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Effectiveness of virtual reality game in foreign language vocabulary acquisition

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A R T I C L E I N F O

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A B S T R A C T

This study explored the influence of the virtual reality (VR) game *House of Languages* on the English as a Foreign Language (EFL) vocabulary acquisition of intermediate school students. A quasi-experimental design helped determine the impact of the VR intervention on the learning process over the traditional EFL vocabulary acquisition method. A nonrandom convenience sample of ($n = 64$) male students was divided into an experimental group and control group; each group contained ($n = 32$) students. The findings from this study of independent *t*-tests at the end of the experimental period indicated that students using the VR game *House of Languages* had greater achievement in vocabulary acquisition than those using the traditional method of vocabulary acquisition. This study seeks to create awareness among educators that the use of the new VR technology as an effective vocabulary acquisition method in the learning process could be engaged to improve vocabulary acquisition and go beyond previous methods to enhance the degree of achievement in classroom.

Many people think of Virtual Reality (VR) as an innovative technology related to science fiction works such as science fiction films and TV shows. Many have already seen today's VR in many different kinds of applications, particularly through video games on computers, tablets, and smartphones. In fact, much of our daily activity occurs in a virtual environment by using online tools. Virtual Reality is also used for a different kind of movie experience at theaters to virtually navigate new places through smartphone applications. Although most experience VR in entertainment form, there are other uses for it, including in studying cultural heritage and in education, military, and the arts and industrial section (Ibáñez & Kloos, 2018; Loureiro & Bettencourt, 2014). Huawei's global industry vision (GIV) report (2019) predicted that in 2025, global VR users will exceed 337 million, and the output value will exceed US $292 billion. Moreover, by 2025, the percentage of enterprises adopting VR technology will increase to 10%. The same report forecast that by 2028, the revenue of the VR market will reach US $1.3 trillion.

At this point in time, VR is actively being incorporated as a teaching and learning tool to enhance a student's learning experience due to the implications of these developments in the learning process (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2019). Wang, Wu, Wang, Chi, and Wang (2018) confirmed that VR was key for improving meditation and giving users a measure of control over the environment. Some studies conducted in physical classrooms with the 3D immersive virtual environment confirmed that the learners tended to feel more confident, open, participatory, creative, and understanding because they were definitely interested in learning (Cai, Chiang, Sun, Lin, & Lee, 2017; Loureiro & Bettencourt, 2014; Pellas, Fotaris, Kazanidis, & Wells, 2018).

Astronomy students can discover the solar system and how it rotates by physical engagement in a VR environment, which is not a possible experience in real life. *Titans of Space and GeoDome* are experiences in which VR users can see planets, stars, and earth and

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move around them. Hence, virtual reality helps students and teachers to find out and explore precise information regarding objects and micro and macro visualizations that are not possible to experience in real life with the naked eye. This is evidenced through qualitative results in a study by Young, Farnsworth, Grabe, and Guy (2012). Now impressive literature exists on virtual reality in education, learning science, learning environment, and EFL writing performance (e.g., Dolgunsöz, Yildirim, & Yildirim, 2018; Parong & Mayer, 2018; Peeters & Dijkstra, 2018; Zizza et al., 2018); however, there is still limited research on foreign language vocabulary acquisition through VR technology.

In this study, through the high-impact application *House of Languages,* the teacher brought the benefits of learning trips and life experiences to the classroom without the expense needed for an educational trip. Students got a hands-on experience to discover, interact, learn and enjoy 12 different locations such as the airport, cinema, zoo, cafe, and museum. The author used the 12 different locations because that content is aligned with the content criteria used at the Ministry of Education in Saudi Arabia at the intermediate stage. The researcher hoped to bring the course content to the hands and minds of students in a fun, engaging setting, adopting creative learning methods through immersion in a virtual environment.

In this paper, the researcher formulated the following Hypothesis to help establish the goals and objectives of the study:

Hypothesis. The participants who use virtual reality score significantly higher on foreign language vocabulary acquisition achievement as compared to those who use the traditional method of foreign language vocabulary acquisition.

1. Review of the literature

1.1. Language learning

With the growing demands associated with globalization, more and more people are deciding to familiarize themselves with other languages. The Chinese, Koreans and Japanese are taking up English as a special course to equip their populations with knowledge of the said language in preparation for the global political, social and economic societal contexts (Honna & Takeshita, 2014). This came with their belief that learning this skill would give them an edge especially in the field of business and international relations (Honna & Takeshita, 2014).

Foreign language speakers have often struggled with limited vocabulary in general as they were learning a new language. This struggle is intensified when trying to learn vocabulary, or jargon, for a specific field of study. The importance of the vocabulary to foreign language learners has focused on effective vocabulary teaching strategies that have lead to an increase in the acquisition of vocabulary, especially in writing development as well as writing performance. A study in 2016 demonstrated that productive knowledge of vocabulary in a foreign language is correlated strongly with foreign language writing performance. Their results indicated the higher-performing of foreign language writers examined in this study had significantly higher total productive vocabulary test scores (Johnson, Acevedo, & Mercado, 2016). Hence, a productive, working knowledge of vocabulary when studying a foreign language is especially important to the overall development of authentic application of the knowledge of foreign language vocabulary skills.

1.2. Computer games

Computer games are popular among children and teenagers, and many adults even participate, because the games are exciting and fun to play. During recent years, many parents have raised their concerns over the negative effects that computer games have on their children, but research shows that games can be used to enhance learning (Debabi & Bensebaa, 2016) by using serious game-enhanced algorithmic learning and teaching. Results showed that the students who played *AlgoGame* have encouraging positive results in writing the sorting algorithm compared to students who write a sorting algorithm without knowing about the game. In Malaysia, research on computer game-based learning endorsed the belief that the Educational Game (EG) is engaging and motivated students in approaches that traditional learning has not. Students who used the EG version gained significantly higher achievement mean scores in comparison with the achievement of the students who used the traditional learning style, with the Wilk's lambda value of 0.950 as indicative of the significance, $F\,(3{,}192) = 3.336$, $p < .05$ (Teh, Wan Ismail, & Toh, 2010).

Based on the research of Younis and Loh (2010), gaming promotes learning and builds necessary skills because games provide mental challenges to the players. Their research concluded "serious games are computer games with entertainment characteristics, but designed for serious purposes like corporate training and education" (p. 1). Likewise, teachers who are advocates of modern methods in teaching find digital video games help students learn essential skills such as adopting, adapting, collaborating, creating, and writing (Younis & Loh, 2010).

Furthermore, modding (modifying) is defined as "a design process that allows game 'modders' to explore concepts, apply skills, and test them within virtual environments that mimic the real world" (Younis & Loh, 2010, p. 1). "Mods" themselves are the "fan-made changes to a video game with a range of complexity from simple adjustments in game play or variables to 'total conversions' where an entire game is redesigned" (Postigo, 2003, 2007; Sotamaa, 2004), and "modders" is the colloquial term for fans who make and disseminate mods. Likewise, the modding of Commercial Off-the-Shelf (COTS) games varies in classrooms due to the form of learning activities such as experiential learning, teaching computer programming logical thinking skills, and script writing. They also serve as a technical platform to introduce learners to the concepts of information technology and story writing skills (Younis & Loh, 2010).

In addition, game-based learning teaches content that is able to contribute to the standards of learning theories and 21st century skills. For example, massively multiplayer online games (MMOG) like *World of Warcraft* and *Call of Duty* teach the importance of collaboration. These games also foster better communication and help reenact or practice strategies that can be used in real-life scenarios. Lastly, well-designed games (i.e., even children's games like Angry Birds) often require players to solve various complex problems, and thus gamers learn critical thinking and problem solving skills (Miller, 2012).

1.3. Virtual reality

Virtual reality is "a computer technology that gives the illusion, to those who use it, of being immersed in a virtual environment that does not really exist. It is a computer simulation of a real situation where the human subject may interact with the virtual environment, sometime by the means of non-conventional interface like glasses and helmets on which the scene is represented and the sounds reproduced" (Fassi et al., 2016. p. 140).

1.4. Initial attempts at virtual reality

Concepts of virtual reality existed before Jaron Lanier coined the term *Virtual Reality* in 1987. The following is a brief glimpse into the technology progression and innovators' path for developing the virtual reality that is overwhelmingly popular and fashionable today.

The first attempt in the discovery of 3-D was in 1838 by Charles Wheatstone when he created a stereoscopic motion picture. Charles Wheatstone believed that the human brain treats the different two-dimensional pictures from each eye to see a particular object of three dimensions (Weinbaum, 2015). We can see concepts similar to this used in Google Cardboard today.

Pygmalion's Spectacles by science fiction writer Stanley Weinbaum in the 1930s was the second attempt to describe a goggle-based virtual reality. *Pygmalion's Spectacles* talks about the idea of a pair of goggles that enables the wearers to enter completely into the action of a story and gives sight, smell, taste and touch to the experience (Weinbaum, 2015). *Pygmalion's Spectacles* enhances the idea that virtual reality has been a part of our lives for decades.

Sensorama by Morton Heilig in the mid-1950s was the first creation that immersed audiences into a film through an arcade-style theatre cabinet that stimulated all the senses. Heilig created six films titled *Motorcycle, Belly Dancer, Dune Buggy, Helicopter, A Date with Sabina*, and *I'm a Coca Cola Bottle*. All these films involved 3D, sounds, colors, smell and feelings of motion (Jonassen, 2004), similar to what we term a 4D experience today. Later in 1960, Morton Heilig invented the telesphere mask, which is considered the first VR-head mounted display (HMD). The headset offered 3D vision compounded with stereo sound (Plant & Murrell, 2007).

In 1969 a virtual reality computer artist, Myron Kruegere, developed artificial reality. Artificial reality was a group of experiences that utilized a sensory floor to perceive the applicants' actions around the environment (Plant & Murrell, 2007).

After all these early attempts at VR, there was not a term to describe all these developments in the research area. In 1987 Jaron Lanier coined the term "Virtual Reality" when his company, Visual Programming Lab, developed a range of VR gear. Visual Programming Lab was the first company in the world to sell VR goggles.

1.5. Virtual reality and education

Education has adopted virtual reality in the teaching/learning process to present complex data in an accessible, fun and easy way for students to learn. Thus, VR not only allows students to interact with each other individually or in a group in a 3D environment, but goes beyond that to enable students to interact with objects in the VR environment to find out information, explore and build their own knowledge. Recent study in exploring virtual memory palaces in both HMD and Disk-Top for recalling information (Krokos, Plaisant, & Varshney, 2019) suggests that using virtual memory palaces by HMD enhances productivity through better recall of large amounts of information compared to Disk-Top. In this study, a majority of participants (95%) reported that they preferred HMD because they were more focused in the task.

Piovesan, Passerino, and Pereira (2012) outlined many advantages of using virtual reality for educational purposes:

> Virtual Reality can be used to make the learning more interesting and fun with the purpose of improving the motivation and attention, decreasing costs when using the objective and the real environment no matter how expensive the simulation is. It also makes possible that situations that were impossible to explored in the real world can be done, for example: exploring a planet like Mars, traveling inside the human body, doing submarines explorations or inside caves, visiting very small places to be seen (molecules) or very expensive or very far away, or yet because this place is in the past (historical places) [*sic*]. (p. 256)

This supports the belief that virtual reality may be a cornerstone of instructional practice as a valid mechanism for motivating and engaging learners. Hence, Ghanbarzadeh's research states modernizing production in the virtual reality applications will serve a wide range of people and organizations: practitioners, nurses, administrators, universities, clinics, healthcare companies and the private sector (Ghanbarzadeh, Ghapanchi, Blumenstein, & Talaei-Khoei,. 2014). Thus, virtual reality can serve to enhance learning performance through its ability to simulate a real-life environment. Applications and research in this area for K-12 and higher education are just starting to be a huge growth area.

Additional support for VR education is evidenced in Huawei's global industry vision (GIV) report (2019) that predicts that using cloud-based VR education and surgery simulations will be the ideal way to overcome the difficulty that students have when studying autopsying. Thanks to VR technology, students will be able to precisely monitor their subject of study and also be able to repeatedly perform the same simulated practice. As a choice, they will be able to broadcast their practices, experiences and surgeries live or record them and share them with their teachers, friends and communities. A study by Aim, Lonjon, Hannouche, and Nizard (2016) was conducted to determine the effectiveness of VR technology in orthopedic surgery. The results of this study indicated that VR training facilitates technical skills in orthopedic surgery.

The development of VR applications add new perspectives to how learners perceive and understand the world around them, enabling learners to broaden their ability to sense and perceive beyond the limitations of the classroom. Several educational content companies design pre-packaged VR lessons. These contents utilize either a self-contained lesson for the classroom or a supplementary resource. The following is a brief glimpse at the most recent VR simulations that may have the most pervasive impact on education.

- *Titanic VR.* This immersive educational interactive game enables learning through 6 h of game-play as if one is in a deep underwater submarine. Learners will go from exploring to understanding the historic, tragic story of the sinking of the RMS Titanic in the early morning of April 15, 1912 in the North Atlantic Ocean (VR Education Holdings PLC., 2018).
- *Google Expeditions.* This VR app enables teachers to take their students on virtual trips anywhere in the world. What make this app unique is that students' HMDs are synchronized to teacher devices which have the ability to control the environment and direct students' attention to a discussion or another class activity (Google LLC., 2019). According to Lanthier, Jarick, Zhu, Byun, and Kingstone (2019), Expeditions facilitates the learners' visualization with simulations and through inquiry-based learning.
- *ENGAGE.* This advanced VR training and education platform enables learners from anywhere in the world to attend their classes and communicate with their classmates virtually within a VR environment (VR Education Holdings PLC, 2019).
- *Titans of Space Plus.* This immersive application enables learners to take a deep-dive journey into our solar system and bring them beyond that to discover and explore precise information regarding a few of the largest known stars that cannot be seen with the naked eye (Drash VR LLC, 2019).
- *Google Earth VR.* This VR app helps people virtually fly as a bird to explore our planet earth and puts the whole world within their reach. Through this app, one is able to stroll along the street of New York City or stand over the top of the highest peaks such as Everest and K2 (Google ARVR, 2019).
- *Unimersiv.* This is a package of educational VR apps containing four educational experiences designed to help students:
  o Explore the International Space Station
  o Study Human Anatomy
  o Travel to learn about Stonehenge in Wiltshire, England, as it was 5000 years ago
  o Explore the Titanic virtually like never before (Unimersiv, 2019).
- *InMind.* This scientific game enables learners to experience a tour into a patient's brain looking for the neurons that cause mental disorder. Through this application, learners submerge into the microworld and experience the miracles of the human mind (Luden.io, 2017).
- *Egyptian Mysteries.* The main goal of this investigation game is to teach learners about ancient Egypt through a journey inside the pyramids of Giza and the Ramses Temple. This application helps learners to improve problem-solving skills through finding out what happened to the hero's brother who disappeared (Unimersiv, 2019).

This current study leads a new initiative through using the *House of Languages* App developed by the Estonian game company Fox3D and Samsung VRGear (Fox3D Entertainment, 2015) for the purpose of exploring virtual reality in classroom contexts as a means to improve the foreign language vocabulary acquisition of intermediate school students. Unlike the computer 3D environment and other applications currently in the market based on "see the object from the different perceptions," *House of Languages* presents a new vocabulary learning style with mini-games such as a word guessing test and puzzles which enable players to use several channels of perception in interactive VR real life environments. The limited studies in the literature that address the effectiveness of VR experience with high levels of immersive practice and interaction in the field of foreign language vocabulary acquisition led the author to conduct this study.

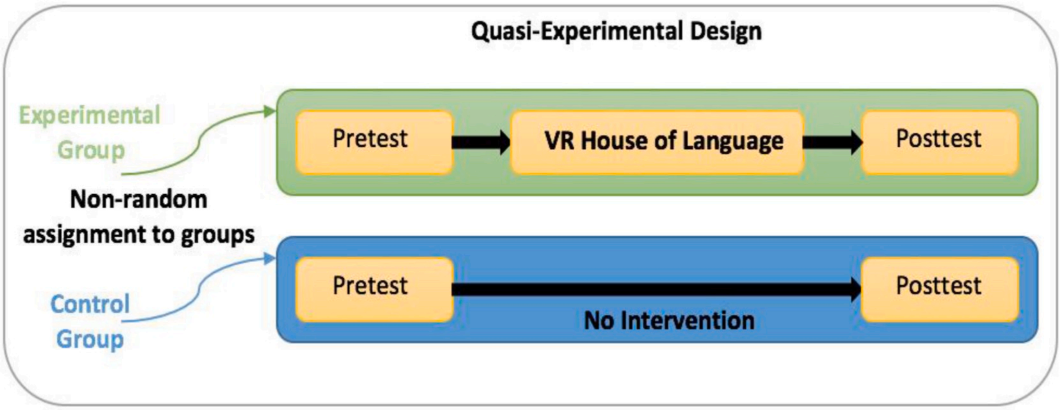

Fig. 1. Quasi-experimental design.

2. Methodology

With respect to the quantitative analysis, the researcher adopted quasi-experimental methods (see Fig. 1). Quasi-experimental methods enable the researcher to manage the research situation so that causal relationships among variables may be evaluated (Cooper & Schindler, 2008). The dependent variable was vocabulary acquisition. Post-test analysis was used to compare pre-intervention and post-intervention data collection points among all groups. The independent variable was the method of study to facilitate in the teaching and learning process.

2.1. Participants

Participants in this study were male students ages 12–15 who were engaged in vocabulary acquisition in a non-native language learning course in Saudi Arabia. The educational system there is segregated by gender, which means males are separated from females in the place of learning. Participants were non-randomly selected using convenience sampling. The author sent six applications to six different schools that teach English as a foreign language course and have a minority of English native-speaker students. The author got an acceptance from one school to conduct the study. The classrooms were chosen based on those enrolled in an EFL course that semester. Both classrooms had the same teacher to teach the course. He had been a teacher for six years but did not have VR classroom instruction experience. The vocabulary acquisition program was analyzed in term of effectiveness with and without the inclusion of virtual reality for 12 days, for 35–45 min during school-day class time. The consent forms and the confidentiality statements were signed by students, teacher and parents. The implementation of this study occurred in intermediate school classrooms in the Eastern Region, Al-Khobar, Saudi Arabia.

2.2. Instruments

2.2.1. Pre-/post-vocabulary test

A pre-/post-test was developed by the researcher and reviewed by three experts as well as the classroom teacher. A 30-word vocabulary test was given to the students. (Appendix A). The words were taken from six different topics and combined in one test which students were asked to take. The test measured the vocabulary learning objectives of the participant groups (Appendix A). The researcher developed the test based on the Wesche and Paribakht Vocabulary Knowledge Scale (1993) (Paribakht and Wesche, 1993). The basic ideas of the scale is to measure progressive degrees of word knowledge. Students have to rate how well they know a word on the following scale:

I. I don't remember having seen this word before.
II. I have seen this word before, but I don't know what it means.
III. I have seen this word before, and I think it means ______. (translation in Arabic).
IV. I know this word. It means _____. (translation in Arabic).

2.3. Technology intervention

2.3.1. House of Languages virtual reality app

The author of this paper suggests the use of a VR environment game called *House of Languages* to facilitate vocabulary acquisition (see Fig. 2). *House of Languages,* created by the Estonian game company Fox3D, is a VR app to learn Spanish, German, Russian and English. The VR experience in *House of Languages* places players in a cartoon house with a pretty raccoon character host named *Mr.*

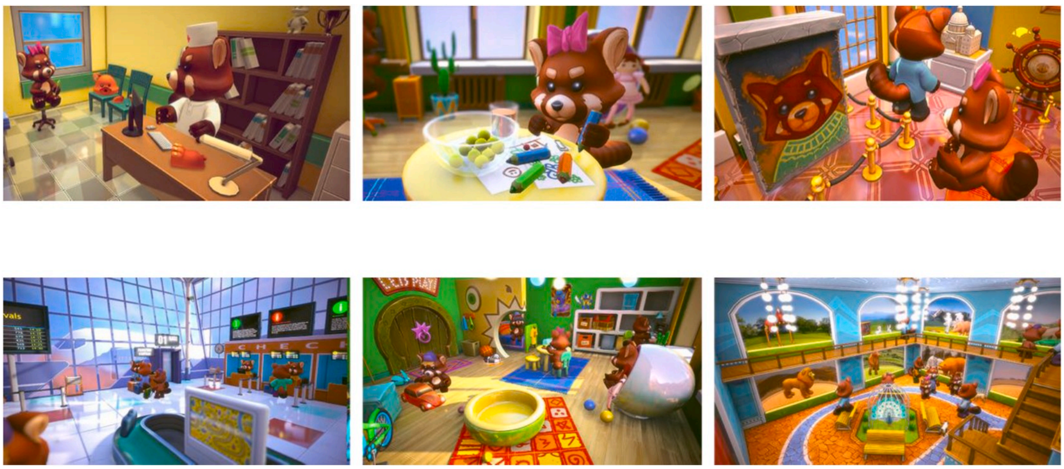

Fig. 2. Sample of the game virtual reality environments.

Woo, who walks with the player around the environment teaching them a foreign language. When players gaze at 3D objects within the game environment, they are able to observe object names and hear the pronunciation. The objective of the game is to facilitate students in learning new foreign words and improve their language skills in an interactive VR environment. Vocabulary difficulty gradually increased within each location, starting with "find the object" activities and ending with some mini-games such as a word guessing test and puzzles.

2.3.2. Samsung Galaxy Smartphone Gear VR

Fig. 3 presents Samsung Galaxy Smartphone *Gear VR* (Samsung Gear, 2016). The headgear is designed to accommodate the Samsung Galaxy smartphone, which you can see in the figure, to provide a high quality VR experience. Samsung headgear and handset controllers enable the user to move in real space to gain a different view of the same object, manipulate objects, and interact with the environment seamlessly as in real life. Also, *House of Languages* is designed exclusively for the Samsung Galaxy smartphone and its headgear. The author played a brief explanation video to the intervention group to introduce the VR Gear and *House of Languages* App, including their functionalities, and to model how to use the proposed technique. Additionally, participants took a training session on how to wear the VR headset and how to deal with the handset controllers to prepare the game before the study began. The training session aimed to make sure that participants felt relaxed and comfortable with the technology and processes and that all had the same procedure to use.

3. Procedures

In this specific context, the researcher believes the study required experimental methods to provide a clear path to understanding the research Hypothesis. The experiment included 12 days of 35–45-min sessions during school-day class time that commenced and concluded with an evaluation (pre-test and post-test). It was established that the training program varied in several aspects: the presentation of lessons, training time, and the type of evaluation to measure learning, even though the participants were given enough time to practice until they felt comfortable with the Samsung headgear. These methods can be explained and classified through multiple characteristics or elements (See Table 1). This warranted the use of primary data.

Both groups had the same teacher teaching the course. He had been a teacher for six years. Both groups took a comprehensive vocabulary test of 30 words that matched vocabulary content to know their baseline in the beginning of the experiment period. This test contained various vocabularies from basic level to advanced vocabulary level (see Appendix B). As the study occurred at the beginning of the semester, the classroom teacher expected that both groups would perform equally well in the pretest (as evidenced by the pretest analysis).

Students in the experimental group depended on only the virtual reality game during the experiment period to meet the requirements of the course. The teacher used VR technology each day for 12 days, totaling 35–45 min daily of exposure to VR. Students exchanged VR headsets after participating in a VR game for an established, timed session to ensure that all students had the same opportunity to play the game in a controlled environment. The actual learning time differed from one student to another, but ranged between 5 and 8 min in each trial based on individual achievement in each task. The teacher walked around the classroom to ensure that students were engaged in the learning process. Those who were waiting for their experience were monitored by the teacher.

The control group depended on the traditional way of learning vocabulary, using a book, lecture and worksheets during the experimental period in the learning process to meet the requirements of the course. At the end of the experiment period, the two groups again took the same comprehensive vocabulary test. The questions in the pre- and post-exam were identical; the post-test question order was randomized from the pre-test.

Results from these exams were collected before and after the experiment period from each group and were processed and analyzed quantitatively through SPSS. The researcher chose this design to determine if virtual reality games would improve vocabulary acquisition by comparing and analyzing the results of the intervention group with the result of the control group.

Fig. 3. Sample of samsung gear VR.

Table 1
Procedural step and timeline.

Procedural Step	Timeline
Develop pre-/post-test and review for validity and reliability	Prior to data collection
Select control and experimental groups	
Administer the equipment training	Prior to administering the pre-test
Administer pre-test	First class session of the experiment period
Vocabulary learning activities implemented by classroom teacher. (Experimental group will use VR technology during this time.)	12 days (experiment period minus first and last day) of 35–45 min of game playing daily
Structured observation by researcher	Approximately four times per week during the experimental period
Administer post-test	Last class session of the experiment period

4. Data analysis

For the purpose of evaluation, the proponent used Independent Sample *t*-tests to address the research Hypothesis. In addition, to assume the difference, the proponent applied the use of frequency distribution, weighted mean, and percentage. To be more specific, the researcher looked to the sample means and standard deviations for classroom outcomes to measure by intervention status.

Independent *t*-test analysis was considered an "analysis of independencies" to compare means across groups of participants that were not related to each other in any way. Independent *t*-test analysis was conducted to compare the post-test scores to find any significance between the experimental and control groups in vocabulary acquisition.

4.1. Reliability and validity

4.1.1. Reliability

Reliability was examined for both vocabulary tests using an internal consistency procedure to calculate Cronbach's Alpha. According to Altman's Benchmark Scale (Gwet, 2014), an α between 0.81 and 1.00 is very reliable. The vocabulary test showed high reliability (Cronbach's $\alpha = 0.899$).

4.1.2. Construct and content validity

Construct and content validity refers to the extent to which a specific item in the test reflects content domain (DeVellis, 2012). To look at the construct and content validity of the test, three experts in K-12 education, as well as the researcher, reviewed the items in the vocabulary test. All experts examined the same items using the Content Expert Review Form developed by the researcher (see Appendix C). The experts were selected based on their experiences and backgrounds. All the expert reviewers had similar background training of at least 10 years' experience in teaching English as a second language. To maintain the independence of the reviews, all reviewers were asked to conduct the reviews individually; the identity of the other reviewers was not known to anyone but the researcher. In the vocabulary test created to match vocabulary content, reviewers were asked to rate:

1. How consistent was the test in relation to the content to be taught in classrooms during the experimental period?
2. Were there any spelling errors?
3. Were there any grammatical mistakes?
4. Did the reviewer have any other recommendations to further improve the test?

Responses from the experts were in 100% agreement that the test was consistent in relation to the content. They were also in 100% agreement that the test was free of spelling errors and grammatical mistakes. According to the experts' responses, the vocabulary test can be considered to have construct and content validity.

Table 2
Independent sample statistics for both experimental and control groups.

	Mean	Standard Deviation	*N*
Pre-Test			
Treatment	58.53	14.70	32
Control	59.06	14.62	32
Total	58.80	14.55	64
Post-Test			
Treatment	81.47	18.68	32
Control	71.16	13.09	32
Total	76.31	16.83	64

5. Results

Individual pre-test and post-test scores were calculated by summing each student's ratings, with a possible range from 30 to 120 for the total rating of the test. Once the students completed the tests, the researcher scored the results. The results were imported into Excel for analysis. The data was analyzed by using the Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp, 2015).

5.1. Independent sample t-test analysis

The corresponding Hypothesis test considered the means of the post-test scores for the experimental and control groups (H_o: $\mu_1 = \mu_2$, H_a: $\mu_1 \neq \mu_2$). Before this hypothesis could be tested, it first had to establish that no initial differences existed between the two groups. Baseline scores on the vocabulary pre-test for the students indicated that the students had acceptable initial knowledge of the content topics. Table 2 shows the pre-test average of the experimental group ($\bar{x} = 58.53$) and the control group ($\bar{x} = 59.06$). Table 3 shows the variance of populations are equal ($p = .795$), so the independent samples test assumes equal variances. Table 3 also shows no statistically-significant difference in pre-test scores between students in the experimental group and control group [$t\,(145) = 62$; $p >$ .05 two-tailed], suggesting both groups had the same vocabulary level at the onset of the experimental period. As it appears both groups come from similar populations prior to treatment, the hypothesis can be tested regarding post-test scores to see if a difference between the two groups exists after the experiment was conducted.

An independent samples *t*-test was conducted to see if a statistically-significant mean difference in post-test vocabulary levels between the experimental and control group exists. As Table 4 shows, the variance of populations for post-test scores are not equal ($p =$ .003), so the independent samples test will not use assumed equal variances. Table 4 also shows a statistically-significant difference does exist in post-test scores between students using the VR vocabulary learning game and those that did not [$t\,(55.53) = 2.56$; $p < .05$ two-tailed].

Table 5 shows the variance of populations for the difference are not equal ($p = .000$), and will not be assumed in the independent samples test. As Table 5 shows, a statistically-significant difference does exist in the difference between the pre-test and post-test scores among students using the VR vocabulary learning game and those that did not [$t\,(38.25) = 3.82$; $p < .05$ two-tailed].

The groups show little difference at the beginning of the experiment, while showing statistically-significant differences after the treatment. Furthermore, the result at the end of experimental period indicated that students using the VR game *House of Languages* had greater achievement in learning vocabulary than those using the traditional method of learning vocabulary.

The mean difference between the two groups is shown in Table 4, along with the 95% confidence interval of the difference. The effect size for difference between means (mean difference = 10.313, 95% *CI*: 2.232 to 18.393) in the treatment conditions was medium (eta squared $\eta^2 = 0.09$). Students who used the VR method scored 0.09 standard deviations higher on the vocabulary acquisition test than the untreated population of $\bar{x} = 71.16$.

The sample means are displayed in Fig. 4, where students in the VR group are shown to have scored significantly higher on vocabulary acquisition than students in the traditional group (for VR group, $\bar{x} = 81.47$, $sd = 18.68$; for traditional group, $\bar{x} = 71.16$, $sd = 13.09$).

6. Discussion

This study set out to identify the effectiveness of VR technology in the learning process, particularly in the field of EFL vocabulary acquisition. The results were positive and supported the study Hypothesis.

6.1. Greater achievement in learning vocabulary

Students in the experimental group showed their ability and enthusiasm to interact with the new learning method that contributed positively to their achievement in learning vocabulary as compared to those using the traditional method of learning vocabulary in the control group. This suggests that the study's main goals of providing and engaging an effective approach to enhance EFL learners' vocabulary acquisition were achieved. This finding is consistent with findings from studies by Tarng, Ou, Yu, Liou, and Liou (2015), and Cihak, Wright, and Bell (2016) showing that Augmented Reality (AR) technologies are an effectual approach for teaching science vocabulary. Students had greater achievement when they used AR as a learning method to learn science vocabulary. Virtual reality and AR technologies share many similarities; thus, this study had similarly positive effects on students' learning and experiences.

Table 3
Independent Samples *t*-test: Pre-test.

Pre-test	*F*	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal Variances									
Assumed	.068	.795	.145	62.000	.885	.5313	3.665	−6.795	7.8572
Not Assumed			.145	61.998	.885	.5313	3.665	−6.795	7.8572

Table 4
Independent Samples *t*-test: Post-test.

Post-test	*F*	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal Variances									
Assumed	9.89	.003	2.56	62.00	.013	10.313	4.033	2.251	18.374
Not Assumed			2.56	55.53	.013	10.313	4.033	2.232	18.393

Table 5
Independent Samples *t*-test: Difference between the Pre- and Post-tests.

Difference	Levene's Test for Equality of Variance		*t*-test for Equality of Means						
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal Variances									
Assumed	21.45	.000	3.82	62.00	.000	10.844	2.842	5.165	16.523
Not Assumed			3.82	38.25	.000	10.844	2.842	5.094	16.594

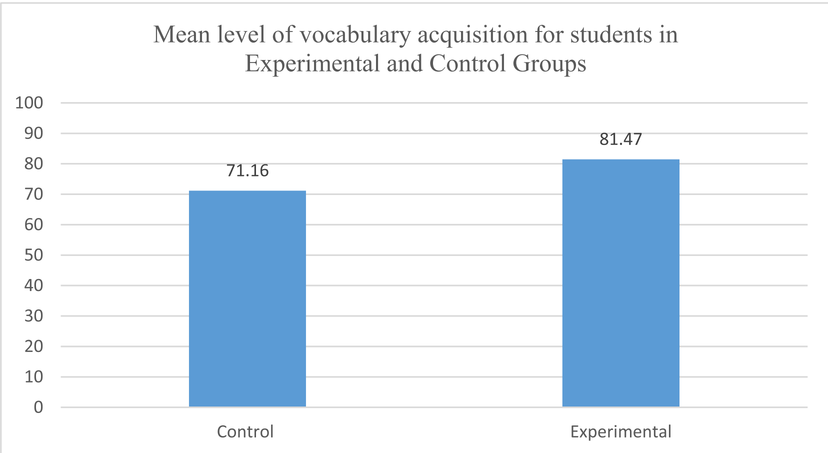

Fig. 4. Mean levels of vocabulary acquisition for students in Experimental Group and Control Group (Significant Differences Observed).

This study discovered that the VR game *House of Languages* simplified the teaching and learning of EFL vocabulary by placing students directly into field trips. For example, with a dramatic tour of a virtual zoo to see the animals and learn the new vocabulary, students were psychologically transported to that location. The students seemed engaged the whole time as their behaviors and discussion were on task with the expected learning activity. It is the belief of this researcher that the extended engagement with vocabulary through the VR experience was how they remembered the new vocabulary; it was through *learning it by living it*.

One explanation is that during the VR set, students maintain eye contact with the VR environment and with the teacher (*Mr. Woo*–raccoon character host), while students cannot make eye contact at all times with a real classroom teacher during the traditional method. Hence, there will be more attentiveness during the VR set (Helminen, Pasanen, & Hietanen, 2016; &; Lanthier et al., 2019) than in the real classroom lecture with more than 32 students. As a result, by increasing attentiveness, the vocabulary acquisition increased as compared to the traditional learning activity that generated minimal eye contact and engagement with content.

In the digital age, sitting down in one place (classroom) is confining for students and reflects the efficiency of an earlier era. Most students have seen, particularly through internet use, much more than their parents and grandparents had at the same age (Buckingham, 2013). It is no surprise that students want the freedom to explore: to go ahead and experience more than what is in the static pages of the now less-often used books and lectures. Although the promise of VR appears heightened for certain subject matters such as science and arts, this study found that it can be applied to other fields, and it is expected that any subject can be taught in this setting. Facilitating learning processes in EFL vocabulary acquisition was done with the convenience and cost efficiency of VR and reflected positively on the outcome of students' word acquisition.

One explanation for this phenomenon is that the excitement for the VR technology for students is higher than for traditional learning method, keeping the students both motivated and engaged. The researcher observed the students' excitement during the experimental period in many sessions. For example, by the end of the first week, five students had bought five sets of VR equipment to use during the experimental period. Also, students expressed excitement about VR technology through coming to the class during the experimental period without any absences. Every day during the experimental period, at the end of class, students came to the class teacher to ask to be the first VR user in the next topic. This level of engagement was an exciting ancillary outcome of the project but, from a researcher's perspective, it also introduced a potential for additional time spent attending to learning by participants in the experimental group and, thus, could have contributed to the increased growth of vocabulary knowledge. Student participants who purchased their own VR devices were not questioned about their extended use of the tool for vocabulary learning outside the formal learning experience.

Another possible explanation was that interacting with a native English-speaking teacher (*Mr. Woo*–raccoon character host) motivated students to develop their productive vocabulary acquisition of the targeted words and application in simulated contexts and increased their efficiency in learning, motivation and comprehension (Wang et al., 2018) more than interacting with a real, but non-native, English-speaking classroom teacher.

Last, it seems that this study opened the doors to treat the most complex issue in teaching EFL, which is the individual differences among students. The VR game *House of Languages* allowed students to learn individually without interrupting the classroom lecture. In other words, each student felt that he had his own individual "teacher" during his time using the VR technology in a truly interactive learning process. The main classroom teacher confined his role to supporting, guiding, and focusing on students who needed extra effort to increase their understanding of the subject material and achieve the main goal of learning vocabulary in context. Students who needed no help were self-sufficient with the VR instruction. This means that each student felt that the entire class time was devoted to him to learn.

Students with low or poor vocabulary achievement were going to have questions to gain understanding, while students with high vocabulary achievement were going to continue their task at an advanced vocabulary level without losing the entire balance of the class time in repeating what they had already learned. This allowed high achievers to move faster and deeper into content without being held back while the other minds in the classroom were being helped. Low achievers were also not pushed through complex tasks to keep pace without having the time to understand the content. This is different from the traditional classroom mentality of moving as one cohesive unit, often to the detriment of either the high or low achievers (Lah & Hashim, 2014). Overall, the confidence of participants in the new technology and the fascinating virtual environment may explain how students in the experimental group achieved more and can better apply what they had learned (Krokos et al., 2019) than their peers in the control group.

Threats to internal validity included the following:

- Pre-testing. One of the potential threats to external validity is that the prior experience (pre-test) can have a somewhat expected effect on the sample that took the pre-test. (Huitt, Hummel, & Kaeck, 1999). This reaction occurs when one of the comparison groups take a pre-test and the other does not. This can raise doubts as to the improvement obtained by either group in comparison to one another. This threat was mitigated by giving both comparison groups the same test.
- Interaction. This threat occurs when the sample subjects are non-randomly selected (Huitt et al., 1999). This threat was addressed by selecting a quasi-experimental research design in which sample subjects were placed into groups with as much randomness as possible. The sample could not be fully randomized because the school was a nonrandom convenience sample; however, the subgroups were randomly selected.
- Multiple Treatments. This threat occurs when students in the experimental group are exposed to more than one intervention (Huitt et al., 1999). This threat was limited because each group used only one intervention. Also, the learning method in each group did not change during the experimental period.
- Period of Time. This threat occurs when the experimental period time is too short or too long. A period that is too short may suffer from not having enough accumulated change to measure regarding the treatment, while a too-long period may suffer from an inability to claim the treatment was the direct cause of any change, particularly when the experiment is not completely controlled. This study used 2 weeks as an experimental period time, which is a compromise between the two extreme experimental durations (Aceto et al., 2015).

6.2. Limitations

As with all quantitative research, this study had some expected limitations. These limitations included some weaknesses that were beyond the researcher's control for different reasons. The limitations included the following:

1. One of the limitations of this study was the gender-limited nature of the study. The school rules did not allow mixing between the genders in one school, so the study results were weak due to generalizing the results to both genders.
2. This study was not fully random-sample selected; it was a convenience sample–the school was non-randomly selected and the subgroups were randomly selected. Due to these factors, the study might be weak in generalizing the results to those who did not participate in this study.
3. As mentioned, some students pursued purchasing VR equipment on their own during the experimental period. As such, some students had additional time experiencing the intervention at uncontrolled times. Although the author and classroom teacher did not notice any negative side effects (such as vertigo, eyestrain, headaches, disorientation) during the experimental periods in the treatment group from using the VR equipment, they could have happened during the uncontrolled time (beyond the school gate).

6.3. Implications

The study provides a research-based instructional framework for examining the possible effectiveness of VR technology engagement in the learning process to teach EFL vocabulary acquisition for intermediate school students. This study pairs EFL vocabulary with an attractive VR environment through which students can access meaningful content topics to facilitate foreign language vocabulary acquisition. In spite of the fact that the participants of this study were intermediate school students, it is also possible that VR technology will be applicable and effective for primary school and high school students. Thus it is essential to create awareness among educators that the use of the new VR technology is an effective vocabulary acquisition method in the learning process to be engaged in all K12 stages. It will not only improve vocabulary acquisition, but also enhance the degree of achievement. Similarly, while the foreign language that was used in this study was English, the VR game *House of Languages* is capable of delivering content in different languages such as German, French, Russian or Spanish to obtain the same positive result. It might also be applicable to serve vocabulary acquisition in one's primary language.

This study used Samsung Gear VR, Galaxy S7 Edge, and the *House of Languages* application. Other VR systems are not compatible for use with *House of Languages* as it is an exclusive title for the Samsung Gear VR. Nevertheless, many VR vocabulary apps are well suited for other VR systems. While students noted they felt comfortable and productive learning vocabulary via the VR method using Samsung equipment, it is possible that other students might not be comfortable with different types of VR systems.

There was no risk or negative effect shown during the experimental period from using this equipment. Any foreseeable risk or negative effects (such as vertigo, eyestrain, headaches, and disorientation) would likely depend on the quality of the VR system and the application environment quality. There is still a need to conduct more empirical studies on the negative effects of using the new VR technology in the long term.

6.4. Future research

Future research is needed regarding using VR in the learning process relevant to foreign language vocabulary acquisition because very little research about VR and education exists. In the future, it would be useful to conduct a similar study taking into account the following considerations:

1. Sample Size. Future research will need to increase the sample size to be at least

$N = 70$ based on the *Gpower* calculation in each group (the experimental and the control group) instead of $N = 32$ in each group to improve the accuracy and generalization of the outcome.

2. Sample. Using a full random sample will help to generalize the result in contrast to using the convenience sample.
3. Gender. Future research will need to be conducted to study both genders (male and female) to improve the accuracy and generalization in the outcome and treat the limitations of the current study. A further consideration is the extent of improvement between genders using VR technology.
4. Age. Applying VR to a wider group of students and people of different ages such as adults or older people might give different results and insight into the mechanisms of vocabulary acquisition with a VR intervention, taking into account their comfort level with the new technology. Also, future research needs to examine a similar study on college students, such as international students, to see if it generalizes the results across different learning levels and ages.
5. Virtual System. It is recommended for future research to use different VR systems, as they might provide different results in vocabulary acquisition, taking into account the VR system quality and application environment.
6. Language. This study was conducted on non-native English-speaker students and teacher, and gave a positive result on vocabulary acquisition. Future research will need to examine a similar study in different foreign languages such as French or Spanish to see if the results can be generalized across different languages.
7. Language. One can change the language that is being learned, but a future study may also include more of a question regarding the language of origin (the native language) of the students, which was not addressed in this study.
8. Different Aspects of Vocabulary. Since this research was limited in using VR technology to enhance EFL vocabulary acquisition, further research is recommended to address different vocabulary aspects such as pronunciation and spelling.
9. Period of Time. Since this study had an experimental period of only two weeks, the students were motivated to use the new VR technology, and that reflected positively on their degree of achievement. It would be of interest to examine their level of achievement over an expanded experimental period, possibly for more than eight weeks, to see if the degree of achievement would be maintained or reduced due to the novelty of the technology wearing off from prolonged use.
10. Research Design. Qualitative studies should also be considered (or a mixed methods research design) to gather more in-depth information about what's going on in the classroom and how students perceive this VR approach to learning vocabulary.

7. Conclusion

The outcomes suggest that integrating VR technology in teaching EFL is a promising strategy and can be more successful than the traditional learning method for vocabulary acquisition. The intention behind conducting this research is to establish a motivating foundation to integrating VR technology in the field of foreign language vocabulary acquisition. Today VR technology is in its empirical-study phase, but it has incredible potential to improve our lives. Educators and the VR community expect much from this promising technology in the learning process. Five years from now, VR technology may supersede the traditional method due to its quick growth and its low cost, coupled with its current and meteoric rise in popularity. Many prominent companies, e.g., SONY–PlayStation, HTC, Facebook–OCULUS, Microsoft and Samsung remain in competition to release highly-advanced VR headsets due to the rapid growth of the VR technology among end users.

Teachers could benefit from the rapid growth in the technology to develop students' skills in the field of vocabulary. This requires teachers to show a desire to improve their technology skills to be able to deal with the fast changes brought about by this technological innovation. Without having the knowledge, the skills or the support to use more advanced technology, teachers will be unable to keep up with the requirements of the new generation. New generations connect deeply with the world surrounding them and want to see, grab and move to explore things instead of sitting down during the classroom lecture to indirectly experience the same things. Virtual reality provides an opportunity for teachers to transport students to another place and time by wearing the VR headset and looking around to explore and understand. Teachers can adopt this technology inside the classroom to both empower and inspire students. Finally, the researcher hopes more universities, schools and curriculum designers will collaborate with VR technology companies to realize this full potential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compedu.2020.103893.

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