

Enhancing EFL Listening Comprehension through a Customized Immersive Virtual Reality Application: A Study on Computer Science Students

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Abstract: Listening comprehension is a crucial component of language acquisition, yet it remains a persistent challenge for students across diverse fields of study. This study develops a Virtual Reality app to address a gap and enhance computer science students' listening comprehension skills. This study employed a quantitative design with a paired t-test and a Likert-scale questionnaire. The participants in this study are 20 students from the Computer Science Faculty at the University of Putra Indonesia, YPTK Padang. Pre-test and Post-test were administered to evaluate improvements in listening Comprehension, as shown by a t-value of -5.501 and a p-value of $< .001$, while a questionnaire was also given to assess students' experiences and opinions after using the VR app. The VR app design required a few improvements in device settings, yet it still significantly enhances students' English comprehension skills, as shown by a paired t-test, and practically increases students' motivation. A VR app can be used in language learning to improve students' abilities, increase their motivation, and reduce anxiety, especially in listening comprehension.

Keywords: EFL students, listening comprehension, virtual reality.

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■ INTRODUCTION

The importance of learning English has been emphasized since elementary school in Indonesia. Thus, most university students have been learning this language for more than a decade. However, for some students, progress is still slow and falls short of expectations. Most students continue to struggle with English, particularly in listening skills. Listening comprehension is a crucial component of language proficiency, as it enables learners to understand and respond effectively to their interlocutors. Listening to a second language requires the learner to process various linguistic and paralinguistic cues, such as pronunciation, vocabulary, grammar, and body language (Goswami & Rahman, 2023).

Alharbi & Al-Ahdal (2024) has found four main reasons for students' poor listening

comprehension skills. Namely, lack of studying time, lack of facility, lack of vocabulary mastery, and difficulty in grasping English phonetics. In fact, as a language, English has many accents and intonations that sometimes vary depending on the context in which the conversation is held, for instance, students learning English as a second language often need help grasping the pace and rhythm of conversational speech or the idiomatic phrases used in daily interactions, as textbook dialogues are typically slower and lack the spontaneity of real-life conversation (Herlina, 2023). Also, the complexity of students' native language can sometimes interfere with the students' ability to absorb new language (Amna, 2018).

Recent research shows that the listening comprehension students learn and practice in

traditional class, like using tape during class hours, cannot fully represent the situation in a real conversation (Ye & Kaplan-Rakowski, 2024). Listening skill requires students to maintain their focus during the activity. However, if students only listen without additional contextual and visual aids, they often become passive, easily lose focus, become distracted, and become overwhelmed by new information and vocabulary (Peixoto et al., 2024; Zou et al., 2024)

To address these challenges, educators have explored the potential of VR technology to enhance listening comprehension skills (Hwang et al., 2025). Virtual reality can create immersive, interactive environments that simulate real-world scenarios, allowing learners to practice their skills in a safe, controlled setting. By creating a realistic virtual environment, virtual reality can provide language learners with opportunities to engage in authentic conversations and interactions, exposing them to a wide range of accents, speech patterns, and contextual cues. This environment can help students better understand the target language, improve their ability to comprehend natural speech, and develop more effective communication strategies (Lu, 2025). Additionally, the interactive nature of Virtual Reality enables learners to receive immediate feedback, practice repeatedly, and gradually build their confidence and proficiency in listening comprehension (Sadiev et al., 2021; Nersesian et al., 2018).

Research on the effectiveness of VR in language learning is supported by the Cognitive Theory of Multimedia Learning (CTML), which states that learning is more effective when images are used rather than just words. In CTML, effective learning occurs when words and images are processed through verbal and visual cognitive channels in a balanced manner (Mayer, 2011). Liao & Wang (2024) stated that VR can present information simultaneously through verbal

and visual channels, thereby helping distribute cognitive load and strengthen motivation, engagement, and conceptual understanding through an immersive learning experience.

Virtual reality is a technology that enables students to enter and feel truly present in the virtual world. VR video content can help language students see that the language they are learning can be applied and used in real-life situations. (Forester and Meyer, 2015). In addition, VR can be accessed on mobile phones, which most language students already have, making it easier for them to use. Virtual Reality aims to create experiences that allow students to feel immersed in a virtual, lifelike world (Obrist and Martínez, 2015) and provide opportunities to utilize culturally relevant physical interactions (Cheng, 2017). As with any technology, introducing this technology raises excellent expectations within the education sector regarding the capabilities it can offer. However, it must also be remembered that these technologies cannot teach on their own and must be implemented effectively to support the learning process.

Virtual Reality applications introduce synthetic sensory information that provides a continuous stream of surrounding stimuli, creating the perception of a closed illusion and interacting with an environment that feels real (Chen et al., 2020). This technology offers an 'immersive' system in which students can enter and interact with the virtual environment using their senses and special devices connected to the computer. Lee et al. (2024) and Sadiev et al. (2021) also stated that an 'immersive' or 'immersion' in Virtual Reality technology for language learning is an interactive, dynamic environment that creates authentic contexts, increases engagement, and provides a sense of presence.

According to Jackson & Jackson (2024), Virtual Reality has four aspects in the learning

approach. The first is representational immersion, which concerns the user's psychological presence. The second is participatory immersion, which relates to the user's interaction with the medium. The third is affective immersion, which relates to the emotions that arise in the user. The last is narrative emotions, which refers to how users are drawn into the storyline within the virtual world.

Current technological advances, especially in Virtual Reality (VR), have increasingly attracted the attention of language students, both tutors and students. Figueroa et al. (2015) have investigated the role of this technology in enhancing the quality of English language instruction and its impact on the language learning process. Furthermore, the virtual ability offered by the VR platform enables social interaction among students in a natural and meaningful way (Lan, 2020).

There has been considerable development in the use of VR in English language learning to improve learning quality. The development of Shabani & Alipoor (2017) and Tai (2022) found an increase in students' English motivation when using VR applications and virtual robots. In this development, it was stated that platform communication was the most attractive factor for students.

In developing the technology-assisted English learning process, many developers have pursued various approaches to using VR for students. Most of these developments involve testing existing, paid VR applications with students. In their development, Soto et al. (2020) tested the ImmerseMe application after using a questionnaire. The result showed that some students expressed interest in using the application and felt motivated to continue improving their English language skills.

Furthermore, Alemi & Khatoony (2020) developed a VR-based application to improve students' pronunciation in English. As a result of

his development, he suggested developing VR applications with more complex and varied linguistic features. Shabir (2022) tested YouTube VR on university students using low-end VR devices such as Cardboard VR or Google VR. The results showed increased interest in learning and understanding English material delivered through YouTube. However, in the trials he conducted, students remained passive, following only the visualization displayed by YouTube VR. In the same year, Revianti (2022) in her development, used the Mozilla Hub social WebVR platform to establish interaction between lecturers and students through remote classes using VR headsets. This development has yielded favorable responses from students and a new learning experience. However, some students later also complained of simulator sickness and audio and video interference. A development by Tai (2022) found an increase in students' English-learning motivation when using VR applications and virtual robots. The student stated that the communication interaction between English students on the platform was one of the most important factors that attracted students' interest. However, in the trial, the students remained passive and only followed the visualisation displayed by YouTube VR. Recently, research by Rahimi & Aghabarari (2024) found that immersive VR with 360-degree video enhances listening activities, particularly in monologue sessions. The participants' perceptions showed a decrease in anxiety during listening activities and an increase in motivation to practice English.

The literature review results indicate that numerous developments have integrated VR technology into English language learning, and many have also been developed by examining the effectiveness of online applications or platforms that students can access. These studies on the effects of VR on language learning have shown that it is more effective than traditional

methods. Among the advantages of VR identified in previous studies are the provision of authentic contexts and a sense of presence, thereby increasing student motivation and interest. However, most of the platforms used and tested in the previous articles are still from existing applications or commercial web-based VR applications. The results of these developments indicate that many aspects remain to be explored and customized to meet students' needs and English proficiency levels.

Therefore, the study is significant for developing VR-based applications tailored to the needs of students in the Computer Science Faculty. The lesson materials in the VR app have been adapted based on students' lessons and English levels. This study aims to answer the following research questions:

1. How does the use of a developed Virtual Reality (VR) application significantly improve the students' listening comprehension scores?
2. What are the students' perceptions regarding the practicality and learning experience of using the VR application for enhancing listening comprehension?

■ **METHOD**

Participants

The study gathered students majoring in Informatics Engineering in the 2023 academic year in the Computer Science Faculty, University of Putra Indonesia, YPTK Padang. The sampling technique used was purposive sampling (Sugiyono, 2011) by selecting Computer Science students because the VR application was specifically designed for material relevant to them, so the data on effectiveness and practicality were collected from the most appropriate target users. A total of 16 students were invited to participate in this study. However, because data collection was conducted during class hours, only 15 students completed the questionnaire.

Research Design and Procedures

This study used a one-group pre-test and post-test design, which is a quantitative research approach. This design was chosen because its purpose was to measure and test the effectiveness of the Virtual Reality application in improving students' listening scores. The study required students to attend three sessions per month. In the first session, the students were given an introduction and overview of how to use the application. In this session, students are allowed to use the VR for any purpose and become familiar with the app. In the second session, students took a pre-test using conventional audio settings with a laptop and speaker in the classroom. In the last session, students were asked to redo the listening activities and take a post-test using the application. The post-test phase introduced the immersive VR listening application. Participants used VR headsets to access 360-degree video content paired with spatial audio, thereby immersing them in simulated real-world scenarios. This setup allowed learners to visually explore the environment, observe speakers' nonverbal cues, and benefit from contextual information accompanying the auditory input. The structure and content of comprehension questions remained consistent with the pre-test to maintain comparability. The implementation of this research was supervised and assessed by a research monitoring team from the University's Institute for Research and Community (LPPM).

Instruments

The study used a listening comprehension test administered via the Virtual Reality application for pre-test and post-test. The tests were analyzed quantitatively using a t-test to assess the application's effectiveness. Moreover, the study used a questionnaire using a 1-5 Likert scale.

Data Analysis

A paired-samples t-test was conducted on students' listening comprehension scores before and after using the application, comparing the post-test and pre-test scores. The effectiveness test aims to measure the product or application's success in achieving the stated objectives. In this case, developing this application aims to enhance students' English skills, particularly in computer science, such as describing IT concepts and features and giving instructions. This effectiveness test compares pre- and post-use learning test results. The t-test is one of the statistical methods used to compare two groups of data (post-test and pre-test) and determine whether there is a significant difference between the two.

The practicality test in the application aims to measure the level of practicality and ease of

use of the application developed. This test ensures that the target students can use this application quickly and effectively. In addition to knowing the level of practicality of the application, this practicality test is also used to identify any potential technical problems, and also for input for improvement (on how this application can later be optimized to increase the benefits of the application, its ease of use, and practicality)

The aspects assessed in this practicality test include ease of use, clarity of instructions, clarity of video and sound display, accuracy of the scores, and user satisfaction. Practicality test data on the results of VR-based English learning applications were analysed using a questionnaire, and the validity percentage was calculated. After the percentage is obtained, grouping is done according to the criteria modified by Purwanto (2010), as in Table 1.

Table 1. The percentage of perception criteria

Interval	Criteria
90 % - 100%	Very Practical
90 % - 89 %	Practical
65 % - 79 %	Practical Enough
0 % - 64 %	Unpractical

VR Application

According to Khatoony (2019) Facilitating conversations with native speakers is one of the most critical components of building a VR app. By interacting with the natives in the virtual world, students can reduce their tension and nervousness in real situations. The application's video shoot was filmed at the University area, a café, a meeting room, and a heritage museum. A previous evaluation found that most of the development process for VR apps in language acquisition is conducted in computer labs (Reitz et al., 2019) and classrooms (Berti et al., 2020), as it is easier for developers to supervise the technology and oversee the development process. Other places

are cultural centres. (Chang et al., 2019) and in universities. (Lee & Park, 2020). The app was built using Unity, a game engine. The development process began by dividing the app into two channels: interactive and comprehensive exercises. Both channels have a series of questions and scores.

The diagram above shows the experience of using a VR app. The sequences of interactive experience are described as follows:

1. When starting the app, a five-second splash screen containing the campus logo and photos will appear.
2. After that, the Unity logo will appear, followed

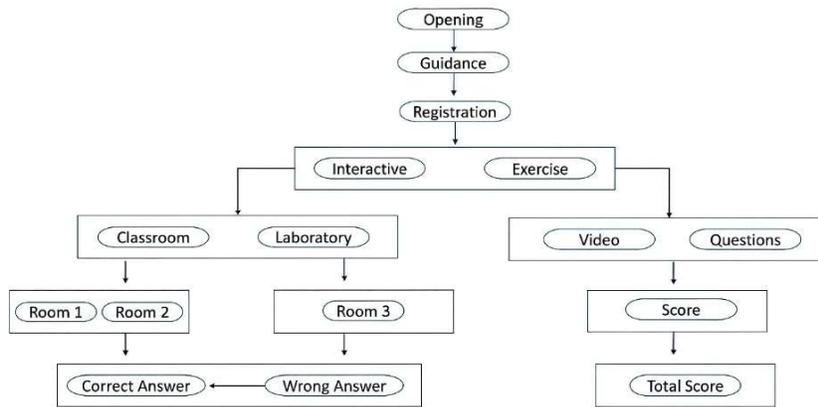


Figure 1. Interactive experiences by students

by a guide to using the app. The guidance is in text-to-speech format, and students can click to hear it.

3. Next, the students will have to register their names and student numbers.

4. The students will come to the Learning Topics (Figure 3). On this page, they can choose between the Listening or Interaction channels.

In the listening channel, students can watch 360-degree videos and rotate them to see the

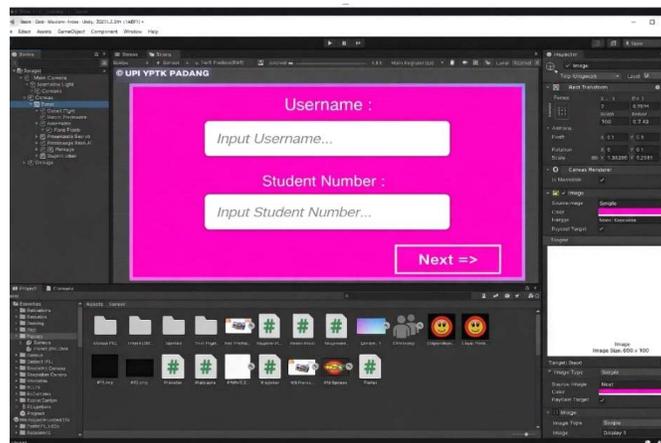


Figure 2. Registering students' names and numbers



Figure 3. Learning topics

entire conversation setting. In the first video, a native speaker speaks to six students for 30 minutes about their hobbies and future dreams. The video was cut into ten short scenes to show

questions and scores. In the interaction channels (Figure 5), the app will show a campus with two direction options: interaction in class (Figure 6) and interaction in the computer lab (Figure 7).



Figure 4. Dialogues with native speakers



Figure 5. Interaction channel



Figure 6. Interaction in the computer lab

In both interactions, students can converse with each other in the video and choose a female or male voice for the interactive activities. For each scene, the students are given questions and alternative correct and incorrect answers. The

following videos cover a range of topics familiar to university students, particularly those in computer science. The topics are using social media, describing IT devices, giving instructions, problem-solving, and job interviews.

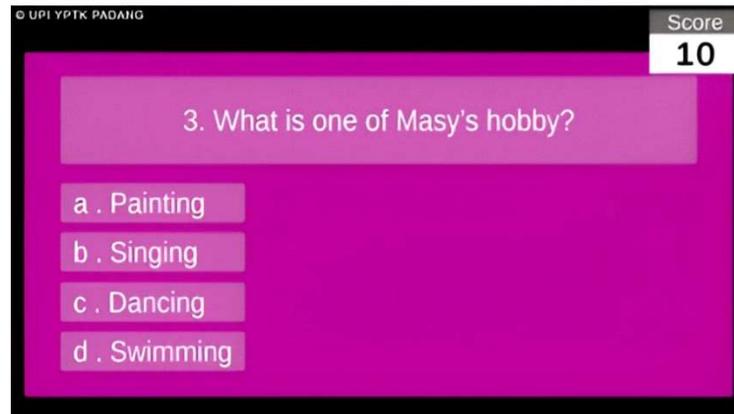


Figure 7. Question and score



Figure 8. Total score

In Figure 7, the question will be given in each short scene. Multiple-choice questions were given to assess students' comprehension after the native-speaker monologue. The score given will increase if the students answer the question correctly. The final score (Figure 8) is shown in the last exercise. The correct answers were discussed in the previous sessions after the students taken the post-test. For scoring, students can use the app in two sessions to listen to the monologues. Sun et al. (2020) argued that VR apps should provide students with opportunities

to receive feedback and create a safe learning environment, thereby lowering anxiety and increasing confidence. Therefore, comfort is an essential consideration when designing language-learning programs. Creating a safe and encouraging environment that reduces fear and promotes active engagement is essential to creating a thriving VR Language Learning environment (M. L. Liaw, 2019). After all, students can feel more comfortable practising and making mistakes in a virtual world and can ultimately deliver the best result.

■ RESULT AND DISCUSSION

The Analysis of the T-Test

To test the application, the development team gathered 16 students majoring in Informatics Engineering in the 2023 academic year to conduct a pre-test using conventional listening comprehension techniques with audio from a laptop and a classroom speaker, and a post-test using VR listening. The score for the listening test with conventional techniques was obtained by

answering a series of questions in Google Forms, and the listening post-test with the application was completed by sharing a screenshot of the results. The theoretical hypothesis was that using virtual reality applications would improve students' listening comprehension scores compared to not using them. Table 2 presents the paired-samples test, and Table 3 presents the paired-samples effect size for the pre-test and post-test.

Table 2. Paired samples test

			Paired Differences			95% Confidence Interval of the Difference		Significance			
			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Test	Post Test	-29.37500	21.36001	5.34000	-40.75695	-17.99305	-5.501	15	<.001	<.001

Table 3. Paired samples effect size

				95% Confidence Interval			
				Standardizer ^a	Point Estimate	Lower	Upper
Pair 1	Pre Test	Post Test	Cohen's d	21.36001	-1.375	-2.055	-.672
Hedges correction				22.50773	-1.305	-1.950	-.638

a. The denominator used in estimating the effect sizes

Cohen's uses the sample standard deviation on the mean difference.

Hedge's correction uses the sample standard deviation of the mean difference plus a correction factor.

The results of the paired-samples t-test in Table 2 show a clear and significant improvement in students' listening comprehension after using the immersive VR application. The mean difference between the pre-test and post-test scores was -29.38, indicating that students scored about 29 points higher on the post-test. This improvement was statistically significant, as shown by the t-value of -5.501 and a p-value of < .001, indicating that the possibility of these differences occurring by chance is very small.

In Table 3, the 95% confidence interval (-40.76 to -17.99) also confirms that the true improvement is consistently positive. In addition

to statistical significance, the effect size was large. The Cohen's d of 1.375 suggests that the VR intervention had a strong and meaningful impact on students' listening comprehension performance. Hedges' g (1.305), which adjusts for the small sample size, also supports this conclusion. Overall, the findings indicate that the immersive VR activity produced a substantial and reliable increase in students' listening comprehension scores. In other words, based on the results of the Paired Sample t-test, the statistical data on participants' pre-test and post-test scores show that most students achieve higher scores after a listening comprehension test using

a Virtual Reality application than after an audio-only listening test. Although the study did not include a comparison group, the findings nonetheless suggest strong potential for the intervention to enhance students' abilities. The

consistent improvement observed across the measures indicates that the intervention may offer meaningful benefits and warrant further investigation through a more rigorous research design.

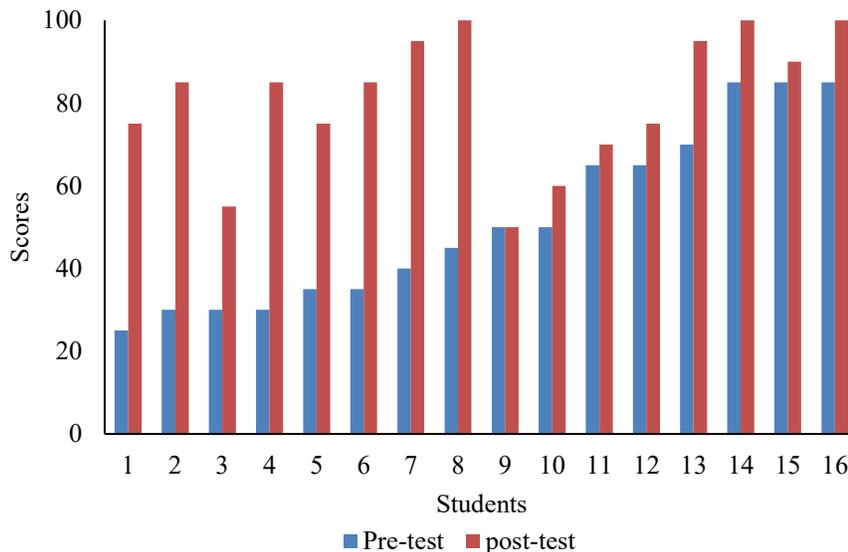


Figure 9. Comparison of pretest-posttest score

Based on the scatter plot and the provided table data, the Post-test scores (red dots) are generally higher than the Pre-test scores (blue dots) for most of the 16 students. Molina et al. (2023) stated that the scatter plot is used to visually represent the relationship between the students' prior knowledge and their final performance after the intervention. The pre-test scores ranged from 25 to 85, with an average in the mid-50s, whereas the post-test scores ranged from 50 to 100, indicating a clear upward shift in performance after the intervention. The visual plot, in which the red dots are overwhelmingly positioned above their corresponding blue dots, suggests that using the immersive VR application was effective in improving students' listening comprehension scores.

Practicality Analysis Test

In addition to observing the benefits of using the application in terms of increased students'

listening scores, this research also examined students' perceptions after using it. Of the 16 students majoring in Informatics Engineering at the University of Putra Indonesia, YPTK Padang registered to participate in the application trial, 15 have completed the questionnaire. The perception assessment questionnaire was distributed using Google Forms. The questionnaire consists of 20 multiple-choice questions with four answer options (strongly agree, agree, disagree, very disagree). The questions are listed according to the VR learning approaches by Jackson & Jackson (2024), which divided VR into four categories: representational, participatory, affective, and narrative. The 20 statements are stated as follows:

Students responded to the 20-item questionnaire via Google Forms using a 4-point Likert scale (1 = strongly disagree; 4 = strongly agree). The instrument demonstrated good internal consistency (Cronbach's $\alpha = 0.71$) and

Table 4. Students’ response toward immersive VR apps usage in EFL learning

Dimension	Item	%
1. Representational	1. The video display can be rotated 360 degrees.	95.00
	2. The instructions for using the media are clear and easy to follow.	93.30
	3. The application has a good appearance and a video display.	90.00
	4. The application uses an attractive color composition.	83.30
	5. The application uses a good layout and division of space	85.00
2. Participatory	6. The sound in the application can be heard clearly.	78.30
	7. The writing in the application can be read well.	86.70
	8. The navigation and direction pane in this application is good enough.	88.30
	9. The application can score accurately.	95.00
	10. The application is responsive enough when used.	98.30
3. Affective	11. This is my first time using an application like this (Listening Comprehension based on Virtual Reality Application).	96.70
	12. This application is exciting to use.	96.70
	13. I enjoy learning English using this application.	100.00
	14. This application can make me practice my English more actively.	90.00
	15. My listening skills will be improved if I use this application very often.	91.70
4. Narrative	16. This application familiarizes me with many new phrases, expressions, and idioms in diverse situations.	91.70
	17. This application provides a relaxed and comfortable learning atmosphere.	93.30
	18. Using this application will improve my pronunciation.	96.70
	19. Using this application frequently will improve my understanding of English in natural conversation.	91.70
	20. This application can increase my motivation and interest in speaking English.	90.00

average score of students perception is 91.5. This results indicated that immersive VR apps is very practical to use in EFL learning. Percentage of students’ response are detailed in Table 4.

Table 4 showed that the highest percentage is 100% for statement 13, indicating that all students enjoy using VR applications to learn English. Meanwhile, the lowest value is in statement six, at 78%. This statement shows that 22% of students still stated that the sound in this application cannot be heard clearly. This score

implied that the developer and researchers need to check the compatibility of the VR devices for each student and ensure that the audio works properly for every user when the application is fully developed.

The first statement on the perception questionnaire is that the video can be rotated 360 degrees. This statement shows whether students understand how to use the application and can use the features smoothly without any obstacles. From the result, it can be seen that 95% of

students agree with this statement. This means that the application can run properly. The second statement is that the instructions for using the media are clear and easy to follow. Some of the instructions in the application include using the application, using buttons, and directional instructions, such as choosing between 'listening activities' and 'interaction experience'. This statement obtained a percentage value of 93%, which means that all navigation buttons work and can be understood by the students. Third, this application has good-quality videos. In general,

the video quality has been rated as 90%. The fourth statement is that the application has a video display with a clear, decent appearance. This application uses an attractive color composition. The colours used are blue, pink, yellow, black, and white. The use of the colour obtained an 83% score. The fifth statement noted that the application features a good layout and effective spatial division. The application uses layout and spatial divisions to provide registration room, session divisions, scoring, etc. About 85% of students like the application's layout.

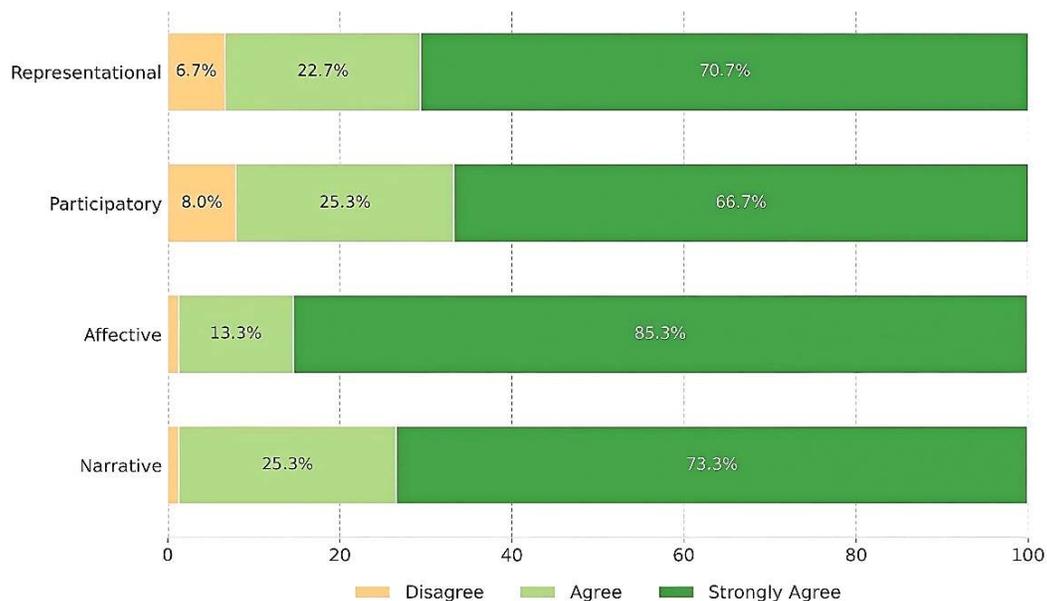


Figure 10. Distribution of students' responses to VR app usage in EFL learning

Sixth, the voice in this app is clearly audible. The voice in the application was recorded in an open room and partly in a closed room. The sound was recorded with a Saramonic microphone and a mobile phone recording app. The noise in the sound has also been minimized using the Unity application. However, 22% of students stated they could not hear the speech clearly. This is because some students were not using the headset/headphones during the application trial. After all, the team needs to develop the application, as it is primarily used to improve listening skills. Seventh, the statement that the text

in this app can be read well obtained a percentage of 87%. Next, the navigation and directions in this app are well understood, with a 88% score. The app is also considered capable of accurately scoring students' work. Each correct answer in the listening activities will be marked with 5 points, so the maximum score the students can get is 100. This ninth statement gains 95%. About 98% of students agree that the app was responsive enough to be used.

The following statements relate to the student's personal experiences. In the eleventh statement, 97% of students stated that using a

VR-based listening comprehension app was a new experience. Previously, some had used VR-based apps only for playing games, not for educational purposes. In statement 12, 97% of students stated that this app was exciting. In particular, they enjoyed listening and learning English using the app. This aligns with the findings by Amna et al. (2024) that the customized VR app can increase students' motivation to study English. The 13th statement obtained the peak score of 100%. The app could serve as a new learning medium for students to enhance their English skills, particularly in listening comprehension. Statement 14 Approximately 90% of students reported that the app could encourage them to practice English actively and independently. Fifteenth, 92% of students believed that their listening comprehension skills would improve significantly if they used the app more often. The students stated that the app would familiarize them with common new phrases, expressions, and idioms in diverse linguistic contexts. Next, for statement 17, about 93% of students stated that the app provides a relaxed and comfortable learning environment. This was because no timer was set, so students did not need to rush and could learn at their own pace and ability. Statement 18: 97% of students agreed that the app will improve their pronunciation skills, and if they practice frequently with this app, their understanding of English in natural conversation will be significantly improved (92%), ultimately increasing their motivation and interest in learning English (90%).

Overall, the survey results show that the VR application is considered very practical, with an average rating of 91.5%. This score represents a high level of acceptance and usefulness among users. The most significant point is the success of VRALL (VR-assisted Language Learning) in the listening activity, as indicated by the highest score for the statement that VR creates a motivated, comfortable, and anxiety-free environment. However, the researcher and developer need to

ensure that the devices are ready and do not interfere with the functional validity of the listening comprehension tasks.

■ CONCLUSION

In designing a Virtual Reality app to enhance students' listening comprehension skills, the study incorporated topics related to students' field of study. The findings strongly support the claim that the VR application improves students' listening comprehension skills, as confirmed by statistically significant differences between pre-test and post-test scores. Although this study employed a one-group pre-test/post-test design without a comparison group, the consistent improvement in students' scores indicates a notable potential for the intervention to enhance students' abilities. Moreover, the findings are particularly important for language learning, as they show that a VR environment can create experiences that are rated as highly practical and have a profound affective impact, namely the ability to increase students' motivation while effectively reducing anxiety. This underscores the importance of VR as a pedagogical tool that overcomes psychological barriers and validates the principles of multimedia cognitive theory by integrating contextual audio-visual input. This integration can help share the learning design towards a technology-based solution-centred approach.

The substantial impact of this study on education is the empirical validation of the effectiveness of VR technology in listening activity for foreign language study. However, the limitations of the study are apparent, given the use of a small sample and a single-group quasi-experimental design without a control group to isolate the intervention's effects.

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