Integrating 360° VR Videos into L2 Listening Instruction: Examination of the Effects of Two Types of VR Learning Experiences on Learning Gains

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***Abstract*—The current study examined the effects of Virtual Reality (VR)-assisted listening instruction on language learners' listening comprehension and vocabulary retention. Sixty-three English as a Foreign Language (EFL) learners were divided into two groups and were tested on their listening comprehension and vocabulary knowledge before and after a one-semester L2 instruction. 360° VR videos were integrated into the pre-listening phase of the instruction in two conditions: Experience + Activity (EA) and Experience-Only (EO). The EA group engaged in watching and exploring the videos and was required to complete some pedagogical activities while or after watching them. The EO group watched and walked through the 360º VR videos without being expected to do any pedagogical tasks. Mixed between-within-subjects analyses of variance revealed that the EA group outperformed the EO group in Part 1 of the listening post-test, which involved multimodal listening tasks. Further analysis displayed a substantial main effect for time with both groups' development of their listening comprehension from pre-test to post-test ($\eta p^2 = 0.512$). Also, a substantial main effect for time with both groups' development of their vocabulary learning from pre-test to post-test was observed ($\eta p^2 = 0.435$). A significant interaction between learning conditions revealed that the vocabulary learning of both EA and EA groups improved from pre-test to post-test. The findings suggest the potential benefits of VR in boosting L2 listening skills and comprehension, and vocabulary learning when integrated into the cycle of teaching listening based on sound pedagogical practices.**

***Keywords*—360º Virtual Reality (VR) videos, learning experiences, L2 listening instruction, English as a Foreign Language (EFL)**

I. Introduction

Emerging technologies have expanded their sphere of influence into almost all human endeavors, endowing them high quality of social life, professionalism, and education. Indubitably, virtualized environments have invigorated the process of teaching and learning and assisted pedagogues in gaining new insights into the nature of human cognition, perception, and interaction.

Virtual Reality (VR) environments "simulate the physical presence of people, objects, and realistic sensory experiences" [1] and immerse the users in 3D-generated visuals that cross the barriers of time and space of the physical world [2]. The Virtual World (VW) constructs an immersive learning experience that amplifies the users' senses, captures their perceptions, promotes human-computer interaction, and describes tangible and intangible concepts [3]. VR allows users to stretch their imaginations, experience the feeling of presence, and be integrated into the VW [4].

VR has remarkable benefits for education as it supports experiential and collaborative learning [5, 6], boosts learning motivation and engagement [7], enhances comprehension of the subject matter [8], and develops problem-solving skills, interest, and enjoyment [9]. In this scheme, the distinct advantages of VR for second and foreign language learning are noteworthy. Virtual environments help the development of communicative competence as they offer opportunities for enhancing the knowledge of language [10], communication skills [11], and strategic investment [12]. Additionally, VR can enhance comprehensible input and output and expand the capacity of technology-enhanced learning environments to develop oral [13] and written [14] language skills.

VR offers unique affordances for oral communication in a second language (L2), including immersion, interaction, creativity, and feedback [13]. VR characterization as multimedia content aligns with cognitive listening models that view listening comprehension as a mental task that requires information processing of various modes of input, including "acoustic and visual signals" [15]. Multimodal input lets Working Memory (WM) fully exploit its resources while doing the listening task, as the input is selected and processed by auditory/verbal and visual/pictorial channels [16] and then integrated into the Long-Term Memory (LTM). As multimedia processing is compatible with human mind architecture, it can foster listening comprehension, reduce the CL of listening, lower listening anxiety, and increase motivation and sustained effort for doing listening tasks [17, 18]. Specifically, VR can more powerfully reinforce contextual clues by giving the feeling of presence and providing a sense of embodiment [19] that simulates the condition and environment of the listening.

Despite a strong theoretical basis, research on the implementation of VR in teaching L2 listening is limited. Review works show that listening is the least-studied language skill in scholarly works published on VR-assisted language learning from 2010 to 2022 [20–22]. Although the number of studies on listening is limited, the effect size of VR on improving listening skills is reported to be large in a meta-analysis study that reviewed the literature from 2010 to 2021 [23]. This indicates that VR is a powerful device for teaching L2 listening and tackling the problems the students face in listening comprehension. Yet, more empirical evidence is required to examine the factors that impact VR-assisted L2 listening to give language experts insights on how to handle the challenges of implementing VR in instruction [24].

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One important concern to address in the implementation of VR applications into teaching and learning processes, however, is the issue of instructional design and how teaching with VR is grounded on sound pedagogical theories and instructional practices [25]. Past literature shows that while VR has countless educational values and benefits, few studies have scrutinized the factors that can influence the design of VR learning experiences [26] and their effects on learning outcomes. Designing VR-assisted instruction that is interconnected with pedagogical approaches and instructional policies gives educators and teachers deeper insights into the ways immersive technologies can be implemented into the teaching procedure appropriately [27].

To shed more light on the discussed issues and to fill the lacuna that exists in the literature, the current study was carried out to cross-compare the impact of VR-assisted L2 listening instruction on the development of listening comprehension in two VR learning experiences, adapting Dreimane's framework [27]: (a) the Experience + Activity (EA) condition where the students were expected to watch the 360º VR videos and do some follow-up educational activities; and (b) Experience-Only (EO) condition where the students were just engaged in watching and walking through the 360º VR videos without being expected to do any pedagogical tasks. The 360º VR videos were integrated into the pre-listening phase of the instruction, where the new words of the lesson were taught and the topic of the follow-up listening task was introduced. The effects of VR experiences on listening comprehension and retention of the taught words were then assessed. The study thus seeks answers to the following questions

1) Does a VR-assisted learning environment as an experience vs. a learning activity impact EFL learners' development of listening comprehension?
2) Does a VR-assisted learning environment as an experience vs. a learning activity impact EFL learners' vocabulary retention?

II. Literature Review

A. VR and Language Teaching and Learning

Throughout its journey from the 50s, Computer-Assisted Language Learning (CALL) has targeted the improvement of language learning with the help of cutting-edge technologies. This includes promoting learning efficiency and effectiveness, providing authentic learning materials and interactive/collaborative learning environments, and making learning more joyful and motivating [28]. Like many other technologies, the potential benefits of emerging technologies for language classes have been recognized by language teachers and researchers. Increased motivation, improved learning outcomes, higher degrees of interaction, and more chances of doing authentic tasks are among the documented merits of emergent CALL [29].

The main learning theory underlying the use of VR in language education is constructivism, which "emphasizes the combination of inputs from the senses, existing knowledge, and new information to develop new meaning and understanding through active, authentic, cooperative, and reflective learning activities" [30]. In the same vein, VR-assisted language learning is supported by Communicative Language Teaching (CLT) where prominence is given to learning through meaningful interaction and genuine communication through collaboration and social mediation [31]. Other cognitive frameworks also support the use of VR in language classes. The Embodied Cognition (EC) approach underscores sensory-motor experiences [32] and how gestures and kinesthetic activities assist learning. Dual-Code theory [33] sets forth that cognition depends on two independent yet interrelated systems, i.e., one for verbal (language-related) and one for nonverbal (visual images) input. Comprehension is enormously affected by the combination of these two types of input. Based on the Cognitive Theory of Multimedia Learning (CTML), multimodal input would best suit human brain architecture as it maximizes the capacity of the WM while lowering cognitive effort. Thus, the resources of WM and LTM are appropriately consumed and allocated to the learning task [34], and this leads to better learning outcomes [18].

There has been a growing literature on the use of VR in language learning in general and EFL setting in particular in recent years. The review of the studies reflects the trend of research toward language learners' psychological characteristics in VR environments with a focus on perceptions/attitudes, motivation, and anxiety [21]. Overall, language learners hold a positive attitude toward VR technology, and their attitude is significantly related to their cognitive absorption and achievement in learning English. The activities in VR learning environments are perceived to be highly motivating and enjoyable and bring about more satisfaction with the instruction and learning content [35]. Further, VR-based language learning can connect students with real-world audiences and engage them in meaningful learning experiences that lower their language learning anxiety [36].

The second course of research is directed towards the effects of VR in developing language micro and macro skills. Speaking and vocabulary followed by writing are among the most frequently researched skills in the VR-assisted language learning domain [21]. VR technology can impact vocabulary retention and learning [10], and this learning is positively associated with motivation and enjoyment [37]. VR is helpful in composition writing by providing language learners with prior knowledge related to the writing subjects and a better experience with abstract concepts [38]. VR is effective in teaching speaking and provides students with real-life scenarios [39]. VR is an effective tool for practicing speaking before formal situations in real life and thus can reduce speaking anxiety [36]. Although the implementation of VR in teaching reading and listening in EFL classes has not been widely surveyed, the results of a few empirical works document the benefits of VR for both listening [40] and reading comprehension [41] with a larger effect size for the usage of VR in listening instruction [23].

One main concern in integrating technologies in general and immersive technologies in particular into instruction is applying pedagogical approaches and practices that are specifically suitable for teaching that content. This issue has been recently addressed by language educators and researchers [42], yet there is a need for more research-grounded principles to spot the most adaptable teaching procedures for language teaching and learning.

B. Listening Comprehension and VR

Listening has a pivotal role in oral communication, and its competency is essentially required for the development of communicative competence [43]. Listening as the source of comprehensible input contributes to language acquisition [44] and helps learners to "build an awareness of the interworkings of language systems at various levels" [45].

Traditional views of language teaching considered listening as a passive act of deciphering linguistic elements. This view, however, was changed by cognitive and communicative frameworks when cognitive, emotional, and behavioral aspects of listening comprehension were underscored. As an active and complex process, listening demands the listener to not only discriminate linguistic features but also be able to interpret the input within a socio-cultural context [46]. The context of listening helps the hearer infer the speaker's objectives and type of speech event by activating the prior knowledge related to that context [47]. Drawing on CTML [48], exploring the value of multimodal input for providing contextual clues by combining visuals, text, and narrations in listening tasks has become the focus of many studies in L2 listening research. Scholarly endeavors on the role of multimodal input in L2 listening were to find "how visual information enhances linguistic input or distorts it or replaces it, and sometimes even contradicts it" [49].

While the general findings of these studies support the educational values of multimodal input for teaching listening, certain limitations and reservations are also reported for integrating multimedia in teaching listening. Rahimi and Soleymani [50] reported a significant impact of multimedia on L2 listening comprehension that is moderated by listening anxiety, particularly its emotional dimension. Lee and Mayer [51] reported that single-mode input led to better listening comprehension than the dual-mode condition as a result of the redundancy effect that presents listeners with repeated or unnecessary information from multiple sources. İnceçay and Koçoğlu [52] reported that the subtitled audio-video condition of listening led to lower comprehension and higher confusion and anxiety, as the students' previous experience with listening instruction made them feel more relaxed when they just listened to the audio. Salmani and Rahimi [53] found a significant impact of using multimedia in doing listening tasks; however, multimedia was more effective in increasing language learners' dialogic rather than monologic listening skills. Sayyadi *et al.* [18] showed that multimedia input is effective in listening comprehension when extraneous principles of multimedia are taken into account in the process of task design.

Despite the usage of a variety of multimedia content in these studies, VR as a type of multimedia [54] that "extends the advantages of traditional videos via immersion and multi-perspective reflection" [55] has not been implemented widely in L2 listening instruction. Above all, contradictory findings are observed in the results of these studies. Ji *et al.* [56], for instance, surveyed the effect of traditional video playback versus VR modes on EFL learners' listening comprehension and cognitive load. The results illustrated that the VR video group experienced higher cognitive load and did not perform better in the listening test in comparison to the traditional video presentation group. Conversely, Tai and Chen [40] examined the effect of VR in comparison to video watching on EFL learners' listening comprehension. They reported that the VR group's listening comprehension and retention were significantly higher than those who just watched the videos. Also, most of the VR group members believed that VR-assisted listening was engaging and helpful. In the same vein, Tai [57] examined the impact of mobile VR on EFL learners' listening comprehension in contrast to the walkthrough video of the VR app on personal computers. The outcome showed that the VR group's listening comprehension and retention were significantly better than those of the video group. Also, most VR players found the content motivating, beneficial, engaging, and convenient for listening comprehension.

The synopsis of the findings of the past literature enriches our understanding of the value of multimedia for teaching L2 listening and the joyful environment it offers for making the listening tasks less tedious. Yet the educational value of integrating VR into L2 listening instruction is still open to further research. Moreover, how VR experiences are designed and the way they are integrated into the cycle of listening instruction needs further investigation. The goal of this study is thus threefold:

1) comparing the effects of two VR experiences (experience + activity vs. experience-only) on the development of L2 listening comprehension when VR is integrated into the pre-listening phase of teaching listening,
2) comparing the effects of two VR experiences (experience + activity vs. experience-only) on vocabulary retention when VR is integrated into the pre-listening phase of teaching listening, and
3) comparing the effects of VR, regardless of experience types, on the development of L2 listening comprehension and vocabulary retention, when VR is integrated into the pre-listening phase of teaching listening.

III. MATERIALS AND METHODS

A. Participants

The participants of this study were 63 EFL learners studying in grade 11 of high school in the academic year 2023–2024. The sample was randomly selected from six grade 11 classes in a public school in the suburb of Tehran, the capital of Iran. The sample comprised female learners who ranged in age between 16 and 17. The participants were comparable regarding their major (humanities), years of English learning (three years), age (16–17 years old), mother tongue (Persian), and language proficiency level (pre-B1). The research setting was Iran, where English as a foreign language is taught in the educational system for six years from K7 to K12. The sample was divided into two groups to receive VR-assisted L2 listening instruction based on the planned conditions: Experience + Activity (EA) group ($n = 31$) and Experience-Only (EO) group ($n = 32$).

B. Instruments

1) B1 preliminary

The listening paper of B1 Preliminary was used to assess the participants' listening comprehension before and after the study. B1 Preliminary is one of the Cambridge English

Qualifications as proof of intermediate-level English. B1 Preliminary proceeds A2 Key and shows the candidates' overall communicative language ability in reading simple English textbooks, writing emails and essays on everyday topics, and understanding facts and opinions of both oral and written texts. B1 Preliminary includes four papers that evaluate all four language skills independently.

The listening section has five parts that assess the candidates' listening comprehension of the details, the gist of meaning, and speakers' opinions and attitudes by listening to short and long dialogues or monologues. The options of the questions include both visual and verbal choices and gap-fill sentences/notes. The reliability of the test was estimated by KR-21 and found to be 0.81 and 0.86 for the pre-test and post-test, respectively.

2) Vocabulary knowledge test

To assess students' vocabulary knowledge before and after the study, the researchers constructed a vocabulary test based on the content of the students' English textbook. The vocabulary test encompassed 30 items in multiple-choice format. After determining the function and format of the test, the test was developed by applying test development phases, including planning, preparing, reviewing, and pretesting. Based on the result of the pilot administration, the efficiency of the items was carefully examined by item analysis, and some revisions were made to some stems or options. The reliability of the test was estimated by KR-21 and found to be 0.92.

3) 360° VR videos

Six 360° VR videos taken from a local site (Namasha.com) were used in the pre-listening phase of listening instruction with a twofold purpose: (a) familiarizing the students with the topic of the listening, and (b) pre-teaching new vocabulary items of the conversation. The videos ranged in length from 3 to 5 min. The videos were watched using the VR Media Player application (Version 1.4.4.1) installed on 8-inch tablets.

4) Worksheets

Six worksheets were designed based on the content of 360° VR videos for the EA group. The activities on the worksheets were designed according to Bloom's taxonomy to assess the participants' cognition in six layers of remembering, understanding, applying, analyzing, evaluating, and creating.

C. Procedure

First, the participants were pre-tested for their vocabulary knowledge and listening comprehension. Both groups participated in VR-assisted listening instruction for one semester (four and a half months). The first and the last sessions were allocated to pre-tests and post-tests. During the instruction, six 360° VR videos were integrated into the pre-listening phase, creating EA and EO learning conditions. The EA group engaged in watching and exploring the videos and was required to complete the worksheets while or after watching them. The EO group engaged in watching and exploring the videos without being expected to do any pedagogical tasks. Collaborative language learning, as one of the frequently used instructional practices of Extended Reality [58], was used to teach listening with VR as explained in detail below [42]:

1) Triggering event: the students become familiar with the 360° VR video and its theme.
2) Establishment of joint activity: the students begin talking about the video. They watch it and discover its content.
3) Articulation of ideas: the students visit different places from different angles and read the clues. Their understanding of the clues or the details of the places may be different.
4) Social negotiation and collective understanding: the students travel back and forth in the video, pay attention to the clues again and again, interact extensively with each other, and try to resolve conflicting views.

While going through these steps, the EA group was expected to complete the task sheets and document their understanding of the 360° VR videos. The EO group did not complete any pedagogical tasks and just collaborated and interacted with each other through steps 1–4. The teacher functioned as a facilitator and encouraged collaboration and teamwork. At the same time, she guided the students and answered their questions about if there were any ambiguities.

IV. Results and Discussion

A. Results

1) Pre-tests

To assess the participants' entry listening proficiency and vocabulary knowledge, an independent samples T-test and a one-way multivariate analysis of variance (MANOVA) were run on vocabulary and B1 Preliminary pre-test scores. The results of the independent samples T-test [$t(1, 61) = 1.93$, $p = 0.058 > 0.05$] and MANOVA [Wilks' Lambda=0.965.; F (4, 58) = 0.523; $p = 0.719 > 0.05$; $\eta p^2 = 0.035$] showed no significant differences between the two groups' vocabulary knowledge and listening proficiency before the study.

2) Effects of VR-assisted listening instruction on listening comprehension

A mixed between-within-subjects analysis of variance was run to assess (a) between-subjects effects and the effects of two VR-assisted L2 listening instructions, that is, EA vs. EO, on the development of listening comprehension at the end of the experiment; and (b) within-subjects contrasts and to examine the effect of VR-assisted L2 listening instruction on participants' development of listening comprehension across two time periods (pre-test and post-test), regardless of the condition of instruction.

First, the results of multivariate tests of between-subjects effects were examined, and a significant difference between the effectiveness of the two teaching conditions was found [Wilk's Lambda = 0.849, F(4, 58) = 2.585, $p = 0.046 < 0.05$, $\eta p^2 = 0.151$].

As the results of tests of between-subjects effects illustrated (Table 1), the differences between the two groups are significant only in Part 1 of B1 Preliminary [F (1, 61) = 10.305, $p = 0.002 < 0.01$). A deeper examination of the results relying on descriptive statistics (Fig. 1) revealed interesting points about the differences between the performance of the two groups on four parts of the B1 Preliminary post-test. As shown in Fig. 1(a) and 1(c), the EA group performed better in Parts 1 and 3 ($M = 4.903$, SD = 0.789; $M = 0.806$, SD = 1.222, respectively) that required them to listen for specific information either by paying attention to visual images or completing gap-fills of a text in comparison to the EO group (M = 3.562, SD = 1.366; M = 0.562, SD = 0.715, respectively). On the other hand, as Fig. 1(b) and (d) display, the EO group performed better in Parts 2 and 4 (M = 1.906, SD = 1.352; M = 2.156, SD = 1.568, respectively) that required understanding the meaning and identifying opinions and attitudes during listening in comparison to the EA group (M = 1.741, SD = 1.24; M = 1.774, SD = 1.203, respectively).

Further, it is noteworthy to pay attention to both groups' performance change in four parts of the listening test from pre-test to post-test, considering the descriptive statistics. As can be seen in Fig. 1(a)–(d), both groups' performance in all four parts of B1 Preliminary improved from pre-test to post-test. However, this difference is substantial in Part 1, where the EA group's mean changed from 3.29 to 4.903, whereas the EO group's mean changed from 3.031 to 3.562.

Table 1. Tests of between-subjects effects

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	Part 1	20.150	1	20.150	10.305	0.002**	0.145
	Part 2	0.210	1	0.210	0.121	0.729	0.002
	Part 3	0.373	1	0.373	0.480	0.491	0.008
	Part 4	0.725	1	0.725	0.375	0.543	0.006
Error	Part 1	119.279	61	1.955			
	Part 2	105.647	61	1.732			
	Part 3	47.484	61	0.778			
	Part 4	118.053	61	1.935			

Note: ** $p < 0.01$

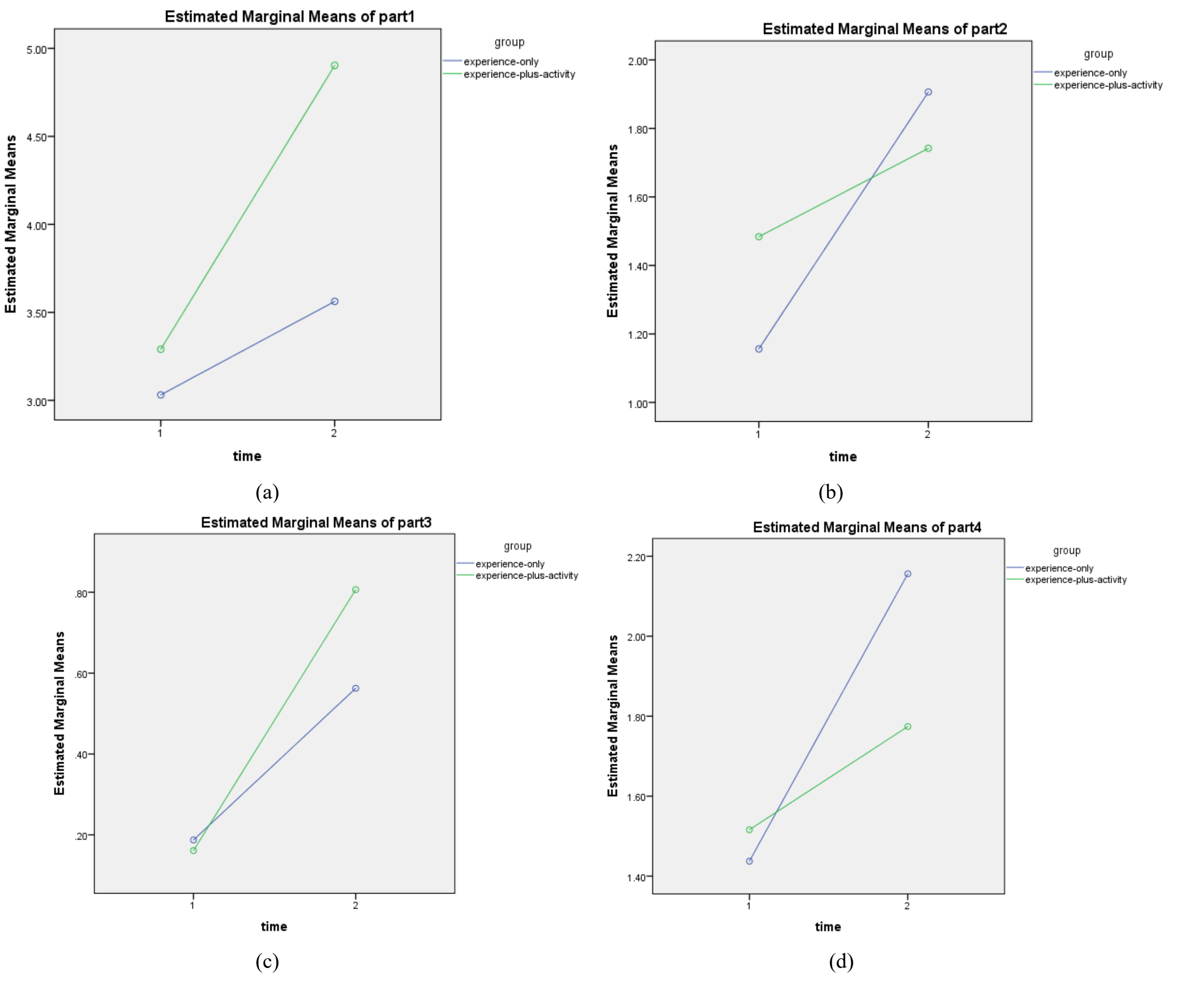

Fig. 1. Estimated marginal means of B1 Preliminary parts. (a) B1 Preliminary-Part 1; (b) B1 Preliminary-Part 2; (c) B1 Preliminary-Part 3; (d) B1 Preliminary-Part 4.

Table 2. Tests of within-subjects contrasts

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	Part 1	36.195	1	36.195	22.842	0.000**	0.272
	Part 2	8.001	1	8.001	7.288	0.009**	0.107
	Part 3	8.194	1	8.194	20.570	0.000**	0.252
	Part 4	7.512	1	7.512	4.714	0.034*	0.072
Error (time)	Part 1	96.662	61	1.585			
	Part 2	66.968	61	1.098			
	Part 3	24.298	61	0.398			
	Part 4	97.202	61	1.593			

Note: * $p < 0.05$; ** $p < 0.01$

Second, the results of multivariate tests of within-subjects contrasts effects were examined and a substantial main effect for time with all participants showing a higher level of listening comprehension across two periods (pre-test and post-test) was observed [Wilk's Lambda =0.488, F(4, 58) = 15.229, p = 0.000 < 0.01, ηp^2 = 0.512]. No significant interaction between teaching condition and time was detected [Wilk's Lambda =0.858, F(4, 58) = 2.392, p = 0.061 > 0.05, ηp^2 = 142].

Table 3. Descriptive statistics of B1 preliminary listening pre-test and post-test (N = 63)

Time	Mean	SD
Part 1 pre-test	3.158	1.504
Part 1 post-test	4.903	0.789
Part 2 pre-test	1.317	1.133
Part 2 post-test	1.825	1.238
Part 3 pre-test	0.1746	0.422
Part 3 post-test	0.6190	0.831
Part 4 pre-test	1.476	1.242
Part 4 post-test	1.968	1.402
B1 Preliminary pre-test	6.127	2.239
B1 Preliminary post-test	8.476	2.638

As the results of tests of within-subjects contrast illustrated (Table 2), the differences between participants' listening comprehension across time are significant in all four parts of B1 Preliminary [F(1, 61) = 22.842, 7.288, 20.570, 4.714, respectively; p values = 0.000, 0.009, 0.000, and 0.034, respectively]. Further, descriptive statistics indicated that the listening comprehension of all participants (N = 63) improved as a result of VR-assisted listening instruction from pre-test to post-test (Table 3).

3) *Effects of VR-assisted listening instruction on vocabulary learning*

Another mixed between-within-subjects analysis of variance was conducted (a) to assess between-subjects effects and the effects of two VR-assisted L2 listening instructions, that is, EA vs. EO, on vocabulary learning at the end of the experiment; and (b) to assess within-subjects contrasts and the effects of VR-assisted L2 listening instruction on participants' vocabulary learning across two time periods (pre-test and post-test), regardless of the conditions of instruction. As Table 4 shows that the results of tests of between-subjects effects revealed no significant difference between the two groups' performance at the end of the experiment [F(1, 61) = 0.757, p = 0.388 > 0.05].

The results of multivariate tests and tests of within-subjects contrasts effects, however, showed a substantial main effect for time with a rise in vocabulary learning of both groups from pre-test to post-test [Wilk's Lambda = 0.565, F(1, 61) = 46.874, p = 0.000 < 0.01, ηp^2 = 0.435] (Table 5).

Table 4. Tests of between-subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	20452.627	1	20452.627	214.091	0.000	0.778
Group	72.341	1	72.341	0.757	0.388	0.012
Error	5827.484	61	95.533			

Table 5. Tests of within-subjects contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	442.976	1	442.976	46.874	.000**	.435
Time* group	92.976	1	92.976	9.838	.003**	.139
Error (time)	576.468	61	9.450			

Note: ** p < 0.01

As the descriptive statistics show, the vocabulary knowledge of all participants (N = 63) improved as a result of VR-assisted listening instruction from pre-test to post-test (Table 6).

Table 6. Descriptive statistics of vocabulary knowledge pre-test and post-test (N = 63)

Time	Mean	SD
Vocabulary pre-test	10.841	6.780
Vocabulary post-test	14.619	7.744

A significant interaction between teaching condition and time [Wilk's Lambda =0.861, F = (1, 61) = 9.833, p = 0.003 < 0.01, ηp^2 = 139] was observed, indicating that the EO group had shown more improvement in their learning vocabulary from pre-test to post-test in comparison to the EA group. To shed more light on this matter, the Estimated Marginal Means of vocabulary pre-test and post-test were examined (Fig. 2). As can be seen in Fig. 2, the EO group's vocabulary mean went from 9.25 to 14.718, whereas the EA group's mean went from 12.483 to 14.516. The steep rise shown by the blue line in Fig. 1 is indicative of a substantial (and significant) difference between the EO groups' performance on the vocabulary test from pre-test to post-test.

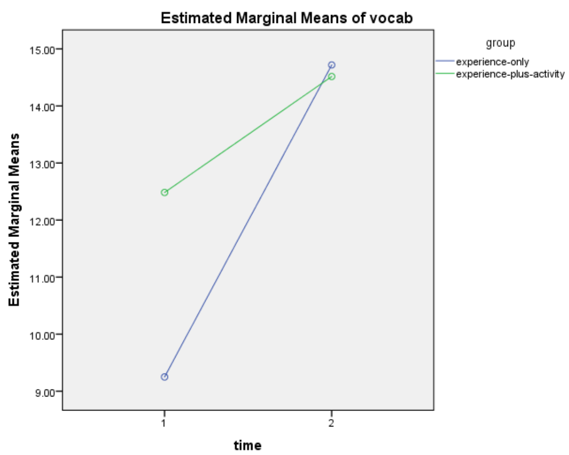

Fig. 2. Estimated marginal means of Vocabulary knowledge.

B. *Discussion*

1) *Effects of VR-assisted listening instruction on listening comprehension*

The findings primarily revealed that the EA group outperformed the EO group in the listening post-test, but this improvement was attributed to the students' performance in listening tasks that had multimodal input supported by visual and verbal clues. In contrast to other listening tasks, here the students were required to process two types of input simultaneously and use both clues to select the correct answer. This outcome can be interpreted from different angles. First and foremost, the finding corroborates CTML, based on which multimedia contributes to a better understanding as WM allocates its full capacity to performing the mental task without being overloaded [16, 34]. The finding is in alignment with the past literature that sets forth a constructive role for multimodal input in L2 listening in boosting comprehension by making the listening task less demanding and more enjoyable [18].

The outcome, however, casts doubt on those studies that undermine the benefit of multimedia for listening due to the redundancy effect and the split attention principles [51]. Based on these premises, multimodal input intrudes on understanding as the simultaneous presentation of text and images diverts attention from the narration [34]. As shown here, performing pre-listening activities with multimedia for one semester has made students more skillful in processing both verbal and visual clues in oral input, particularly as they were required to work on worksheets while interacting with the VR videos. In this way, they became aware of the strategies to exploit all media they had at their disposal for comprehension, including text, audio, and images [59], which ultimately led to a better performance in doing listening tasks. Moreover, VR's capacity to simulate the communication environment made the listening task more interactive. This created a sense of presence in the setting [40] by gathering visual, auditory, and haptic information and amplifying the listeners' multiple senses [60]. This has boosted the listeners' engagement in doing listening tasks, which guarantees better comprehension [61]. Further, students' engagement increased by completing the task sheets that demanded both lower-order and higher-order cognitive processing [59]. The experiment thus made students more attentive to both verbal and pictorial details while processing the input because "deeper learning aimed at meaning-making occurs when learners mentally construct connections between words and graphics" [62].

Interestingly, the outcome of the study showed that when the VR experience type was disregarded, both groups' listening comprehension was developed from pre-test to post-test. In other words, VR-assisted listening instruction influenced comprehension both when it was backed with educational activities and when it was just an entertaining experience. Comparing the results of the four sections of the post-test reveals that this is related to the type of information processing that took place in each learning condition. As Fig. 1(a) and (c) show that accompanying the VR experience with educational activities was beneficial in understanding the audio-visual messages and specific details of the listening task. As Fig. 1(b) and (d) show that the condition of watching, walking through, and talking about the VR video empowered the students of the EO group to comprehend listening tasks that involved understanding the gist of meaning and speakers' attitudes and opinions. Therefore, the two VR conditions improved both group members' listening comprehension as a result of improving two different listening skills. It should, however, be noted that except for Part 1 of B1 Preliminary (Fig. 1(a)), the comparison of post-test scores was based on descriptive statistics. Interpreting this finding with caution, the affordances of VR-assisted listening instruction to provide a unique experience for L2 listening are backed, as it can support all four processes of listening comprehension, i.e., neurological, linguistic, semantic, and pragmatic [49]. In other words, VR embodies the capability of enhancing attention through amplifying senses [3], guessing and understanding the meaning of words through multisensory experience [10], boosting comprehension, problem-solving, and strategy deployment [12], and connecting the listener with the speaker and the simulated environment [13].

2) Effects of VR-assisted listening instruction on vocabulary learning

The findings of the study also revealed that no difference was found between the two groups' vocabulary learning and retention at the end of the intervention, as both conditions assisted students in learning the taught new words. The benefit of VR for learning vocabulary has been extensively researched and verified in different language learning contexts [63]. The reason why VR can boost vocabulary learning has been attributed to its capability of speeding up cognitive processes such as memory retention [64], promoting embodied vocabulary learning through a sensorimotor experience [65], and providing extended engagement with vocabulary [66]. What the outcome adds to the literature is that both instructed and incidental vocabulary learning were found to be supported by watching VR videos. As for the incidental vocabulary learning, the EO group's experience with 360° VR videos provided them with a condition where they could extract the meaning of the word from the context, that is, the simulated reality, and learn it without focusing on the meaning of the word through communication [67]. In this way, vocabulary learning was the by-product of watching 360° VR videos and processing the multimodal input [68]. This provided exposure [69], involvement [70], and an input-rich environment [53] as key conditions of incidental vocabulary learning. In this condition, incidental vocabulary learning assisted learners in remembering the words as it fully involved them in the process of deciphering the meaning through available textual clues [71]. VR also provided the condition of intentional vocabulary learning when the students became aware that they were to do some activities while or after watching the 360° VR videos to learn the new words of the lesson [72]. Here, VR could provide the conditions of vocabulary learning by increasing students' perceptions of contextual clues, attention, and involvement while at the same time, they consciously focused on vocabulary learning. The findings show that the condition of vocabulary learning and the type of input, in addition to task, learner, and assessment variables is a key factor in assisting students in benefiting from intentional vocabulary learning.

Further, as both groups' vocabulary knowledge was comparable before the study, a stronger effect size for the incidental vocabulary learning in the EO condition can be attributed to students' raised "lexical sensibility" [73]. Lexical sensibility or the attitudinal facet of word knowledge is linked to students' enthusiasm about and interest in learning new words and their joy in sharing them with others [74]. Technology-assisted incidental learning, particularly in multimedia environments, makes vocabulary learning joyful and less cognitively demanding [53] through optimizing the students' interaction with the multisensory input [75]. Notably, similar to digital games, mobile applications, short messaging services, and computer software [76], VR is a valuable tool to support incidental vocabulary learning.

Smaller effect size for an intentional learning environment designed for the EA group can be interpreted within the Involvement Load Hypothesis [77]. The tasks may have pre-simplified the vocabulary learning process and reduced the need for students to actively infer meanings themselves. This finding is in stark contrast with the benefits mentioned in the literature for intentional vocabulary learning. As Schmitt noted, "intentional vocabulary learning almost always leads to greater and faster gains, with a better chance of retention and of reaching productive levels of mastery than incidental vocabulary learning" [67]. Nation, relying on literature before 2000, also asserts that "intentional learning results in much more learning in a set time than incidental learning" [78]. However, as the findings of this study, in alignment with Yu and Trainin's meta-analysis of technology-assisted vocabulary learning [76] show, the claims about advantages of intentional vocabulary learning are disputed by incidental learning as a result of the prevalent use of technology in vocabulary teaching and learning.

V. Conclusion

The current study compared two conditions for using 360° VR videos in teaching L2 listening, where two groups of EFL learners were pre-trained on the new words and the topic of a follow-up listening task, either accompanied by educational tasks or as a stand-alone fun activity. The results of the study showed that both conditions were beneficial in improving the listening skills of the students. However, the students who used VR with accompanying activities were more successful in listening tasks involving multimodal input. Also, both conditions supported vocabulary retention and learning, with a stronger effect size for the EO condition that supported incidental vocabulary learning.

The findings of the study should be interpreted by noting its limitations. First of all, the sample included female language learners, and due to practicality and policy issues, the researchers could not perform the study in boys' schools. Therefore, the findings are not generalizable to the entire student population. Second, because of time limitations and the pressure on the teacher to finish the textbook, the study lasted for one semester, that is, four and a half months. Last, the data were gathered through tests, and qualitative data were not gathered or analyzed since the workload of the experimental study was very high.

Follow-up studies are required to shed light on the benefit of different types of educational procedures in using VR in L2 classes in general and L2 listening instruction in particular. Also, further research is recommended by considering language learners of diverse backgrounds, including gender, language proficiency, and age. It would also be revealing if future research focuses on both quantitative and qualitative data-gathering techniques while integrating VR into language teaching and learning processes. Last but not least, future research including a conventional instruction control group (e.g., using static images or audio-only preparation) is recommended to strengthen the evidence that VR-enhanced listening instruction itself, versus any other engaging pre-listening activities, improves EFL learning gains.

Ethical Issues

The participants and their parents were informed of the study's aim and procedure before the experiment, and their consent for voluntary participation in the study and sharing the results was gained. The permit to carry out the current research and approval of the ethical and experimental procedures and protocols were granted by Shahid Rajaee Teacher Training University's Graduate Studies Office under Application No. 18875899 dated 21.09.2022.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

RSH carried out the study, gathered the data, and cooperated in writing the manuscript. MR conceptualized, designed, and supervised the research. MR drafted, wrote, reviewed, and edited the manuscript. Both authors have approved the final version.

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