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ARTICLE

Impact of mobile virtual reality on EFL learners' listening comprehension

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Abstract

Virtual reality (VR) has received increasing attention from researchers and practitioners in EFL listening. However, prior studies are primarily concerned with non-immersive desktop-based VR. Few studies examined the effects of VR via mobile-rendered head-mounted displays (mobile VR). Therefore, this study investigates the impact of mobile VR on EFL learners' listening comprehension. Participants were 49 Taiwanese seventh-graders, randomly assigned to either the VR group or video group. The VR group played with a language learning VR app using mobile VR while the video group watched the walkthrough video of the VR app on personal computers. The effects of mobile VR were analyzed based on listening comprehension post-tests, recalls, and interviews. The results revealed the VR group's listening comprehension and recall were significantly better than that of the video group. The interview data indicated that, for most VR players, mobile VR-mediated EFL listening was motivating, beneficial, and convenient. They felt more engaged in the listening tasks. Simulated real-life scenarios and interactivity, particularly the interaction with virtual characters, led to a stronger sense of presence and a higher degree of immersion, which enabled them to listen as a participant rather than overhearer. Interaction in an authentically fully-immersive context facilitated listening comprehension. The findings suggest that mobile VR may be a useful tool to promote EFL listening and underscore the necessity for additional research on the emerging technology for language learning.

Keywords: *Virtual Reality, Mobile-Rendered HMD, EFL Listening, Interactivity*

Language(s) Learned in This Study: *English*

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Introduction

Listening comprehension is crucial to language learning (Vandergrift, 2007). It is a precursor to acquiring other skills for language learners (Kim & Phillips, 2014; Rost, 2016) and is an essential component of communicative competence (Wagner & Toth, 2014). Listening comprehension is often considered difficult and causes anxiety among EFL learners (Chen, 2019; Jiang & Dewaele, 2019). Lan and Liao (2018) found that auditory input delivered by a CD player is the most frequently used listening material. Such de-contextualized, non-interactive, and teacher-centered listening instruction hinders learners' listening comprehension and limits their motivation (Lan & Lin, 2016).

According to Cross and Vandergrift (2018), authentic contexts and target language interaction are essential for successful L2 listening. Furthermore, learners should take on the role of an active participant rather than that of an overhearer (Rost, 2016; Vandergrift & Baker, 2015). Active participation entails engagement and thus boosts comprehension. In light of this, Lan and Liao (2018) advocate the application of virtual reality (VR) to promote L2 listening. According to Godwin-Jones (2016), VR supports foreign language learning in providing multimodal interaction within immersive virtual learning environments, simulating learners' physical presence and realistic sensory experiences, encouraging learners to experiment and take risks while communicating in the target language, and thus leading to higher motivation and engagement. However,

VR in language learning is not yet a fully-fledged field of research (Alizadeh, 2019; Radianti et al, 2020). Specific EFL listening comprehension benefits based on research evidence have yet to be established Therefore, there is a need to evaluate the impact of VR on EFL listening.

As technology has advanced, so have VR options. This study used VR via mobile-rendered head-mounted displays (HMDs). Silva et al. (2016) indicate that mobile-rendered HMDs have the potential to be as ubiquitous as their power system, the smartphones. They are lightweight, user-friendly, and portable, offering high-resolution displays and fully immersive VR experiences. Hence, mobile VR is now recognized as the most affordable and suitable technology for schools (Fransson et al., 2020; Stojšić et al., 2019). Since mobile VR is still a relatively new technology in L2 education, research has yet to extrapolate its effects on EFL listening comprehension. Therefore, the study aimed to investigate the impact of mobile VR on listening comprehension, focusing on an under-represented learner group – adolescent EFL learners (Radianti et al., 2020).

Literature Review

Mobile VR and Language Learning

VR is defined as "an immersive computer-enabled technology that replicates an environment and allows a user simulation to be present and interact in that environment" (Lloyd et al., 2017, p. 222). In recent years, VR has rapidly changed from desktop applications to mobile devices with HMDs such as Samsung Gear VR and Google Cardboard. According to Ladendorf et al. (2019), mobile VR is a 3D mobile-based virtual environment that simulates a realistic environment and offers learners both auditory and visual stimuli, thus creating a sense of immersion and presence. Silva et al. (2016) indicate that mobile-rendered HMDs have the advantages of being lightweight and portable. They offer a good virtual simulation with low latency and enable stereoscopic views of scenes (Ladendorf et al., 2019). Mobile VR places an emphasis on the transparency of the boundaries between various learning situations in comparison to desktop VR. Most importantly, mobile VR meets Chapelle's (2001) seven criteria for adopting CALL tools. It can fulfill learners' interests and needs (learner fit); its use is authentic and can be applied to other contexts (authenticity); it can increase input and output practice in authentic contexts (language learning potential); it fosters human-machine interactions (interactiveness); some pedagogical theories support it (e.g., Atkinson & Shiffrin's Information Processing theory, 1968; Jonassen's Constructivist learning, 1994; Ladendorf et al.'s Hypothetical Model of Immersive Cognition, 2019; Long's Interactionist approach, 1996; Varela et al.'s Embodied Cognition theory, 2016); it is easy to use in and out of the school (practicality); and it motivates students to learn (autonomy). Hence, some researchers (e.g., Fransson et al., 2020; Stojšić et al., 2019) perceive mobile VR as the most affordable and suitable technology for schools.

Despite its optimistic outlook, the application of mobile VR for language learning remain in its infancy, and only a few studies have examined its specific L2 learning benefits, focusing mainly on vocabulary learning and communication. For example, Alfadil (2017) conducted a study to explore the effects of mobile VR on 64 Arabic ESL learners' vocabulary learning. The experimental group used the VR app *House of Languages* and Samsung Gear VR to learn English vocabulary. The control group was taught using a traditional ESL vocabulary learning method. The results showed that the experimental group achieved better scores in learning vocabulary than the control group and held a positive attitude towards using mobile-based VR applications for language learning. Like this finding, Tai et al. (2020) also used Samsung Gear VR as the primary platform to facilitate EFL learners' vocabulary learning. Due to the fidelity of the representation and interactivity, mobile VR was found to be beneficial for EFL vocabulary learning. In Xie et al.'s (2019) study, they investigated the effectiveness of using mobile VR (i.e., Google Cardboard and Expeditions) on Chinese L2 students' oral proficiency. They found that the vocabulary and content of participants' oral presentations when using mobile VR scored statistically significantly higher than when not using mobile VR. Furthermore, mobile VR encouraged active learning.

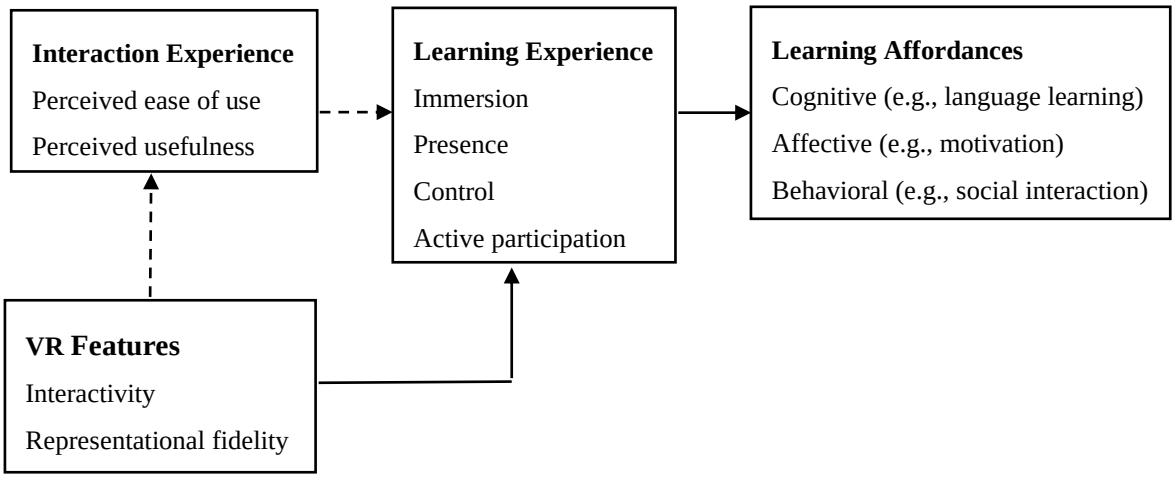
Although the studies above indicate that mobile VR is motivational and beneficial for L2 learning, other researchers (e.g., Dolgunsöz et al., 2018; Lee et al., 2017) have not found that mobile VR-mediated language learning results in statistically significant improvements. For example, Dolgunsöz et al. (2018) examined the impact of mobile VR on EFL learners' writing skills. Twenty-four EFL learners watched a VR and a 2D traditional video in different periods. Samsung Gear VR with the Samsung S7 Edge Mobile Phone was used. The results revealed that mobile VR-mediated learning did not positively affect learners' writing performance, although most learners enjoyed the learning experience. Given the mixed results from previous studies, more research on mobile VR is required to validate its usefulness for L2 learning.

Theoretical Foundations of Mobile VR-Mediated Language Learning

Several pedagogical theories support the use of mobile VR for language learning. Constructivist learning is the first theory aligning with mobile VR integration into language learning. Constructivism regards learning as an active, contextualized process of knowledge construction and encourages learners to construct their understandings and validate them through social interaction (Jonassen, 1994). According to Dalgarno & Lee (2010), the fidelity of the representation and interactivity are the two distinguishing characteristics of VR, which creates a high degree of immersion and a strong sense of presence (Dalgarno & Lee, 2010) (Figure 1).

Figure 1

Learning in a Virtual Environment.



A realistic display of the environment, smooth view changes, and object motion are the three most critical visual features of representational fidelity in a 3D virtual environment. In addition, the availability of 3D audio technologies that provide the spatial perception of sounds can enhance the sense of realism. Accordingly, mobile VR offers a variety of situated learning experiences. Furthermore, there are five types of interactivity in mobile VR-mediated learning environments: (a) dialoguing, (b) manipulating, (c) controlling, (d) navigating, and (e) searching (Moreno & Mayer, 2007). According to Jonassen's (1994) constructivist learning, the interaction between learners and the VR environment is central to language learning and input comprehension.

Another plausible support for mobile VR-mediated language learning is Ladendorf et al.'s (2019) Hypothetical Model of Immersive Cognition (HMIC), which is based on Information Processing Theory (Atkinson & Shiffrin, 1968) and the Embodied Cognition Theory (Varela et al., 2016); according to the authors, the immersion found in mobile VR-mediated language learning can build a brain-body bridge for deeper learning and entrance into long-term memory. Mobile VR provides a sense of immersion and presence by activating visual and motor channels, tricking the brain into believing physical stimuli are present. Learners can observe the objects in a more thorough and complex manner. Such presence could

diminish the perceived distance of the objects and prompt the brain to activate the schema in multiple senses, thus enhancing the learning experience (Ladendorf et al., 2019).

Mobile VR and L2 Listening Comprehension

The unique affordances of mobile VR support some of the crucial principles of L2 listening. First, mobile VR simulation and immersion provide learners with comprehensible input through context-based learning, essential for effective L2 listening given the importance of the target language interaction in authentic contexts (Vandergrift & Goh, 2012),. Furthermore, the multisensory stimuli in the virtual environment enable learners to visualize and understand concepts and build up their knowledge. This multimodal processing might provide L2 learners with a direct link between word forms and the underlying meaning (Lan, 2015) and help listeners activate prior knowledge to make appropriate inferences (Vandergrift & Goh, 2012). As Clark and Mayer (2016) indicated, media with multiple modes of presentation enhances comprehension by providing an additional route for meaning-making, reducing cognitive load in processing, and strengthening retention. In addition, the multimedia learning materials, including audio, textual, pictorial, and visual aids, are adaptable to variations between individuals (Liu, 2018) and thus help learners receive input with a lower affective filter, which facilitates comprehension and information retention (Ray, 2012).

Virtual presence is another critical feature of mobile VR. According to Ladendorf et al. (2019), a sense of presence is necessary to more effectively activate the long-term memory, which helps listeners make the appropriate inferences needed to comprehend the message (Vandergrift & Goh, 2012). Furthermore, virtual presence could reduce anxiety and embarrassment caused by making errors in actual social contexts (Silva et al., 2016), enable the first-person perspective to experience intercultural communication (Zhai, 2017), and foster active participation (Liao & Lu, 2018). Therefore, integrating VR into L2 listening might help students learn from experiencing the relevant context and construct an understanding from a first-person perspective, which supports Vandergrift and Baker's (2015) proposition that effective listeners are active participants. As listeners participate actively in discourse, they become more engaged and thus comprehend more.

Finally, real-time interactivity is one of the best-valued VR features. The interactive VR platform enables social interaction by providing learners with opportunities for real and meaningful interaction through task-based and cooperative learning (Lan, 2020). Learners can communicate with an avatar in real-time through voice chat and interact with the virtual 3D objects using standard input devices. In addition, learning occurs when learners get feedback at critical periods of development and in contexts where they can apply what is being learned. As Jiang and Dewaele (2019) claimed, this just-in-time quality is crucial to the effectiveness of listening comprehension because it might reduce EFL learners' fear of failure and maximize participation and risk-taking .

Based on the above discussion, mobile VR seems to provide deep linguistic immersion and various situated learning experiences, offer social interaction, create a strong sense of presence, and give a space for experiential learning. Despite this optimistic outlook, specific EFL listening comprehension benefits based on research evidence have yet to be established. According to Lan (2020), insufficient empirical evidence will result in tremendous challenges when implementing VR in classroom learning. Hence, studies on the appropriateness, applications, and practices of mobile VR and its influence on EFL listening are urgently required. In particular, one of the medium's critical features, interactivity, has not been thoroughly examined in terms of its effect on listening comprehension. In addition, the processes of the use of VR in K-12 education have been less explored (Radianti et al., 2020; Stojšić et al., 2019). Therefore, this study investigates the impact of mobile VR on adolescent EFL learners' listening comprehension. In particular, the study examines to what degree interactivity with mobile VR would help or hinder listening comprehension. Three research questions were addressed in this study:

1. Does mobile VR instruction facilitate adolescent EFL learners' listening comprehension?
2. What is the effect of the degree of interaction (i.e., watching or playing) with a VR app on listening comprehension?
3. What are the EFL learners' perceptions of mobile VR for English listening comprehension?

Method

Research Design and Participants

This experimental study investigates the impact of mobile VR on adolescent EFL learners' listening comprehension. The participants were 49 seventh graders recruited from two intact classes taught by the same English teacher at a junior high school in northern Taiwan. All of them had received the approval of their parents before participation (Appendix A). In addition, a careful discussion was conducted between the researcher and the principal, experienced English teachers, and home-room teachers of the participating school. The participants received cash incentives (equivalent to NT$200) for their participation in the study.

Students from both classes were randomly assigned to either the experimental or control group. The two groups did not differ significantly in their gender, age, level of education, and overall language proficiency (t = .47, p = .64, η^2 = .01), and listening comprehension ability (t = .38, p = .71, η^2 = .00). Audio materials delivered by a CD player are the main stimuli used in their classes for listening comprehension. Seven participants had experience watching 3D movies and playing 3D computer games; however, none had previous experience using VR for language learning. The demographics for the 49 participants are given in Table 1.

Table 1

Demographic Information of the Participants

Group	*N*	Average age	Gender		Average number of years learning English
			M	F	
VR player	24	14.25	12	12	6.92
Video watcher	25	13.68	15	10	7.00

For the interactive treatment, participants in the experimental group (VR players) played the language learning VR app *Mondly* using mobile-rendered HMDs. They navigated the virtual scenarios and interacted with the virtual characters via dialogues. For the non-interactive treatment, participants in the control group (video watchers) watched a pre-recorded walkthrough video of *Mondly*, which was made by Hyperbot Studio. The walkthrough video viewed on a standard PC screen, showing someone playing through the entirety of *Mondly*, was identical in content to the VR app. They could replay and pause the walkthrough video. The video watchers saw and heard the same virtual characters but could not interact with them.

Instruments

The instruments used in this study were technological learning devices (i.e., Samsung Gear VR, a mobile phone, and a PC), learning materials (i.e., the *Mondly* VR app), a background questionnaire, and instruments of evaluation (i.e., listening comprehension tests, recalls, and interviews).

Learning Devices and Materials

Samsung Gear VR and Samsung Galaxy Note 8 were used as the learning devices for the VR players. A personal computer was used for the video watchers. *Mondly* is a foreign-language learning VR app produced by Ati Studios, which was used as the learning material. The app was downloaded from the Oculus store. It combines VR technology and automatic speech recognition (ASR). The VR app had a total running time of 24 minutes 45 seconds.

Mondly was selected because the topics and vocabulary were appropriate for the participants' proficiency level, as shown in Table 2. They adhered to the Curriculum Development Guidelines for 12-Year Basic Education mandated by the Ministry of Education (MOE) in Taiwan and school-developed required courses for international education of the participating school. Furthermore, *Mondly* had two distinguishing characteristics: the fidelity of the representation and a high degree of interactivity. *Mondly* creates an immersive virtual environment by replicating real-life scenarios (e.g., train, taxi, hotel lobby, hotel room, and restaurant). By wearing VR HMDs, learners have a stereoscopic view of the virtual environment. Spatial audio is used to draw the user's attention and enhance the realism of the virtual experience. High-caliber 3D graphics and virtual characters' movement in the 3D virtual environment provide visual immersion and simulate a realistic effect in the environment, making learners feel like they were there with the virtual characters.

Table 2

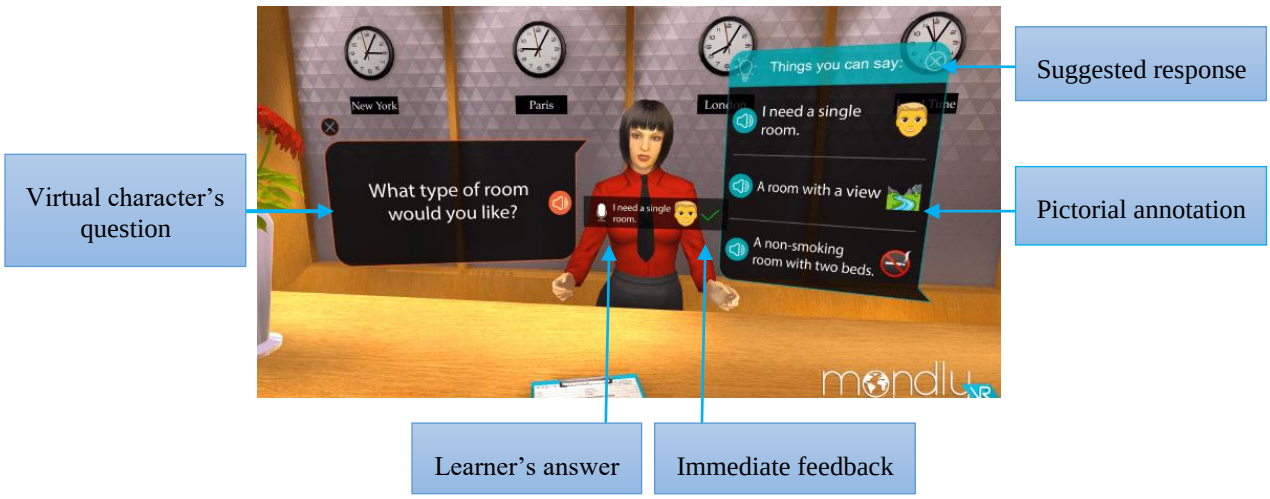
Analysis of the Five Scenarios in Mondly

	Training	**Intervention**			
Scenario	**Train**	**Taxi**	**Reception**	**Hotel room**	**Restaurant**
Topic	Make friends	Take a taxi ride	Check into a hotel	Chat with a manager	Order dinner
Duration	4:34	3:50	5:42	4:22	6:17
Word types	75	63	96	93	115
Word tokens	177	188	203	223	242
Within 2000-word level	94.67%	95.24%	95.83%	93.55%	94.78%

Mondly provided five types of interactivity: dialoguing, manipulating, controlling, searching, and navigating (Moreno & Mayer, 2007). In dialoguing, learners could have conversations with virtual characters and get immediate feedback on pronunciation and suggested responses. Every answer learners give is transcribed on screen (Figure 2). The app listens to learners' words, analyzes the accuracy of their pronunciation, and provides positive feedback if they speak clearly and correctly. A green checkmark will hover over the transcription of what learners say and the virtual character will nod.

Figure 2

An Example of the Interaction with a Virtual Character



For answers that are incorrect or unclear, the learners received linguistic (e.g., “Please repeat.”; “Pardon me.”) or kinesics signals (e.g., staring and gesturing), which underlines the failure (Figure 3). In controlling, learners can decide the learning pace or control the order by using a menu for direct access to a particular scenario. In manipulating, learners can control aspects of the presentation, such as zooming in or out. In searching, learners can seek information, such as receiving options and selecting an option. In navigating, learners can explore the virtual environment and select from available sources by clicking on the suggested response or pronunciation button.

Figure 3

Screenshots of the Virtual Character’s Feedback

Staring Zooming in Gesturing

Demographic Questionnaire

A demographic questionnaire (Appendix B) was given to the participants which contained question items designed to obtain their demographic information, such as sex, age, native language, educational background, previous VR use experience, and familiarity with *Mondly*.

Instruments of Evaluation

The study used listening comprehension tests, recalls, and semi-structured interviews to evaluate the participants’ listening comprehension, the effects of interaction, and their perception of mobile VR-mediated English listening.

Listening Comprehension Tests

To gauge the participants’ listening comprehension, listening comprehension posttests (Appendix C), delayed posttests, and recalls were administered to all participants. The posttest comprised 12 multiple-choice questions. Based on the rationale from Bloom’s taxonomy, the listening test items were classified into four categories: remembering (test items 2, 4, 10), understanding (test items 3, 6, 9), applying (test items 5, 8, 12), and analyzing (test items 1, 7, 11). Each correctly answered multiple-choice question was worth 1 point. To ensure the quality of the spoken stimuli, the test items were pre-recorded by two native English teachers. The question prompt was in spoken form. It was repeated twice, with a 3-second pause in between. The speech rate of the spoken message was approximately 130 words per minute. The validity of the listening materials and tests was established through expert opinion. Two experienced EFL teachers and a native English teacher were asked to rate the test validity based on the relevance and appropriateness of the listening materials. The delayed listening comprehension posttests were identical to their immediate posttests, but the items were reordered.

Recall

After the intervention, a free recall was designed to assess the participants’ listening comprehension and retention. They could write in English or Chinese. Recall protocols were independently scored by two experienced junior high school English teachers based on two criteria: (a) the total number of correct idea

units given, and (b) the number of main ideas and details given. Each idea entry was scored 1 point if two raters accepted the entry as a correct idea.

Semi-Structured Interview

Semi-structured interviews were conducted with the VR players individually to ascertain their interactive experience in the virtual environment and their opinions on the value of VR as a listening tool. They were interviewed in their native language (Mandarin Chinese) for approximately 10 minutes.

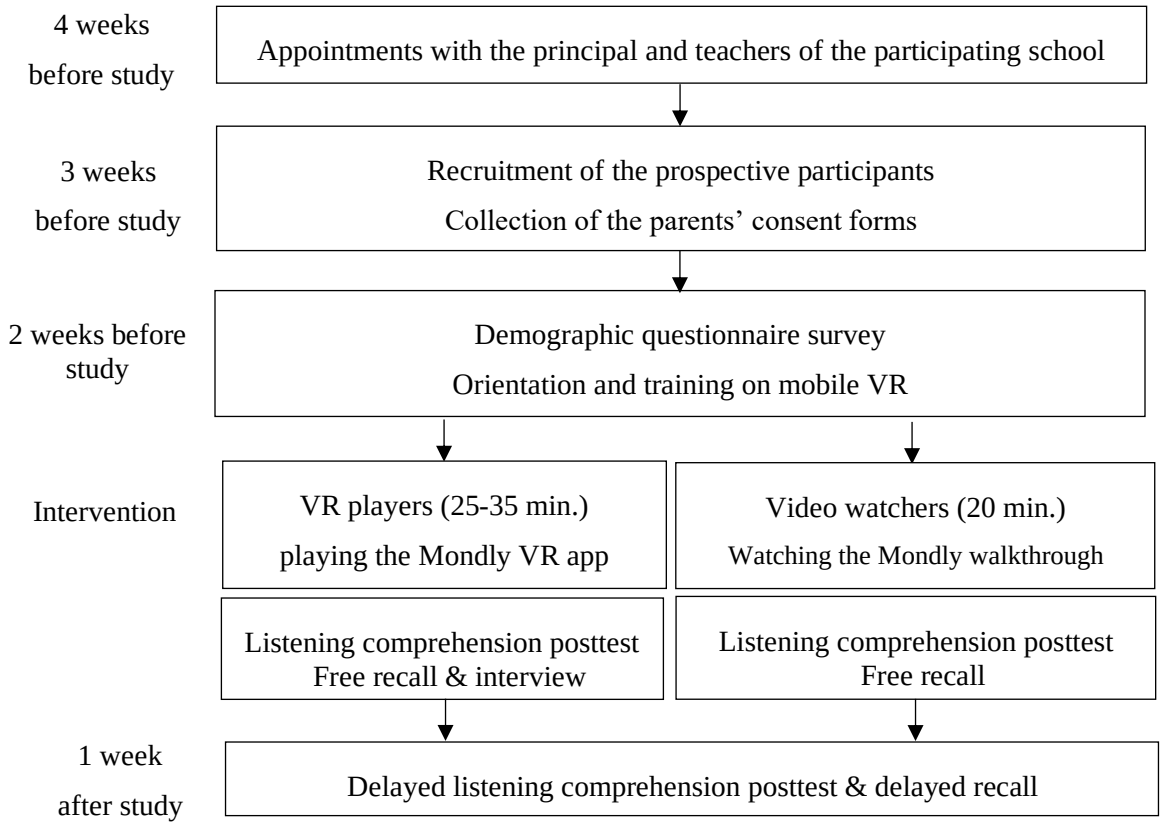
Procedure

A demographic questionnaire was administered to all the participants after careful discussion with the principal and experienced English teachers of the participating school and obtaining parental permission two weeks before the administration of the study. At the onset of the intervention, the participants were given a brief orientation about the task to be completed. A training session on the operation of Samsung Gear VR was held to ensure that all the VR players were familiar with it. They experienced different VR apps, but not *Mondly*, for one week. Then, the VR app learning task was individually administered to each participant. The participant could take a short break between the scenarios. To accomplish the communicative tasks in *Mondly*, the VR players had to navigate the virtual scenarios, interact with the virtual characters, and observe the objects, which took approximately 25 to 35 minutes.

Regarding the video watchers, they also received the intervention individually. They watched the pre-recorded walkthrough video without interacting with the virtual characters for approximately 20 minutes. A listening posttest and free recall were conducted with the participants individually after the intervention. In addition, semi-structured interviews were administered to the VR players. The study concluded with a delayed listening test and recall activity with all the participants 1 week after the intervention. The experimental procedure of the present study is illustrated in Figure 4.

Figure 4

Experimental Procedure of the Study



Data Analysis

An independent-samples *t*-test was calculated to compare the VR players' and video watchers' academic achievements in five monthly English exams before the study to determine any initial differences between the two intact classes regarding their English proficiency level and listening comprehension ability. To compare the listening comprehension and recall of the VR players and video watchers, an independent-samples *t*-test was calculated again to measure the post-test and delayed post-test scores. Then, the paired-samples *t*-test was conducted to determine whether any in-group differences had changed over time. The results of the above quantitative analysis were substantiated by the qualitative analysis of the post-study interview data.

Results

Listening Comprehension Tests

Table 3 provides the results of the *t*-test for the participant's performance in the listening comprehension posttests and delayed posttests. The results showed a significant difference between the VR players (M = 8.25, SD = 1.54) and the video watchers (M = 6.80, SD = 3.01) on the posttest (t = 2.13, p = .04, η^2 = .09). The VR players outperformed the video watchers. Similarly, a significant difference was found between the VR players (M = 7.75, SD = 1.92) and the video watchers (M = 5.96, SD = 3.31; t = 2.33, p = .03, η^2 = .10) on the delayed posttest. The VR players demonstrated better listening comprehension than the video watchers. VR seemed to help the VR players better comprehend the listening content.

Table 3

Results of the Independent Samples t-Test of the Participants' Listening Comprehension

Test	Group	*N*	*Mean*	*SD*	*t*	*p*	η^2
Posttest	VR	24	8.25	1.54	2.13*	.04	.09
	Video	25	6.80	3.01			
Delayed posttest	VR	24	7.75	1.92	2.33*	.03	.10
	Video	25	5.96	3.31			

*p < .05

The paired-samples *t*-test was further calculated to detect whether any significant differences appeared within each group over time. The results, provided in Table 4, indicated the VR players' listening comprehension did not differ significantly between the posttest and delayed posttest (t = 1.33, p = .20, η^2 = .07), even though the VR players had a higher mean score on the posttest (M = 8.25, SD = 1.54) than on the delayed posttest (M = 7.75, SD = 1.92). Similarly, the video watchers performed better on the posttest (M = 6.80, SD = 3.01) than on the delayed posttest (M = 5.96, SD = 3.31). However, no significant difference was found between the two tests (t = 1.56, p = .13, η^2 = .09).

Table 4

Results of the Paired Samples t-Test of the Listening Comprehension Tests within Groups

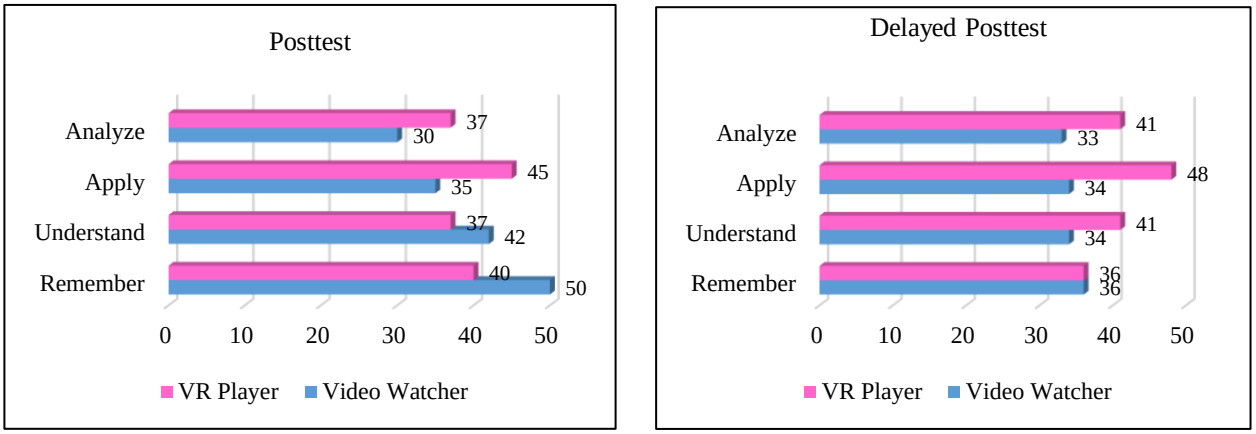
Group	Listening Test	*N*	*Mean*	*SD*	*t*	*p*	η^2
VR	Posttest	24	8.25	1.54	1.33	.20	.07
	Delayed posttest	24	7.75	1.92			
Video	Posttest	25	6.80	3.01	1.56	.13	.09
	Delayed posttest	25	5.96	3.31			

The following section presents a more detailed analysis of the participant's performance on the L2 listening

test items, categorized based on Bloom's taxonomy: (a) remembering, (b) understanding, (c) applying, and (d) analyzing. The descriptive statistics for correctly answered listening item analysis in the posttest and delayed posttest are illustrated in Figure 5.

Figure 5

Total Correctly Answered Listening Test Items in Two Posttests



In the listening comprehension posttest, among the VR players' total correctly answered test items, *applying* test items ranked first (*N* = 45), *remembering* test items came second (*N* = 40), followed by *analyzing* (*N* = 37) and *understanding* (*N* = 37) test items. Regarding the video viewers, *remembering* test items ranked first (*N* = 50), *understanding* test items came second (*N* = 42), followed by *applying* test items (*N* = 35) and *analyzing* test items (*N* = 30). A similar pattern emerged from the delayed listening comprehension test. The VR players performed best in *applying* test items (*N* = 48), while *understanding* and *analyzing* test items came second (*N* = 41), followed by *remembering* test items (*N* = 36). By contrast, for the video watchers, *remembering* test items ranked first (*N* = 36), while *understanding* and *applying* test items came second (*N* = 34), followed by *analyzing* test items (*N* = 33). The results indicated that the VR players performed better at a higher level of thinking ability in Bloom's taxonomy.

Participants' Recalls

Table 5 provides the results of independent-samples *t*-tests for the participants' performance in the immediate and delayed recalls. A significant difference was noted between the VR players (*M* = 15.08, *SD* = 8.35) and the video watchers (*M* = 5.20, *SD* = 6.66) in the immediate recall ($t = 4.59$, $p = .00$, $\eta^2 = .31$, observed power = .99). The VR players outperformed the video watchers. Regarding the delayed recall, there was a significant difference between the VR players (*M* = 15.58, *SD* = 10.78) and the video watchers (*M* = 0.80, *SD* = 2.29) in the delayed posttest ($t = 6.58$, $p = .00$, $\eta^2 = .49$). The VR players showed better retention. By contrast, the video watchers seemed to suffer from a serious loss of retention, particularly in the delayed recall.

Table 5

Results of the Independent Samples t-Test of Recalls between Groups

Recall	Group	*N*	*Mean*	*SD*	*t*	*p*	η^2
Immediate Recall	VR	24	15.08	8.35	4.59***	.00	.31
	Video	25	5.20	6.66			
Delayed Recall	VR	24	15.58	10.78	6.58***	.00	.49
	Video	25	.80	2.29			

***$p < .001$

The paired-samples *t*-test was further conducted to detect any significant differences in the mean scores for each group's immediate and delayed recalls. As shown in Table 6, no significant difference was found between the immediate recall (M = 15.08, SD = 8.35) and the delayed one (M = 15.58, SD = 10.78) for the VR players (t = -0.22, p = .83, η^2 = .00, observed power = .06). The higher mean score for the delayed posttest over the posttest is noteworthy. Instead of attrition, the VR players received slightly higher scores in the delayed recall than in the immediate one. One potential explanation for this finding is that there seemed to be a peer discussion effect on the VR players' retention. Regarding the video watchers, the results revealed significant differences between the immediate recall (M = 5.20, SD = 6.66) and the delayed one (M = 0.80, SD = 2.29). There was a larger decline in scores for the video watchers' delayed recalls (t = 2.95, p = .01, η^2 = .27).

Table 6

Results of the Paired Samples t-Test of Immediate and Delayed Recall within Groups

Group	Recall	*N*	*Mean*	*SD*	*t*	*p*	η^2
VR	Immediate	24	15.08	8.35	-0.22	.83	.00
	Delayed	24	15.58	10.78			
Video	Immediate	25	5.20	6.66	2.95*	.01	.27
	Delayed	25	.80	2.29			

*p < .05

Table 7 presents the results of the independent-samples *t*-test for the participants' recall of main ideas and details in the immediate and delayed recalls. The results indicated that the VR players had significantly better recall of the main ideas (t = 5.04, p = .00, η^2 = .36) and details (t = 2.49, p = .02, η^2 = .12) than the video watchers in the immediate recall. Similarly, the VR players also performed significantly better in the recall of the main ideas (t = 5.30, p = .00, η^2 = .38) and details (t = 5.10, p = .00, η^2 = .36) than the video watchers in the delayed recall. With a high attrition rate in the delayed recall, what was left in the video watchers' minds were a few details, not the main ideas.

Furthermore, the results revealed that the VR players recalled more main ideas than details in the immediate recall (M = 8.29, SD = 6.14 for main ideas; M = 6.58, SD = 4.92 for details) and in the delayed recall (M = 11.13, SD = 10.28 for main ideas; M = 4.50, SD = 3.74 for details). By contrast, the video watchers recalled more details than main ideas in the immediate recall (M = 1.16, SD = 3.27 for main ideas; M = 3.36, SD = 4.12 for details) and delayed recall (M = .00, SD = .00 for main ideas; M = .40, SD = 1.26 for details). Figure 6 illustrates the results of the main ideas and details recalled for both groups in the immediate and delayed recalls.

Table 7

Results of the Independent t-Test of the Main Ideas and Details in Both Recalls

Recall		VR players		Video watchers				
		M	*SD*	*M*	*SD*	*t*	*p*	η^2
Immediate	Main	8.29	6.14	1.16	3.27	5.04***	.00	.36
	Detail	6.58	4.92	3.36	4.12	2.49*	.02	.12
Delayed	Main	11.13	10.28	.00	.00	5.30***	.00	.38
	Detail	4.50	3.74	.40	1.26	5.10***	.00	.36

*p < .05, ***p < .001

Figure 6

Results of Main Idea and Detail Recalls for Both Groups.

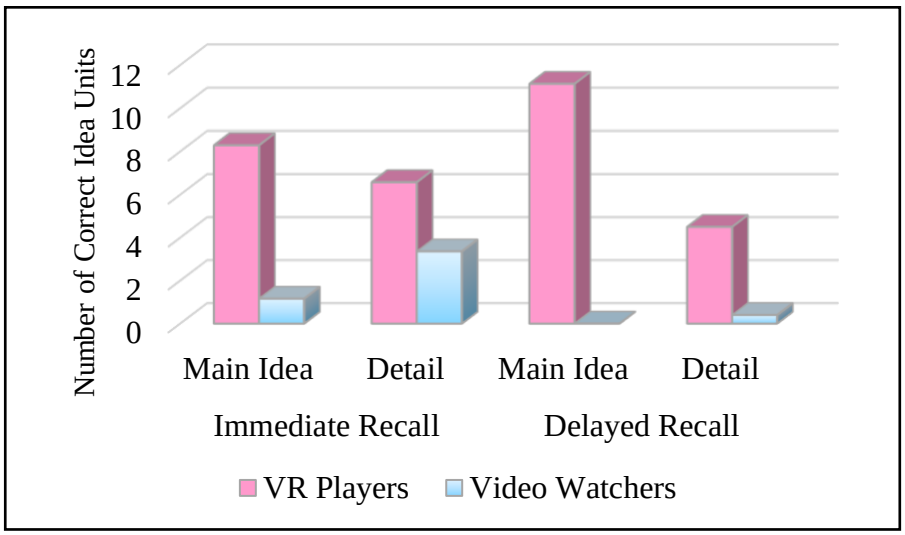


Table 8 provides descriptive statistics and the results of the paired-samples *t*-test for the participants' recall over time. There was no significant difference between the immediate recall and the delayed one for the VR players in terms of the main ideas (t = -1.28, p = .22, η^2 = .066), indicating the VR effect on global information gains and retention. By contrast, a significant difference was found in recalled details over time (t = 2.34, p = .03, η^2 = .028). The VR players had a high attrition rate on the details.

The video watchers' recall of the main ideas did not significantly change over time (t = 1.77, p = .09, η^2 = .089). With a high attrition rate in the delayed recall, what was left in the participants' minds were a few details (t = 3.36, p = .00, η^2 = .32). The very low scores of the video watchers in the recall test immediately following the procedure may explain some of the stability of their scores from the immediate recall to the delayed one.

Table 8

Results of the Paired Samples t-Test of the Main Ideas and Details for Both Groups

Group	Recall	Immediate		Delayed				
		M	***SD***	***M***	***SD***	***t***	***p***	***η²***
VR	Main	8.29	6.14	11.13	10.28	-1.28	.22	.066
	Detail	6.58	4.92	4.50	3.74	2.34*	.03	.028
Video	Main	1.16	3.27	.00	.00	1.77	.09	.089
	Detail	3.36	4.12	.40	1.26	3.36***	.00	.320

*p < .05, ***p < .001

VR Players' Interviews

Table 9 presents the frequency and percentage of the VR players' responses to each question. VR-mediated EFL listening received positive feedback from the majority of the VR players (83.33%). They were highly motivated to listen in an immersive virtual environment and felt fully engaged wearing the HMD. Regarding the usefulness of VR in listening comprehension, 20 VR players (70.83%) appreciated the simulated 3D real-life scenarios for deep linguistic immersion, which helped activate prior knowledge,

make appropriate inferences, and thus reduce the burden of comprehension. Furthermore, 75% of the VR players reported a sense of presence due to a high degree of interactivity and free navigation. In particular, they commented favorably on the role played by the virtual characters in facilitating listening comprehension. The virtual characters helped them feel "like they were there" and reduced listening and speaking panic. Furthermore, the interaction with the virtual characters provided essential scaffolding and immediate feedback, which enabled the VR players to listen to learn. The following extracts were derived from two interviews:

> 我覺得很像真的看著她，和她聊天，很好玩! 她人很好，會教我，給我很多次機會，這樣可以鼓勵我講英文，增加我的信心。 (VR-71233)
>
> *I felt like I was 'looking' at her. It was fun to talk with her! She (the virtual character) was friendly and supportive, giving me many opportunities to practice. This way encouraged me to use English and increased my confidence.*
>
> 在虛擬世界和虛擬人物講英文，比較輕鬆，沒有面對面溝通的壓力! (VR-71208)
>
> *Speaking English with virtual characters within the virtual world was a bit better because I feel more relaxed and less pressure, compared to a face-to-face interaction.*

Based on the above findings, the answer to the second research question is that the higher the degree of interaction with the virtual characters, the more engaged, confident, and active they become, which enhances comprehension.

Regarding VR usability, 19 VR players (79.19%) perceived VR as being easy to use and control. Over half of the VR players indicated that the portability of the mobile-rendered HMDs allowed for flexibility and convenience in listening. Nevertheless, the new technology was not easy for all VR players to use. Challenges arose from the automatic speech recognition (ASR) system (25.00%) and interactivity in the VR environment (8.33%). Some students experienced glitches where they had to speak and reiterate. Considerable self-correction, particularly in pronunciation, was required. Another challenge was the immediacy of interaction. They were unable to manipulate multiple things simultaneously.

Table 9

Summary of the VR Players' Responses to Interview Questions (N = 24)

Category	*N*	*%*
Motivation		
Yes	20	83.33
Interesting, motivating, beneficial	17	70.83
Unique learning experiences of VR (e.g., immersion, presence)	16	66.67
Reduced listening anxiety	12	50.00
A sense of security	7	29.17
No	3	12.50
Lack of diversity in interaction (e.g., linear order)	2	8.33
Not beneficial for English tests	1	4.17
Neutral	1	4.17
Perceived Usefulness of VR		
Yes	20	83.33
A sense of presence: Active first person participation	18	75.00
Immersive virtual environment: Enhanced engagement and contextualized listening	17	70.83
Interactivity: Dialoguing, navigating, controlling, and searching	16	66.67
Multisensory input and learning support	12	50.00
No		
Immediacy of interaction: Limited cognitive ability	2	8.33
Too much functionality: cognitive overloading	1	4.17
Neutral	1	4.17
Perceived Usability of VR		
Easy to use	19	79.17
Portability: Flexibility and convenience in learning	13	54.17
Technical problems	8	33.33
ASR system	6	25.00
Unfamiliar with the VR interface and interactivity	2	8.33

Discussion

The first research question concerns the impact of mobile VR on EFL learners' listening comprehension. The results indicated that the VR players' listening comprehension was significantly better than the video watchers' in the posttest and delayed posttest. Furthermore, the recall scores of the VR players were significantly higher than those of the video watchers on four measures: total recall, recall of global information, number of inferences, and application added to recall. The VR players showed better retention. By contrast, the video watchers seemed to suffer from a serious loss of retention. This striking between-group difference indicates that VR is not only effective in facilitating global comprehension of the listening content but also in retaining the details. The findings corroborate prior research revealing the beneficial effect of VR, which offers an ideal environment for linguistic immersion and target language interaction in authentic contexts, which are essential for effective L2 listening (Cross & Vandergrift, 2018; Lan & Liao, 2018). In addition, more time spent interacting with the virtual characters and objects in the virtual environment might also contribute to the VR players' better listening comprehension and retention.

The second research question explores the effects of interaction (i.e., watching or playing) with a VR app on listening comprehension and retention. Mobile VR provides a simulated environment that is realistic and immersive, which allows the VR players to experiment and explore. Following Vygotsky's (1986) theory of cognitive development, they were active knowledge constructors. They acquired knowledge by exploring the virtual world and experiencing language use from a first-person perspective. They were granted the opportunity to interact with virtual characters under different situations, which allowed them to experience interaction dynamics as they interacted with native speakers in authentic contexts.

Most importantly, the interaction with the virtual characters provided essential scaffolding and immediate feedback, which were crucial for the VR players' effective listening comprehension and retention. The findings provided empirical evidence supporting Long's (1996) Interaction Hypothesis that interaction contributes directly to language acquisition. By contrast, the walkthrough video content proceeded linearly without interaction. The video watchers, as overhearers, listened but had no right to interact with the characters and the context, which might result in their less effective learning.

The third research question investigates the VR players' perception of mobile VR-assisted listening comprehension. Most VR players enjoyed the VR learning experience. They were motivated to listen using the mobile-rendered HMD. The findings were consistent with prior research that revealed immersive VR learning environments elevate learners' motivation and interest compared with learning in a 2D-animated environment (Dolgunsöz et al., 2018). Specifically, the interaction with virtual characters provides the VR players a sense of embodiment and strengthens the sense of "being there" within a virtual environment. This type of virtual presence helps reduce the affective filter, entails engagement in an event, and enables a first-person view of the environment (Mikropoulos, 2006), conducive to the VR players' listening comprehension. However, the unfavorable comments should not be ignored. They echoed the distractions and problems with cognitive overload found in Ladendorf et al. (2019). When participating in activities in the virtual world, students sometimes found it difficult to concentrate on the learning activity. In other words, the dual input of spoken messages accompanied by simultaneously written text and real-time interactions increased the cognitive load. Therefore, when designing or preparing VR-based learning activities in the EFL context, the teacher should consider learners' differences (e.g., learning styles, proficiency, and needs).

Limitations of the Study

This study is limited by the relatively small number of participants for an experimental study and the short time they used the VR software. A related issue is the novelty effect. In addition, the varying exposure time between the VR players and video watchers might affect the participants' listening comprehension and retention. Another significant concern is the limited selection of mobile VR apps. Only a few mobile VR apps have been developed specifically for language learning. Therefore, it is recommended that forthcoming studies be undertaken with longitudinal studies incorporating various types of VR apps, which might mitigate the novelty effect and provide more substantial evidence. Furthermore, this study specifically targeted English listening. Future research hopefully can investigate learners' development and performance in other language skills, particularly productive skills (e.g., writing and speaking), to provide more comprehensive results on the role of mobile VR in facilitating EFL learners' language learning, helping practitioners make informed decisions on integrating mobile VR into curricula.

Conclusion

This study aimed to investigate the impact of mobile VR on adolescent EFL learners' listening comprehension and their perceptions. The results show that mobile VR can facilitate EFL learners' listening comprehension and retention. The VR players' recalls included more information on four measures: total accurate information recall, recall of main ideas, number of inferences, and application added to recall.

Based on the analysis of the interview data, mobile VR-mediated EFL listening received positive feedback

from the majority of the VR players, which they considered motivating, interesting, and beneficial. They appreciated the simulated 3D real-life scenarios for deep linguistic immersion, which helped activate prior knowledge, make appropriate inferences, and thus reduce comprehension burden. In addition to the fidelity of the representation, a high degree of interactivity, in particular the interaction with the virtual characters, helped them greatly feel "like they were there". In addition, the portable character of mobile-rendered HMDs, allowing for flexibility and convenience in learning, was another factor contributing to their motivation and listening.

From a pedagogical perspective, the study supports the inclusion of mobile VR in an EFL context because many scenarios on the interactive VR platform can offer teachers readily accessible teaching materials. This helps learners easily immerse in the target language community, meeting the needs of EFL learners as they lack an authentic English learning environment. Furthermore, this study has significant implications for the assessment of EFL listening. Suppose the goal of a particular test is to assess how well a learner can understand the target language in a real-world context by immersing language learners in a simulated real-life communicative context, interacting with virtual characters, and receiving immediate feedback. In that case, one can make more valid inferences about the test-takers listening ability in real-world communication.

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Appendix A: Consent Form for the Participants' Parents

Consent Form for the VR Players' Parents

Dear Parents,

The purpose of the study is aimed to investigate the impact of mobile VR on junior high school students' listening comprehension and their perception of mobile VR-mediated EFL listening. The participants will use mobile VR (VR via head-mounted display, Samsung Gear VR) to learn to listen in English. Then, listening comprehension posttests and interviews will be conducted with the participants. The study will end up with a delayed listening comprehension posttest. The participation was voluntary and confidential. All the survey results will be used only for academic research purposes and provide parents information. The participants' performance will not affect how the teacher grades their progress in the English class. The participants will receive cash incentives (equivalent to NT$200) for their participation in the study.

Yours faithfully,

(The Researcher)

--------✂----------

Reply Slip

The study purpose and related information have been noted.

Please put a √ in the appropriate box.

□ I agree that my son/daughter participate in the study.

□ I disagree that my son/daughter participate in the study.

_____ _____

Name of Parents/Guardian Signature

_____ _____ _____

Name of Student Class & No. Date

Consent Form for the Video Watchers' Parents

Dear Parents,

The purpose of the study is aimed to investigate the impact of mobile VR on junior high school students' listening comprehension. The participants in the control group will listen with the walkthrough video. Listening comprehension posttests and delayed posttests will be conducted with the participants immediately and one week after the intervention, respectively. The participation was voluntary and confidential. All the survey results will be used only for academic research purposes and provide parents information. The participants' performance will not affect how the teacher grades their progress in the English class. The participants will receive cash incentives (equivalent to NT$200) for their participation in the study.

Yours faithfully,

(The Researcher)

--------✂----------

Reply Slip

The study purpose and related information have been noted.

Please put a √ in the appropriate box.

□ I agree that my son/daughter participate in the study.

□ I disagree that my son/daughter participate in the study.

_____ _____

Name of Parents/Guardian Signature

_____ _____ _____

Name of Student Class & No. Date

Appendix B. A Demographic Questionnaire

Dear Student,

Thank you for taking the time to complete this survey. This questionnaire asks for information about your English learning experience, especially in listening comprehension and vocabulary acquisition. Your responses will give your instructor information about your needs. The survey takes about 20 minutes of your time. All survey results will be used only for academic research purposes. Your answers will not affect how the teacher grades your progress.

SECTION I

Part I: Background Information

1. Name: _____
2. Year of birth: _____
3. Gender: □ Male □ Female
4. Number of years I have studied English: _____

Part II: VR Technology Experiences

1. Directions: Place a check mark (√) in the following VR environments you have experienced.

□ 3D Computer Display	□ CAVE	□ 3D Movie	□ 3D Video
			

Others: _____

2. Directions: Place a check mark (√) in the following VR technology you have experienced.

□ Oculus Rift	□ Sony PlayStation VR	□ HTC Vive
		
□ Samsung Gear VR	□ Google Cardboard	□ Google Daydream View
		

Others: _____

3. Have you ever used the app *Mondly* to learn English? □ Yes □ No

Appendix C. Listening Comprehension Test

1. According to the dialogue you heard in this scene, why does the speaker need to take a taxi?
   (A) He is looking for a hotel.
   (B) He is late for the concert.
   (C) He is going to the airport.
   (D) He hates to wait for a bus.

2. When does the speaker most likely take a taxi?
   (A) In the middle of the morning.
   (B) Early in the afternoon.
   (C) Late in the evening.
   (D) At night.

3. According to the dialogue you heard in this scene, what is the best title for it?
   (A) Book a room.
   (B) Ask for room service.
   (C) Check into a hotel.
   (D) Be a friendly waitress.

4. According to the dialogue, what does the bellboy do for the speaker?
   (A) Introduce herself.
   (B) Give the speaker a map.
   (C) Show the speaker around the hotel.
   (D) Listen to the speaker's complaint.

5. The bellboy asks, "Is this your luggage?" What will he most probably do next?
   (A) Ask for the tip.
   (B) Help the speaker check in.
   (C) Show the speaker around the hotel.
   (D) Carry the speaker's luggage to the room.

6. According to the dialogue you heard in this scene, what is the best title for it?
   (A) Good room service.
   (B) A room with good view.
   (C) Make a complaint to the waiter.
   (D) Make your trip worry-free.

7. Why does the speaker need to call the manager?
   (A) The speaker likes room service.
   (B) The speaker is angry with the waiter.
   (C) The speaker needs to book another room.
   (D) The speaker is not satisfied with the room.

8. The speaker said, “Do you have a quieter room?” to the waiter. What does the speaker mean?
   (A) Leave me alone.
   (B) Book another room.
   (C) Ask for room service.
   (D) Change the room.

9. What is the speaker and the female customer’s conversation mainly about?
   (A) Place they want to visit.
   (B) Getting to know each other.
   (C) Activities they enjoy together.
   (D) Plans they have for tomorrow.

10. What do you know about the female customer from the dialogue?
    (A) Her job.
    (B) Her family.
    (C) Her hobby.
    (D) Her appointment.

11. According to the dialogue, who is the female customer?
    (A) The speaker’s former classmates.
    (B) The speaker’s language teacher.
    (C) The speaker’s good friend.
    (D) None of them.

12. Why did the female customer ask, “What time is it?”
    (A) She needed a watch.
    (B) She wanted to start a new topic.
    (C) She asked for the time.
    (D) Time to get off work.

About the Author

Tzu-Yu Tai is an assistant professor in the Global Foreign Language Education Program, Providence University, Taiwan. Her research interests include CALL and TESOL.

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