objective of each test is the same which is to observe vocabulary acquisition, and the metric recorded are also the same.

In each session, the control group is given 5 minutes to learn using the learning board and then given a test using the test board. After all session, all students are given another post-test to analyze retention.

Accuracy scores are key indicators of performance. To calculate these scores, we considered reaction time, the number of guesses made, the number of correct guesses, and the number of wrong guesses where each result will be displayed in the table. Accuracy was determined during the testing phase, where participants were presented with a series of numbers. For each number in the series, responses were recorded as either correct or incorrect. The accuracy score was calculated as the ratio of correct responses to the total number of responses.

IV. Result and Discussion

The results are presented in this chapter together with some discussion of their relevance in the framework of current knowledge. Especially for logographic languages, the data is examined to evaluate the efficiency of immersive virtual reality flashcards in L2 vocabulary acquisition. By contrasting these results with past research and pertinent theoretical models, the importance of these discoveries is underlined even further.

A. Result

Prior to the experimental sessions, a pre-test was administered to all participants to gauge their baseline vocabulary knowledge. Table 2 showed the overall participants pre-test scores (control + experimental).

Table 2. Participants pre-test scores

Group	Pre-Test Mean	Standard Deviation	z-value	*p*-value
Control	45	19.59	0.4164	0.6773
Experimental	54	20.28	-	-

The Mann-Whitney U test resulted in $z = 0.4164$ and $p = 0.6773$, indicating that the pre-test differences between the control and experimental groups were not statistically significant. This confirms that both groups had comparable baseline vocabulary knowledge before the intervention, ensuring that any post-test differences can be attributed to the experimental treatment rather than initial disparities in vocabulary proficiency.

Before the experiment, VR-based students were given 5 minutes to test and learn vocabulary using the flashcard available. In this study, two scenarios were conducted where scenario focuses on number learning and color learning. The following is the formula to show how the accuracy score is obtained, as in Eq. (1), where C is the number of correct answers and N is the number of total answers:

$$Accuracy(\%) = \frac{C}{N} \times 100 \quad (1)$$

The following is the result for both scenarios. The means and standard deviations for both scenarios are shown in Table 3 and Table 4.

Table 3. Means and standard deviations of VR-based results number learning

No	Reaction Time	No. of Guesses	Correct Guesses	Wrong Guesses	Accuracy (%)	M/SD
1	8.62	37.47	28.87	8.93	77.09	M
	2.603	7.060	8.264	5.540	0.19	SD
2	5.51	59.00	54.27	4.73	91.86	M
	1.959	11.823	15.714	6.304	0.18	SD
3	5.59	56.73	50.87	5.87	89.56	M
	1.047	11.307	16.792	7.818	0.17	SD
4	5.43	57.60	52.00	5.60	90.22	M
	0.472	4.559	9.277	6.347	0.10	SD
5	4.85	62.73	57.93	4.80	92.39	M
	0.563	6.114	9.369	7.268	0.11	SD

Table 4. Means and standard deviations of VR-based results color learning

No	Reaction Time	No. of Guesses	Correct Guesses	Wrong Guesses	Accuracy (%)	M/SD
1	5.6	33.3	18.7	14.7	54.58	M
	2.60	7.06	8.26	5.54	0.19	SD
2	5.4	35.1	21.5	13.5	60.91	M
	1.96	11.82	15.71	6.30	0.18	SD
3	5.0	37.6	27.1	10.5	69.87	M
	1.05	11.31	16.79	7.82	0.17	SD
4	4.8	39.2	31.0	8.2	77.95	M
	0.68	4.84	8.57	4.71	0.14	SD
5	4.2	44.3	35.4	8.9	79.38	M
	0.35	3.44	6.45	3.77	0.09	SD

It is shown through the mean that VR-based language learning does increase student recognition of a word. Reaction time is generally down with correct guess going up along with accuracy. It is also shown through steady value of evaluation metric that the use of VR promotes retention of vocabulary learning. These results showed a positive inclination that is aligned with other previous research [16, 48].

Table 5 and Table 6 shows the means and standard deviations of control group on both scenarios.

Table 5. Means and standard deviations of control group number learning

No	Reaction Time	No. of Guesses	Correct Guesses	Wrong Guesses	Accuracy (%)	M/SD
1	12.700	25.000	11.000	14.000	41	M
	2.993	5.669	8.211	5.940	0.26	SD
2	12.553	29.667	13.400	16.267	44	M
	1.609	4.419	8.052	6.692	0.24	SD
3	11.527	29.667	15.067	14.600	51	M
	1.069	4.806	7.196	6.749	0.22	SD
4	10.060	31.667	16.867	14.800	53	M
	1.683	5.563	6.906	6.570	0.20	SD
5	8.940	36.333	20.400	15.933	56	M
	1.285	6.399	7.614	7.025	0.18	SD

Table 6. Means and standard deviations of control group color learning

No	Reaction Time	No. of Guesses	Correct Guesses	Wrong Guesses	Accuracy (%)	M/SD
1	12.80	24.00	9.27	14.73	37.89	M
	1.59	3.38	4.85	3.97	0.18	SD
2	12.11	27.33	12.40	14.93	44.69	M
	0.87	4.95	6.20	5.47	0.20	SD
3	11.55	29.67	14.27	15.40	48.26	M
	1.03	4.81	4.74	5.04	0.15	SD
4	10.34	31.67	15.93	15.73	50.02	M
	1.57	5.56	5.28	4.86	0.14	SD
5	10.33	33.33	17.33	16.00	50.85	M
	1.50	4.50	7.31	5.24	0.18	SD

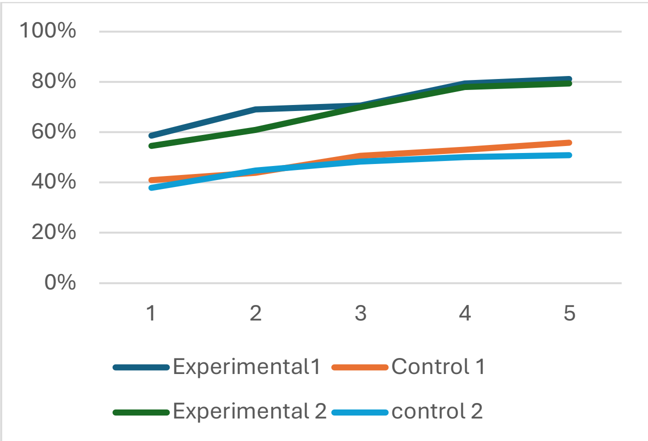

Fig. 2. Accuracy comparison.

To better depict the difference between both groups, the following chart is created. Fig. 2 shows the comparison of accuracy between control and experimental group. It is shown that although each group showed improvement with time, VR-based learning showed a significantly better result. However, it is unclear whether the observed retention is attributable to VR based learning or merely to repetition, as both groups demonstrated retention, as shown on Fig. 2. It is also noted that the experimental group answers more questions than the control group. Fig. 3 showed the difference between those groups. This difference however is not only attributed to the increased knowledge of the student but rather also on the digital interface enabling the user to pace the test faster rather than waiting for a test instructor to show a new question.

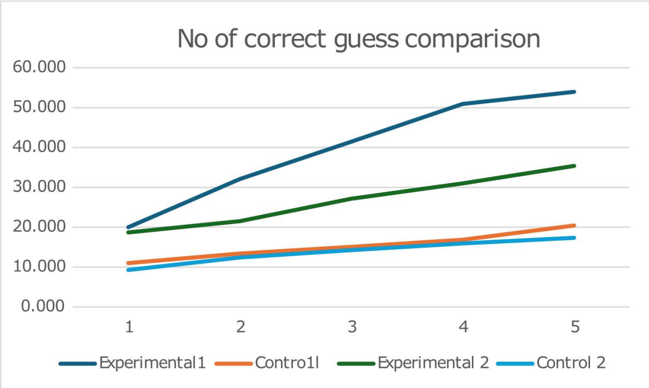

Fig. 3. No guess comparison.

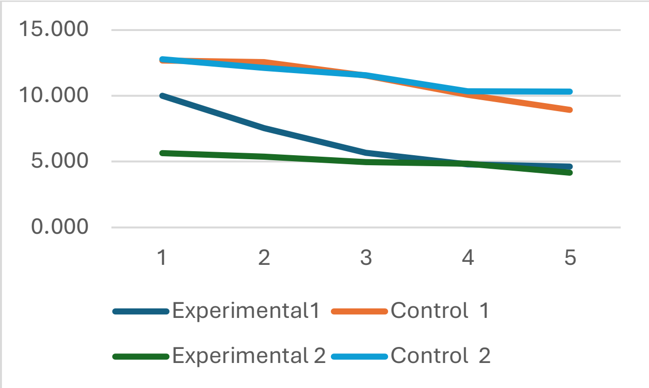

Fig. 4. Reaction time comparison.

Fig 4. shows that reaction time between control and experimental group is better over time although the experimental group showed a lower reaction time. One interesting thing to note is the jump that happened right after the first test to the second test. After the initial test, the experimental group showed a significant improvement on the second test and then started to fluctuate on subsequent tests. This however requires more experiments to conclude causality.

At the end of the experiment another test is conducted to calculate the vocabulary acquisition of both groups. The results can be seen in Table 7. Table 7 provides evidence for the positive inclination by showing the pre-test and post-test results for both the VR (experimental) and non-VR (control) groups. The post-test scores for both groups improved, but the experimental group's increase was more significant (54 to 79) compared to the control group (45 to 58). This demonstrates that the VR-based learning led to better vocabulary acquisition.

Table 7. Post-test results

Group	Pre-test	Post-test
VR	54	79
non-VR	45	58

Fig. 5 shows the results in visual, and it is shown that the post-test for both groups is improving, but the experimental group increases more.

To show statistical significance of the treatment, A Mann-Whitney-U test is conducted over the result of the post-test for the experimental group and control group. Null Hypothesis for the treatment is that the mean of both groups is identical. The calculation is conducted with the following result. For the experimental group of color learning the mean is 79.33 with $df = 14$ and $s = 10.997835$ while the control group mean is 69 with $df = 14$ and $s = 11.254629$ The resulting U test resulted in $p = 0.02151$, and p-value < 0.05 meaning the difference in mean is statistically significant.

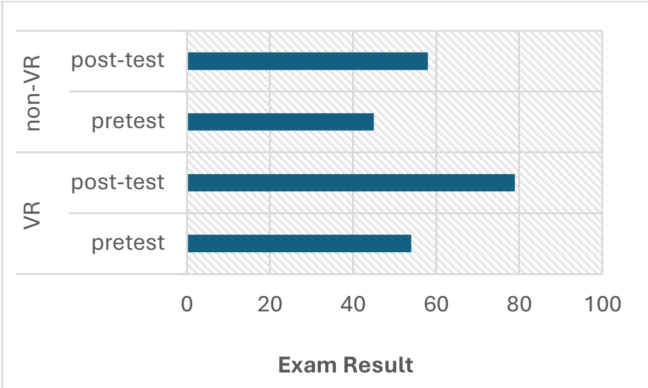

Fig. 5. Pre vs post experiment test comparison.

Using repeated measure ANOVA test on the weekly test it is also reported that the mean is statistically significant. This means that the improvement over several training is fruitful. Table 8 shows the ANOVA test on number learning.

The same could be said for color learning as seen on Table 9.

Table 8. Repeated measures ANOVA test on number learning

Source	DF	Sum of Square	Mean Square	F Statistic	*p*-value
Between Subjects	14	13,032.72	930.9	13.1639	5.67e-13
Between Treatments	4	4966.29	1241.5	17.557	2.17e-9
Error	56	3960.13	70.71	-	-
Total	74	21,959.15	296.74	-	-

Table 9. Repeated measures ANOVA test on color learning

Source	DF	Sum of Square	Mean Square	F Statistic	*p*-value
Between Subjects	14	14,229.76	1016.41	12.24	2.39e-12
Between Treatments	4	6913.90	1728.47	20.82	1.469e-10
Error	56	4647.64	82.99	-	-
Total	74	25,791.30	348.53	-	-

To evaluate the participant motivation response, a survey using the Instructional Materials Motivation Survey (IMMS) [49] is also conducted, this is also used to answer the level of student engagement on VR-assisted vocabulary acquisition as mentioned in RQ3. The IMMS is a 36 questions survey using a 5-point Likert scale. The survey was distributed among the participants but only 25 out of 30 responded.

The overall result of the survey is positive towards the use of VR as a learning tool. Fig. 6 shows the respondent positive views on VR as an education tool. With the value of one being strongly disagree and 5 being strongly agree.

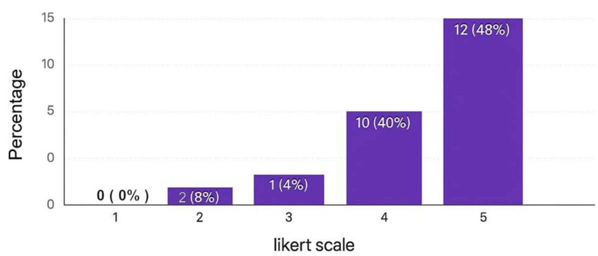

Fig. 6. How interesting VR learning is to you.

Surveys also show an 80% of participants consider using VR as learning tools to help with their focus. Fig. 7 shows the result of the question: "Does the information within the VR experience helps you to focus".

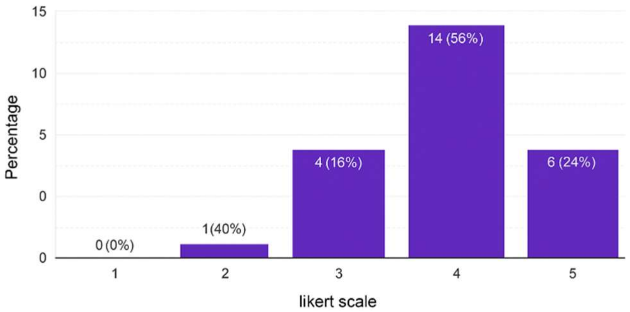

Fig. 7. VR helps participant's focus.

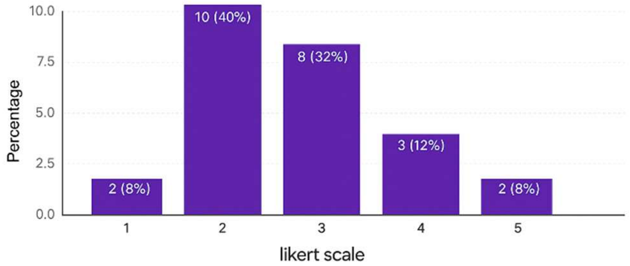

Fig. 8. VR helps with boredom.

This also aligns with previous research on engagement in VR [10]. One of the problems with language learning is repetition that causes boredom. But the use of VR tools gives an additional novelty that survey shows to reduce boredom in learning. Fig. 8 shows the survey result of the question 'does the amount of repetition in this VR experience bored you'.

Building upon prior research demonstrating the positive impact of virtual reality on language learning, this study provides quantitative data on vocabulary acquisition using VR flashcards in a logographic language. Results indicate that VR accelerates vocabulary acquisition and increases learner motivation, aligning with established language acquisition theories. Furthermore, the study highlights the importance of integrating technologies like VR into language pedagogy to enhance student engagement and knowledge retention, suggesting the potential of VR to transform language learning by creating immersive experiences. Future research should focus on expanding vocabulary complexity and participant pools and exploring the nuances of logographic language acquisition.

While this study provides compelling evidence for the benefits of VR in logographic language acquisition, it is important to acknowledge certain limitations. The sample size of 30 students, while sufficient for initial exploration, may limit the generalizability of the findings. Additionally, the focus on simple, single or two-character Kanji words does not fully represent the complexity of vocabulary acquisition in logographic languages. Further research with larger participant groups and more complex vocabulary is needed to confirm and expand upon these findings. Finally, the study's duration and the specific aspects of logographic language acquisition explored could be expanded in future research.

B. Discussion

The findings of this study confirm the effectiveness of immersive VR flashcards in facilitating L2 vocabulary acquisition, particularly for logographic languages. This section provides a deeper discussion by comparing our findings with previous research, examining the implications for retention, and situating the results within relevant language acquisition theories

1) Comparison with previous research

Numerous studies have investigated the effects of virtual reality on second language vocabulary acquisition, mainly in alphabetic languages. Alfadil [16] demonstrated that virtual reality enhances vocabulary learning; however, his study concentrated on English as a foreign language and did not consider the complexities of logographic languages. Our study enhances existing knowledge by demonstrating that VR is effective for learning Japanese kanji, which necessitates the memorization of distinct characters lacking direct phonetic correspondence.

Legault *et al*. [47] demonstrated that immersive VR enhances vocabulary acquisition by providing context-rich environments. Nonetheless, their research did not evaluate long-term retention. This study demonstrates that virtual reality enhances initial vocabulary acquisition and improves retention over traditional flashcard methods, as evidenced by multiple testing sessions conducted over several weeks.

Chen and Yuan [48] conducted research on the use of VR in Chinese language learning, highlighting enhancements in engagement and vocabulary acquisition. Nevertheless, their research did not conduct a direct comparison between virtual reality and conventional methods. This study provides a direct statistical comparison between VR-assisted and traditional vocabulary learning methods, addressing an existing gap in the literature

2) Vocabulary retention and speed of acquisition

The findings demonstrate that VR-based learning yields markedly superior retention rates compared to conventional methods. This corresponds with the findings of Kaplan-Rakowski *et al*. [39], which indicated enhanced engagement and performance in language acquisition with IVR. The expedited reaction time in our experimental group indicates that VR improves cognitive processing speed, enabling learners to identify and retrieve terminology more effectively.

These enhancements can be elucidated by cognitive burden theory, which asserts that diminishing extraneous cognitive burden enhances learning efficacy. In our study, virtual reality offered an interactive and immersive educational experience, potentially diminishing cognitive load and enhancing retention. Moreover, dual coding theory posits that the integration of visual and verbal cues improves memory encoding, corroborating our finding that students learning kanji via VR outperformed those utilizing conventional methods.

3) Implications for logographic language learning

The findings demonstrate that VR-based learning yields markedly superior retention rates compared. In contrast to alphabetic languages, learning logographic languages presents distinct challenges, as memorization is contingent upon the recognition of character structures rather than phonetic signals. Handwriting skills were the primary focus of prior research, such as that conducted by Kim *et al*. [46]

on VR-based logographic writing, rather than vocabulary acquisition. Our research offers novel insights by illustrating that VR can facilitate the direct acquisition of logographic vocabulary, rather than merely character formation.

Additionally, our findings indicate that VR improves engagement and diminishes tedium, which are prevalent obstacles in conventional, repetitive learning methodologies. The study is consistent with prior research on the motivational advantages of VR [48], thereby supporting the argument that VR is a viable solution to the cognitive and affective obstacles that are ascribed to the acquisition of logographic languages.

4) Future research directions

This study presents compelling evidence regarding the effectiveness of virtual reality in second language vocabulary acquisition; however, additional research is necessary to investigate its influence on more intricate vocabulary structures, including compound kanji words. Furthermore, expanding the sample size and integrating eye-tracking or neurocognitive measures may yield more profound insights into the impact of VR on cognitive processing in vocabulary acquisition.

By integrating insights from prior research with our findings, this study strengthens the case for using immersive VR as a pedagogical tool for language learning. Future studies should investigate how different VR learning strategies affect learners with varying proficiency levels and learning styles.

V. Conclusion

The test results show that virtual reality is effective as a tool for vocabulary acquisition. It also shows that the knowledge gained by the experiment, although reclining is retained through several weeks. This aligns with research from other researchers that show retention of knowledge from the use of VR. This result is attained despite the test subject being a logographic language showing no real differences between VR vocabulary acquisition of other language. This might stem from using simple vocabulary that only contains a single or two letter max. It is yet to be explored in depth, however, and further research needs to be done to explore specific aspects of logographic language that might disrupt vocabulary acquisition, like for instance using words that are formed from several other words. User engagements results are shown to be positive and are in agreement with other research on VR for language learning and learning in general. This shows that there is good reception of VR as learning tools. Another limitation in this research lies in the number of subjects being tested, which is quite small. A larger pool of participants would result in better, more conclusive research. Further research could be done using a more complex and larger pool of vocabulary with larger sets of participants.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

SS conducted the research, EDH analyzed the data, DJS wrote the paper; all authors had approved the final version.

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