Razi University

Technology Assisted Language Education

ISSN: 2981-1465

Homepage: https://tale.razi.ac.ir

Developing a New Augmented Reality Mobile Application to Improve School-Age EFL Learners' Vocabulary Acquisition

Shiva Khatoony[1], Behdokht Mall-Amiri[2]*, Sholeh Kolahi[3]

[1]Department of English Education, CT.C., Islamic Azad University, Tehran, Iran. shivakhatoony@yahoo.com

[2]Corresponding Author, Department of English Education, CT.C., Islamic Azad University, Tehran, Iran. bmallamiri@gmail.com

[3]Department of English Education, CT.C., Islamic Azad University, Tehran, Iran. sholeh.kolahi@gmail.com

Article Info

Article type:
Research Article

Article history:
Received February 21, 2025
Received in revised form June 10, 2025
Accepted June 22, 2025
Published online June 30, 2025

Keywords:
Augmented reality, English vocabulary acquisition, School-age EFL learners, Mixed-Methods Research

Abstract

An innovative method for improving English language learners' linguistic skills is augmented reality. This study investigated the impact of a newly developed augmented reality-assisted language learning (ARAL) smartphone application on learning English vocabulary using the phonics technique. Thirty-six first-time language learners, ages 6 to 8, participated in the study. They were randomly divided into two groups of 18: the control group, which received traditional instruction using flashcards and repetition, and the experimental group, which used the ARAL application. Results from an independent sample t-test comparing pre- and post-test scores indicated a significant difference between the two groups ($t(24.32) = 8.83$, $p < 0.001$). The experimental group showed a mean gain score of 2.72 ($SD = 0.97$), significantly higher than the control group's mean gain score of 0.47 ($SD = 0.46$). These findings provide robust statistical evidence that the ARAL application significantly outperformed traditional methods in vocabulary acquisition. Additionally, structured interviews revealed that the experimental group had a favorable attitude toward using augmented reality in their language learning. This study offers valuable insights for EFL teachers and researchers interested in integrating augmented reality into language education.

Cite this article: Khatoony, S., Mall-Amiri, B., & Kolahi, S. (2025). Developing a New Augmented Reality Mobile Application to Improve School-Age EFL Learners' Vocabulary Acquisition. *Technology Assisted Language Education*, *3*(2), 120-143. doi: 10.22126/tale.2025.11840.1097.

Publisher: Razi University.

DOI: http//doi.org/10.22126/tale.2025.11840.1097.

Introduction

Technology integration is becoming essential in education, particularly when it comes to teaching and learning languages (Eren, 2020). Rapid advancements in technological capabilities have revolutionized language education, providing innovative approaches that enhance the educational experience for learners, especially school-age students. These advancements improve accessibility, portability, and availability, significantly boosting educational outcomes among language learners (Shadiev & Yang, 2020). Teachers and learners can update their understanding of technology use in language contexts to enhance proficiency, including vocabulary acquisition, while fostering a creative learning space (Fathi & Ebadi, 2020; Kljun et al., 2020). Additionally, material developers, such as program designers and curriculum developers, can engage learners by utilizing available technological resources (Ghahfarokhi & Tavakoli, 2020). Technologies like Augmented Reality (AR) have gained prominence in recent years, particularly through Augmented Reality Assisted Language Learning (ARAL), which enhances vocabulary development for school-age EFL learners. ARAL leverages creative applications, virtual environments, pictures, and dynamic models to support vocabulary learning (Greene & Jones, 2020; Lin & Wang, 2022). By integrating AR technology, ARAL applications offer innovative ways to develop language abilities, focusing on vocabulary acquisition.

The introduction of AR technology into language education promises to address existing challenges and create a more immersive and engaging learning environment for students (Eren, 2020). This focus on school-age learners is crucial as it represents a pivotal stage in language development. Many language learners struggle with vocabulary retention and applying knowledge in real-world contexts (Greene & Jones, 2020). For instance, an AR-based vocabulary app could allow students to point their mobile devices at everyday objects, displaying corresponding words in the target language along with interactive exercises to reinforce learning (Shadiev & Yang, 2020). Recent studies demonstrate that AR can enhance learners' abilities to acquire vocabulary by providing comprehensive 3D multimedia concepts that enrich the learning environment (Khatoony & Altinpulluk, 2021; Legault et al., 2019; Shadiev & Yang, 2020). Research suggests that AR can impact language learners' performance, particularly in vocabulary learning, by facilitating greater noticeability and easier retrieval of vocabulary items. For example, Hsu (2017) found that AR-based activities improved vocabulary learning compared to traditional teaching techniques, attributed to AR's interactive and multimedia-rich nature. Similarly, Dünser and Hornecker (2007) showed that AR enhanced spatial visualization abilities, closely linked to vocabulary development. Chen and Wang (2021) demonstrated that AR flashcards improved vocabulary acquisition and retention, boosting learner motivation in elementary English classes. These studies highlight a common theme: AR enhances language learning by integrating 3D multimedia concepts into real environments, enriching the educational experience (Legault et al., 2019).

Given the significance of ARAL in vocabulary acquisition, examining its effectiveness for school-age learners is crucial for curriculum designers, language educators, and policymakers seeking to optimize technology integration in classrooms (Fathi & Ebadi, 2020). Despite the interest in ARAL, research gaps remain, particularly regarding its specific effectiveness as an application (made by the researchers) for vocabulary acquisition in non-native contexts like Iran. Iranian learners often face economic challenges limiting their access to English as a Second Language (ESL) resources and technological devices. Investigating ARAL's effectiveness can inform the development of engaging language programs in Iran, ultimately leading to improved proficiency and better academic outcomes. Furthermore, although numerous studies have examined the overall advantages of AR in language learning, there is a lack of research focused on the use of mobile AR applications for vocabulary instruction among school-age learners in EFL settings. The researchers believe that using AR for school-age learners in non-native contexts like Iran is a promising area for exploration. By improving language learning methods through AR and integrating native-like characteristics into everyday life using mobile phones, ARAL can offer important insights into the advantages and drawbacks of this technology in EFL contexts. This understanding can assist educators in choosing effective technology-based teaching strategies for their students and aid curriculum designers in developing engaging, interactive materials that address various learning needs (Pan & Gan, 2020).

Additionally, while most studies on AR have been quantitative (Greene & Jones, 2020; Shadiev & Yang, 2020), this study adopts a mixed-methods design, enriching the literature. It aims to investigate the influence of ARAL, a researcher-made AR application, on vocabulary acquisition among Iranian school-age EFL learners. By integrating quantitative and qualitative data, the study will provide a multifaceted analysis of ARAL's effects on vocabulary learning. The quantitative component will measure vocabulary gains, while the qualitative aspect will explore students' perceptions, attitudes, and experiences with the AR-based tool. This integration can yield a richer understanding of the phenomenon, contributing significantly to the field of technology-enhanced language learning.

In sum, the purpose of this study is to examine how ARAL affects Iranian school-age EFL learners' vocabulary development. Its objective is to enhance language instruction and learning in non-native EFL contexts, including Iran and other developing countries. The research aims to contribute to the existing knowledge of technology-enhanced language education by offering a thorough examination of ARAL's impact on vocabulary learning through the use of a mixed-methods methodology. To do this, the study's researchers posed the following research questions:

- Does newly developed AR application significantly affect school-age EFL learners' vocabulary acquisition through alphabet 3D representation?

- What feelings and perceptions did school-age EFL learners have about using newly developed AR application as a mobile application for vocabulary acquisition after using it?

Therefore, here are potential purposes for the study based on the given research questions:

- To investigate the impact of newly developed ARAL application on school-age EFL learners' vocabulary acquisition through the use of 3D alphabet representation.
- To explore the feelings and perceptions of school-age EFL learners towards using the ARAL mobile application as a tool for vocabulary learning.

Simply put, the study sought to ascertain how the ARAL approach—which makes use of 3D alphabet representations—affected school-age EFL learners' vocabulary development. It also aimed to comprehend the emotive elements of vocabulary acquisition with the ARAL mobile app, including the viewpoints and general experience of learners.

Literature review

The literature review in this area of the study is based on empirical research on AR and vocabulary learning as well as a theoretical framework.

Theoretical Frameworks Behind ARAL

Due to its potential to improve vocabulary acquisition and retention among school-age language learners, AR technology has garnered a lot of interest in the language learning community lately which is known as ARAL. Several well-established ideas and concepts of instructional design, cognitive psychology, and language acquisition form the theoretical foundation for ARAL's efficacy.

The Cognitive Load Theory (CLT) is a fundamental framework for ARAL, suggesting that by integrating interactive 3D visuals and multimedia into the real-world learning environment, ARAL can lower unnecessary cognitive load and improve vocabulary learning (Yilmaz et al., 2022; Dünser & Hornecker, 2007; Legault et al., 2019). The Dual Coding Theory (DCT) further supports ARAL's usefulness, as it allows learners to form both verbal and visual mental representations of words, enhancing recall and retention (Yilmaz et al., 2022; Chen & Wang, 2021; Hsu, 2017).

Additionally, the Situated Learning Theory (SLT) emphasizes the significance of learning in real-world, contextualized settings, which ARAL can complement by providing an engaging, dynamic, and realistic environment for vocabulary acquisition (Eren, 2020; Ji & Shin, 2019; Shadiev & Yang, 2020). The Lexical Approach to Language Teaching highlights the importance of teaching vocabulary in meaningful chunks and collocations, which ARAL can support by offering thorough, contextual representations of lexical patterns (Lee et al., 2019; Khatoony & Altinpulluk, 2021; Kljun et al., 2020).

Thus, the well-established theories of cognition, learning, and language acquisition form the theoretical foundation for ARAL's beneficial effects on school-age language learners' vocabulary development (Khatoony, 2019). By reducing cognitive load, enhancing dual coding, contextualizing learning in real-world settings, and facilitating the teaching of vocabulary in meaningful lexical chunks, AR technology has promise for enhancing language acquisition (Kljun et al., 2020).

Vocabulary Learning through Multi-media like AR

For meaningful communication in both written and spoken forms, vocabulary is regarded as a basic component of language (Min, 2008; Naderiheshi, 2022). Vocabulary acquisition is crucial for English as EFL learners, teachers, and material creators because language learners find it difficult to properly communicate their intended meanings when they lack sufficient vocabulary. Various language learning materials, from textbooks to mobile applications, incorporate vocabulary items to enhance learning.

Vocabulary can be acquired through three primary methods: incidental, implicit, and explicit learning. Incidental vocabulary learning occurs through exposure to language without the intention to learn, leading to gradual, subconscious acquisition (Yilmaz et al., 2022). Implicit vocabulary learning involves repeated exposure and associations, often without explicit awareness of the learning process (Khezrlou et al., 2017). In contrast, explicit vocabulary learning focuses on intentional study and memorization of words, employing strategies like flashcards and mnemonics, which are deemed effective (Tnomat et al., 2022).

To support effective teaching, researchers have proposed various strategies for mastering English vocabulary, including memorization and repetition (Alemi & Khatoony, 2020; Hanafi et al., 2020; Tnomat et al., 2022). Recent studies emphasize cognitive, metacognitive, and consciousness-raising strategies, such as highlighting and noticing, to facilitate vocabulary acquisition (Ibrahim & Alshami, 2022; Tayyebi, 2021). Additionally, supplementary materials and technologies, including flashcards, photo dictionaries, and multimedia tools, enhance vocabulary learning (Alahmadi et al., 2018; Nejati et al., 2018).

The rise of technology-assisted language learning (TALL) has transformed vocabulary instruction. Technologies like computers, mobile phones, and AR have improved the efficiency of vocabulary acquisition by integrating various media, such as images and audio (Alemi & Khatoony, 2020; Khatoony & Altinpulluk, 2021). Studies indicate that computer games, language software, and mobile applications significantly support vocabulary learning among EFL learners (Lee et al., 2019; Nejati et al., 2018).

AR technology, which combines the actual and virtual worlds in real time, is a particularly promising tool for language acquisition. AR adds virtual components, such as 3D words and images, to the actual world, in contrast to Virtual Reality (VR), which builds completely virtual settings. This skill provides contextualized learning experiences, increases motivation, and captures students' attention. Applications of AR have been shown to improve input and output,

motivate users, and accommodate different learning styles (Shadiev & Yang, 2020; Khatoony & Altinpulluk, 2021).

Educational technology encompasses tools and methods that enhance learning experiences, with scholars noting its effectiveness in language classrooms (Altinpulluk & Yildirim, 2023; Ibrahim et al., 2018; Pujola & Appel, 2020). Technology can provide meaningful input, facilitate classroom interaction, enhance feedback, and improve motivation, ultimately fostering a more enjoyable learning environment (Parmaxi & Demetriou, 2020; Zhang et al., 2020).

Teachers and students looking to enhance their language proficiency are increasingly using VR and AR into language instruction (Alemi & Khatoony, 2020; Khatoony & Altinpulluk, 2021). Both technologies offer unique features, such as portability, accessibility, availability, and feasibility, making them valuable tools in language teaching (Kljun et al., 2020). VR can create immersive environments for learners, while AR allows the use of mobile devices to enrich real-world contexts (Hanafi et al., 2020). AR is becoming more popular in education, especially for language acquisition, according to recent trends. According to studies, AR can improve students' attitudes and help with a number of language learning tasks (Ibrahim & Alshami, 2022; Lee, 2022). ARAL (Augmented Reality-Assisted Language Learning) is an important developing technique in education that bridges actual and virtual experiences thanks to the combination of developments in computer and mobile technology (Alemi & Khatoony, 2020; Kljun et al., 2020).

The accessibility of AR on portable devices like smartphones enables learners and teachers to utilize it for educational objectives. Students can engage in real-world activities enriched with additional visual information, enhancing their learning experience (Altinpulluk, 2019). AR's ability to overlay data onto three-dimensional spaces increases information accessibility, benefiting both learners and instructors (Altinpulluk et al., 2020). ARAL can be effectively employed in diverse contexts, providing safe access to information for learners and teachers alike (Hanafi et al., 2020; Luck et al., 2021; Tomlinson et al., 2020).

In summary, vocabulary acquisition is a critical area of focus in language education, supported by various learning strategies and technological advancements. The integration of AR and multimedia tools into language instruction offers innovative approaches to enhance vocabulary learning, engaging learners in dynamic and interactive ways.

Method

Information on methods is provided in this section of the study:

Design

This study is designed as an exploratory investigation, aiming to provide initial insights into the impact of ARAL on vocabulary acquisition among school-age EFL learners. The exploratory nature of the research acknowledges the small sample size and emphasizes its value for laying the groundwork for further, more extensive studies in this area. By adopting a mixed-methods

approach, the study combines both quantitative and qualitative data to explore the effectiveness of ARAL-based mobile applications in enhancing vocabulary learning. Despite the limitations of the sample size, the study serves as a crucial first step toward identifying trends, developing hypotheses, and guiding future research in this emerging field. In order to give comprehensible points of view, Figure 1 outlines the study's objectives in accordance with the research design. As shown in Figure 1, the researchers used a mixed-methods strategy to examine the effects of ARAL-based mobile applications on the vocabulary acquisition of Iranian school-age EFL learners.

Mixed-Methods Study	
Quantitative Phase (Purpose: Investigating the Impact of ARAL on Vocabulary Acquistion or Vocabulary Gaining) * First Research Question	Pre-test, Treatment (ARAL), Post-test
	Instrument: Teacher-made Test
	Data Analysis: T-test (Gain Score)
Qualitative Phase (Purpose: Investigating the Participants' Feelings about Using ARAL in Language Lessons) * Second Research Question	Design: Descriptive Analysis
	Instrument: Interview
	Data Analysis: Response Analysis (Finding Similarities and Differences)

Figure 1. Current Study's Purposes and Design Scheme

More particularly, this study started with a quantitative phase (see Table 1), which investigated the vocabulary gains of school-age learners to measure the improvement and efficiency of the researcher-made ARAL application.

Table 1

Quantitative phase design based on Ary et al (2018)

Groups	Pre-test	Treatment	Post -test
Experimental(R)	T1	ARAL	T2
Control (R)	T2	Traditional Activities (PLACEBO)	T2

Note: R= Randomized group, T1= Test 1, T2= Test 2

Using SPSS software, the research employed independent samples t-tests on pre- and post-test scores from the experimental (ARAL) and control groups for quantitative analysis. By deducting post-test scores from pre-test scores, this research calculated gain scores, which represent increases in participants' performance (Plonsky & Ghanbar, 2018). Structured interviews were also used in a qualitative phase to find out how students felt about the ARAL

application. Using the IPR approach, the researchers ensured the validity of the interview questions by classifying replies to find similarities and discrepancies. To enhance the data representation, direct quotes from school-age, beginning students were used (Ary et al., 2018).

In the qualitative phase of this mixed-methods study, the aim is to explore the participants' feelings and perceptions about using ARAL in language lessons. The second research question seeks to understand how the participants experience and engage with ARAL as a tool for vocabulary learning. To collect data, structured interviews are conducted, providing participants with the opportunity to express their thoughts on the ARAL application, its usability, and its impact on their learning process. The interviews are designed to gather detailed, descriptive feedback from the participants. For data analysis, response analysis is employed, where the researchers categorize and code the responses to identify key themes, similarities, and differences across the participants' experiences. By analyzing these responses, the researchers can uncover valuable insights into the emotional and cognitive impact of ARAL on young learners, complementing the quantitative findings from the pre- and post-test results. This qualitative phase provides a comprehensive view of the students' attitudes, offering a richer perspective on how ARAL affects not only vocabulary acquisition but also learner motivation and engagement.

Participants

The study involved 36 beginner-level English language students in Iran, aged 6-8 years, selected through convenience sampling. They had no prior language learning experience and were randomly assigned to an experimental group (n=18) and a control group (n=18), maintaining equal gender distribution. Both groups used the same textbook, but only the experimental group received the ARAL intervention, designed to teach the English alphabet through AR. This age group was chosen because the ARAL app targets school-age students with limited English knowledge. The app provided an engaging, interactive way to learn foundational elements of English, enhancing the learning experience beyond traditional methods.

Table 2

Necessary information of participants

	Nationality	Gender	Age Range
Participants	Persian/Iranian	Female (18) Male (18)	6-8 years old
Total Number		**36**	

It should be mentioned that, the ethical approval for this study was obtained by distributing a physical consent letter to the parents of the participating children before the study commenced. The letter clearly outlined the importance of the research, its potential impact on language learning, and the benefits of using AR in enhancing early English language

acquisition. In addition, the researchers assured the parents that the ARAL application was safe for their children, with no risk of harm. Parents were required to sign the consent letter, thereby confirming their informed consent. The signed letters were securely stored, and the identities of the participants were kept anonymous to protect their privacy.

Instruments

The instruments of the study are described below:

ARAL Application.

The study utilized a mobile-based application called ARAL, which was designed using AR technology and the Unity Software Pro Version 2019.3.2 platform by the researchers of the study. The ARAL application was developed by the researchers to teach English vocabulary to beginner learners in IOS and Android version. The key features of the ARAL application include (See Figure 2, 3, and 4):

Vocabulary Games Based on English Alphabets: The ARAL application incorporates simulated vocabulary games that are based on the alphabets of the English language. This approach is tailored for beginner learners and is grounded in the phonics method, where students first learn the whole word and then associate each letter with its corresponding sound.

3D Object Interaction: The vocabulary pieces are represented by realistic and significant 3D objects created by the ARAL program using augmented reality technology. Through image tracking techniques, learners may interact with these 3D objects, giving them a physical and immersive way to explore, alter, and interact with the language.

Multimodal Learning: The ARAL games introduce vocabulary items through a combination of visual (3D objects), auditory (word sounds), and kinaesthetic (object manipulation) modalities. The goal of this multimodal method is to improve students' vocabulary word recall and understanding.

Flexible and Engaging Gameplay: Learners can instantiate multiple 3D objects, name each selected object, and drag-and-drop them into the real-world context. This interactive gameplay is intended to create a safe and secure environment for learners to explore and practice the vocabulary.

Systematic Game Design: Based on a thorough analysis of the literature, the researchers meticulously planned and created the scenarios for each of the 26 game episodes—one for each letter of the alphabet.

The CALL, MALL, and VRALL ideas were used into the design of the ARAL application (Alemi & Khatoony, 2020). VRAL investigates the possibilities of virtual reality for immersive language learning settings, MALL concentrates on mobile devices, and CALL refers to the use of computers and digital technology to facilitate language learning. The researchers were able to take use of best practices and provide a more thorough and successful learning experience

by establishing the ARAL app in these associated domains of technology-assisted language learning (Alemi & Khatooni, 2021). Additionally, the ARAL app's use of 3D alphabet items introduced an immersive and interactive aspect that lets students securely view, track, and manipulate the objects against a real-world backdrop. This approach was designed to enhance the learners' comprehension and retention of the vocabulary words (Khatoony, 2019).

In the study, the experimental group underwent the ARAL-based language learning treatment for four weeks, with each session lasting 60 minutes. Participants used the instructor's pre-installed ARAL application on mobile devices, enabling them to engage in augmented reality vocabulary games in a controlled and supervised environment. This choice standardized hardware and software configurations while allowing for instructor support. The setup facilitated close monitoring of learners' engagement and interactions, helping researchers collect data on the effectiveness of the ARAL approach. By utilizing mobile devices, the study leveraged the accessibility of technology to create a personalized and interactive language learning experience.

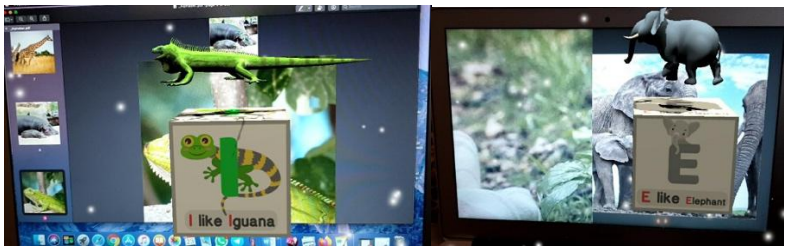

Figure 2. 3D Augmented Reality Objects by Focusing on Vocabulary through Alphabet

Figure 3. Representation of Vocabulary Items through Alphabet in AR Environment

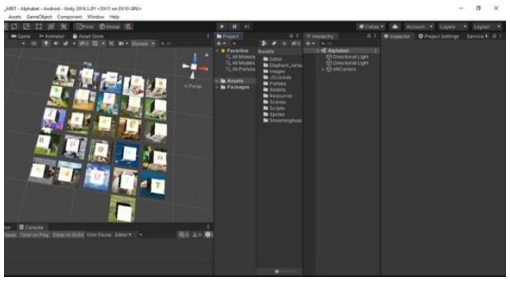

Figure 4. ARAL in Unity Software Program (Designing Phase)

In sum, the ARAL application stands out due to its innovative design and its potential to revolutionize language learning, especially in resource-limited settings. By leveraging AR and 3D object interaction, the app creates an immersive, interactive learning experience where students engage with realistic vocabulary objects that can be manipulated in real-world contexts. This multimodal approach—integrating visual, auditory, and kinesthetic elements—supports various learning styles and enhances vocabulary retention. One of the unique features of ARAL is its use of the phonics method in vocabulary games based on the English alphabet, which helps beginner learners build a strong foundation by associating words with their corresponding sounds and letters. Moreover, the app is designed for mobile devices—both iOS and Android—making it widely accessible, even in environments with limited technological resources. This mobile-first design ensures that the application can be used on commonly available smartphones, democratizing access to high-quality language learning tools. The ARAL app's ability to offer a rich, interactive learning experience through mobile technology makes it an ideal solution for enhancing language education in low-resource settings, where traditional educational tools and infrastructure may be lacking.

Teacher-Made English Test

The study measured the EFL learners' vocabulary knowledge before (pre-test) and after (post-test) the therapy using a teacher-made vocabulary exam. This test was fully picturized, which means that it evaluated the students' vocabulary development using visual aids like pictures and illustrations. To ensure that it correctly tested the target vocabulary, the exam was created with the words and material presented in the therapy in mind. There were thirty items on the vocabulary test, and students had to respond to them verbally. Cronbach's Alpha, a statistical indicator of internal consistency, was used to determine the test's reliability. A high degree of dependability was shown by the reported Cronbach's alpha value of.872 (Nunnally & Benstein, 1994). A 30-item vocabulary test with strong internal consistency (Cronbach's α =.872) was utilized in the research. To guarantee authenticity, the content was examined and verified by professional EFL teachers, and the test words were chosen from resources intended for beginning students.

Table 3

Cronbach alpha’s statistic result for vocabulary test

Measure	Number of Items	Cronbach's Alpha
Vocabulary Test	30	.872

The Structured Interview

The researchers conducted structured interviews to explore the effectiveness of the ARAL application, focusing on learners' perceptions and experiences with AR-based learning.

Participants were from the experimental group who used the ARAL app, with interviews lasting approximately 10 minutes each. The interview consisted of five questions derived from an online survey about AR platforms (https://pt.surveymonkey.com/r/ar-ch-en). The interview was prepared using the four-phase Interview Protocol Refinement (IPR) methodology (Castillo-Montoya, 2016). In the first phase, questions were aligned with the study's qualitative purpose. The second phase involved organizing an inquiry-based conversation between two experts to clarify the interview. In the third phase, sample participants provided feedback on the clarity of the questions, with interviews conducted in Persian and later translated into English for analysis. Finally, the fourth phase piloted the interview, resulting in a finalized set of questions regarding ARAL's efficiency in EFL classrooms. The finalized interview about the ARAL efficiency in EFL classrooms consisted of five general questions:

1. Could ARAL increase your interest in learning new vocabulary through alphabet? (Yes/or No, Briefly explain how do you feel after using ARAL?)
2. Can you play and use ARAL application easily? (Yes/or No, Explain your feelings, after using ARAL)
3. Can ARAL provide an opportunity to learn alphabet-based vocabulary items better?
4. What are the positive and negative points of using ARAL in language classrooms?
5. Do you like to use ARAL in your next English class? (Yes/No)

Data collection procedure

Using the Unity Software Pro edition, the researchers initially created an AR-based mobile application in order to carry out the data gathering processes for this study. This program was made to work with basic cellphones, including those running iOS and Android. Based on the English alphabet, the researchers developed simulated vocabulary games aimed at beginning students using the Phonics Books. Through image tracking techniques, the researchers were able to use augmented reality technology to produce meaningful and lifelike 3D objects that enhanced the learners' word understanding.

The researchers chose 36 EFL children in elementary school, ages 6 to 8, in accordance with the study's goals. Since they reside in Iran, a non-native nation, and must study English as a foreign language rather than a second language, these students had never taken any language learning classes before. Stated differently, the study's participants were non-native English as a Foreign Language (EFL) learners with no prior language learning experience. For this reason, students had to master the alphabet before they could begin studying the language. They were split into two groups of eighteen (control and experimental) at random. The ARAL, which was entirely focused on alphabet-based learning, was given to the experimental group's students as a therapy for acquiring basic vocabulary. It should be noted that the experimental group had 60-minute sessions of therapy for four weeks. The instructor's mobile smartphone was used to introduce the ARAL application to the participants during these sessions. Put another way, the instructor—who was also one of the study's researchers—installed the program and used it to

deliver the lesson. The control group's members, on the other hand, got the conventional method of acquiring new vocabulary through flashcards, classroom activities, and repetition. Stated differently, the control group is regarded as a placebo group. Both groups' curricula were created using the Phonics Book as a guide.

To make sure they were at the same level, learners were divided into experimental and control groups, and then each group took a pre-test. The images from the ARAL application served as the basis for the pre-test material. Under the direction of an experienced instructor, the experimental group used ARAL to interact with 3D pictures in a real-world setting while learning new words and the English alphabet using phonics. The control group, on the other hand, was given conventional teaching that included instructor explanations, flashcards, and printed images. Both groups used their mobile devices to access content, such as augmented reality graphics from a PDF file, throughout the nine sessions, which were held three times a week. The post-test phase came after the treatment was administered. At this point, the post-test, which was identical to the pre-test, was taken by both groups to gauge each participant's progress or gain score.

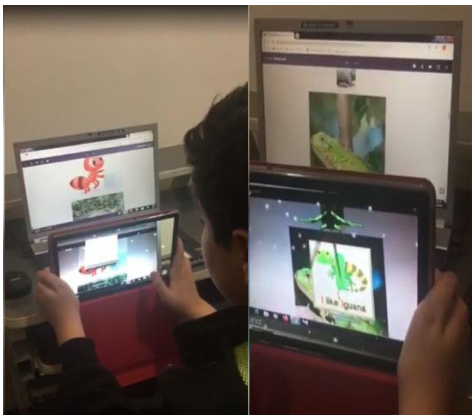

Figure 5. *Experimental Group, ARAL Alphabet Learning*

Data analysis

SPSS software (Version 23) was used to analyze the quantitative data, while content analysis was used to examine the interviews. One of the researchers used structured interviews to find out how the experimental group felt about the ARAL application once the quantitative phase was over. To put it another way, interviews were done to find out how participants felt about employing ARAL in language classes following the study's quantitative phase (the post-test). By comparing and contrasting the participants' replies, the data were examined using content analysis of the interview transcripts.

Findings

The researchers divided the findings of the study into two phases of quantitative results and qualitative results as below:

Quantitative Phase of the Study

The researchers examined the impact of the newly developed ARAL application on school-age EFL learners' vocabulary acquisition over time using an independent-samples t-test to compare the difference between pretest and posttest scores for students in the experimental (ARAL group) and control groups. Before executing the t-test, the researchers verified that the normality assumption was met. The skewness and kurtosis estimates for the experimental and control groups were both within the range of -2 and +2, suggesting that the normality assumption of the independent-samples t-test was satisfied (Tables 4 and 5)

Table 4

Descriptive statistics of two testing times of the experimental/ARAL group (n = 18)

	Min	Max	Mean	Std. D	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Pretest	2.60	4.20	3.27	0.48	0.25	0.53	-0.88	1.03
Posttest	4.30	8.30	5.99	1.08	0.63	0.53	-0.19	1.03

Table 5 displays the descriptive information for the pretest and posttest findings for the control group (N = 18). The mean score on the pretest was 3.30 (SD = 0.49), with a range of 2.50 to 4.20. The score distribution was relatively favorably slanted and had a flatter-than-normal curve. The posttest mean was 3.78 (SD = 0.66), with scores ranging from 2.70 to 5.20. The score distribution was heavily favorably slanted and had a curve that was a little flatter than usual. Compared to the experimental/ARAL group, the control group's mean scores improved less from the pretest to the posttest, suggesting less progress. The ARAL group's gain score was significantly greater (MDifference = 2.72, SD =.97) than that of the control group (MDifference =.47, SD =.46), with a very large effect size (Cohen's d = 2.96), t(24.32) = 8.83, p =.00.

Table 5

Descriptive statistics of two testing times of the control group (N = 18)

	Min	Max	Mean	Std. D	Skewness	Kurtosis

	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Pretest	2.50	4.20	3.30	0.49	0.14	0.53	-0.84	1.03
Posttest	2.70	5.20	3.78	0.66	0.40	0.53	-0.19	1.03

Table 6

The descriptive statistics of vocabulary gain scores of different groups from the pretest to posttest

Group		N	Mean Difference
Gain Score	EXP (ARAL)	18	2.72
	CNT (Placebo)	18	0.47

Note: EXP = Experimental (ARAL), CNT = Control

Table 6 displays the descriptive information for the vocabulary growth scores from the pretest to the posttest. The experimental ARAL group's mean gain score was 2.72, whereas the control group's was 0.47. Given the comparatively high effect size (Cohen's d = 2.96) and the significant difference (t(24.32) = 8.83, p =.00), it is reasonable to assume that the ARAL intervention enhanced the experimental group's vocabulary acquisition results relative to the control group.

Table 7

Independent samples t-test for comparing gain cores of groups from the pretest to posttest

	Levene's Test		t-test				
						95% CI	
	F	Sig.	t	df	Sig	Lower	Upper
Equal variances assumed	4.79	0.03	8.83	34	0.00	1.72	2.76
Equal variances not			8.83	24.32	0.00	1.72	2.76

assum
ed

Table 7 presents the results of an independent samples t-test comparing the ARAL and control groups' vocabulary gain scores. The difference was very significant ($t(24.32) = 8.83$, $p < 0.001$), and the effect size was rather large (Cohen's $d = 2.96$). The ARAL group had a mean gain score of 2.72 (SD = 0.97), compared to 0.47 (SD = 0.46) for the control group. The mean gain score difference's 95% confidence interval (CI) ranged from 1.72 to 2.76. These findings provide strong statistical evidence that the ARAL intervention significantly outperformed the conventional schooling of the control group in terms of vocabulary development. The enormous effect size further demonstrates the ARAL therapy's substantial impact on vocabulary learning.

Qualitative Phase of the Study

Following the study's quantitative phase (the post-test), interviews were done to learn more about the participants' opinions on the use of ARAL in language classes. The interview transcripts' content analysis was used to examine the data. The following is what an eight-year-old pupil thought about utilizing modern technology in the classroom (question one):

"I think using new technologies in the language classrooms can make it more interesting."

Another student, who was younger (8 years old), gave a similar answer to this question:

"I love ARAL because it can help remind me of the words and vocabularies better. It can increase my interest in vocabulary, especially the animal part, of the class. I love those animals especially Zebra".

Based on these perspectives from the students, ARAL can help learners have simplified learning as it uses 3D pictures with a beautiful and enjoyable design which can enable learners to remind the new vocabularies items. In addition, English vocabulary acquisition can be more interesting and fun for learners in comparison with traditional English environments.

In their responses to the second question on the ease of using the application, two students stated:

"Yes. You only need to open the application and select the vocabulary you want."

"ARAL has a friendly and funny environment. You can use the 3D pictures really easily by choosing them from the menu of the application. You can move the animals and objects and track them in their real environment."

The students believed that ARAL is user-friendly and can facilitate the learning process with 3D pictures. Ease of access, tracking the objects, and moving them in the real environment can be added to ARAL's positive features.

In response to the third question about picturing the new words with ARAL, two of the EFL learners stated that:

"I can remember the new vocabularies better with ARAL. As the teacher taught us new words, like Zebra, I chose them in the application, and I found them more sensible and meaningful".

"Because of the 3D images of this application, I can remember the words better, and I can imagine them better than with pictures in a book".

Therefore, ARAL can make language learning, especially vocabulary acquisition, more sensible and meaningful as they have the actual and real presentation of vocabulary items in the AR environment that uses 3D images. Additionally, as the learners stated, ARAL can help learners remember words better than other traditional instruments like books. The positive and negative points of ARAL applications, as found in the learners' responses, are categorized in Table 8.

Table 8

Positive and negative points of using ARAL based on the similarities and differences of the responses

Category	Positive Points	Negative Points
Engagement	1. Interesting and funny, Captures learners' attention 2. Fully 3D pictured objects 3. Moving and tracking the objects	Sometimes we distract from class by playing it
Usability	Easy to use and it can remind new vocabulary items	Mobile battery consuming (in some cases)
Portability		We cannot take it home
Content Realism		Some students reported that if the pictures were real, it would be better

According to the summary in Table 8, the ARAL application had a mix of positive and negative points as reported by the study participants. On the positive side, the participants noted that ARAL effectively taught English vocabulary in an engaging and humorous way, leveraging fully 3D objects that could move and be tracked. Additionally, the learners found the application easy to use and felt it helped them remember the vocabulary better. However, the participants also identified several drawbacks, including high mobile battery consumption, limited availability for use outside of the classroom setting, potential for distraction, and low quality of the visual imagery. In addition to this, Figure 6. shows the results of frequent vocabulary items that participants used in their responses in a word cloud.

Figure 6. *Word Cloud of Participants' Responses*

As Figure 6. shows, these words suggest that the participants found the learning experience to be engaging, interactive, and enjoyable. Words like "moving", "magical", "imaginative", and "hands-on" indicate that the learning activities had a sense of wonder and creativity. The prominence of words like "mobile", "3D", and "easy" imply that the technological aspects of the learning platform, such as the mobile-friendly design and 3D interactive elements, were well-received by the participants. Overall, the word cloud provides valuable insight into the participants' perceptions and attitudes towards the learning experience. The prevalence of positive words suggests that the platform was successful in generating enthusiasm and interest around language learning.

The last question was about learners' interest in using ARAL in future lessons. All responses to this question were yes. The learners in the experimental group stated that they would like to continue their classes using the AR-based platforms. This unanimity of interest in continued use of the AR-based platform is an very encouraging finding. It indicates the ARAL approach has strong potential to enhance language learning when implemented effectively. This feedback will likely be useful in guiding future development and deployment of the platform.

Discussion

The study examined how the ARAL application affected Iranian EFL learners' vocabulary learning and found that ARAL significantly and significantly improved vocabulary acquired using 3D alphabet principles. This indicates that ARAL, as an AR-based educational tool, can effectively teach new vocabulary to young EFL students. These findings align with previous research demonstrating that emerging educational technologies, including mobile-assisted and AR-based approaches, significantly enhance language skills for EFL learners (Alemi & Khatoony, 2020; Khatoony, 2020). Such technologies are especially beneficial for school-age learners in non-native contexts like Iran, as they are often more engaged by multimodal, interactive digital experiences.

The researchers argue that ARAL's design is particularly suited for young language learners, who respond positively to interactive digital learning. Compared to traditional flashcard methods, ARAL greatly improved student engagement and learning outcomes. This supports existing research suggesting that technology-enhanced methods leveraging mobile devices and

AR make language input more comprehensible and compelling for young learners (Sydorenko, 2010; Ji & Shin, 2019; Khoshnevisan, 2021; Lee et al., 2019). Additionally, the study's results are consistent with Khatoony and Altinpulluk (2020), who found that integrating new technologies into education benefits various fields, including English language learning. Qualitative findings indicate that ARAL fosters more positive attitudes toward learning English among young EFL students, particularly those without access to native-like language environments (Derakhshan & Khatir, 2015; Khatoony & Altinpulluk, 2021; Pan & Gan, 2020). The interactive and gamified aspects of ARAL enhance motivation and involvement in the language learning process.

The findings of this study can be linked to **CLT** and **DCT**, providing a framework for understanding how ARAL impacts vocabulary acquisition. CLT suggests effective learning occurs when cognitive load is optimized (Sweller, 1988). ARAL, using 3D objects, auditory pronunciation, and kinesthetic interaction, reduces cognitive overload and helps learners retain new vocabulary more efficiently (Chen & Wang, 2021). This multimodal input aligns with CLT by distributing cognitive load, making learning easier (Dünser & Hornecker, 2007). Similarly, DCT supports the use of both verbal and visual information to enhance learning (Paivio, 1986). ARAL's integration of 3D visuals and verbal vocabulary allows learners to process language through dual channels, improving retention and comprehension (Hsu, 2017). The results confirm that ARAL enhances vocabulary acquisition and engagement, validating the use of these cognitive theories to optimize language learning in young EFL learners.

The overall advantages of ARAL for young EFL learners seem to exceed the technical constraints of AR apps, which include restricted functionality, tracking concerns, and interface problems (Altinpulluk, 2019; Alfadil, 2020). It is anticipated that educational uses of ARAL and related technologies will become more and more useful for successfully involving and assisting young language learners as AR technology develops. Given the positive impact of ARAL on vocabulary acquisition, the researchers recommend that educators and policymakers consider integrating AR-based language learning applications into curricula for young EFL students (Pujola & Appel, 2020). Incorporating ARAL and similar technologies could significantly enhance vocabulary development, language proficiency, and learner motivation among this demographic.

Conclusion

This study looked at how a recently created augmented reality application affected school-age EFL learners' vocabulary development. The results showed that the ARAL application had a beneficial effect on vocabulary acquisition and that learners in the experimental group performed much better. Participants reported that ARAL was an enjoyable and effective method for learning English vocabulary, noting that the integration of 3D vocabulary items in real environments made the words more tangible and comprehensible. Learners also found the application user-friendly. Despite some areas for improvement, both teachers and students held positive attitudes toward using ARAL in language learning. In conclusion, the study suggests

that ARAL is an effective tool for L2 vocabulary acquisition based on its influence on learner performance and perceptions. Researchers recommend integrating AR technology like ARAL into language instruction to enhance motivation and engagement. However, they faced limitations due to AR's emerging status, which necessitates further software development and hardware accessibility. The study focused on basic vocabulary lessons with alphabets, as more complex content demands substantial resources. Additionally, the research was restricted to early education and beginner-level learners. To build on these findings, the researchers suggest further exploration of ARAL and similar applications in various educational contexts, expanding the types of language components addressed, and investigating learners' motivation and learning styles. Moreover, the small sample size and short intervention period (four weeks) may limit the generalizability of the findings, as they may not fully represent the diverse range of learners or account for long-term effects. Additionally, the focus on basic alphabet vocabulary restricts the scope of the research, leaving room for future studies to explore the efficacy of ARAL in teaching more complex language structures, such as grammar, sentence construction, or advanced vocabulary. These areas warrant further investigation to assess how ARAL can enhance a broader range of language skills.

Despite the limitations, to optimize vocabulary acquisition and engagement with ARAL, several interconnected strategies can be suggested to EFL beneficiaries such as teachers, learners, and admintrators. Short, focused sessions of 10–15 minutes help maintain engagement and prevent cognitive overload, while spaced learning and massed learning balance review and concentrated practice, reinforcing vocabulary retention. Clumped learning, grouping related words together, enhances comprehension, aligning with DCT by connecting visual and verbal learning through 3D models or flashcards. Interactive games further boost engagement, and regular review sessions ensure long-term retention. Personalized learning caters to individual needs, and pair or group work encourages peer collaboration. Incorporating physical movement with activities like scavenger hunts keeps learning dynamic. Teacher-led demonstrations help students effectively use ARAL. These strategies combine to create an engaging, effective vocabulary learning environment for young EFL students.

As a next step, it is recommended to test ARAL with more complex vocabulary, including abstract terms and advanced language structures, to determine its scalability and effectiveness beyond basic vocabulary acquisition. Additionally, exploring ARAL's potential to enhance other language skills, such as grammar, pronunciation, and reading comprehension, could provide a more comprehensive understanding of its impact on overall language proficiency. Future studies could incorporate tasks that require students to use these skills in context, such as sentence construction or storytelling, to assess ARAL's contribution to deeper language learning. Furthermore, testing ARAL with a larger and more diverse sample, including different age groups, proficiency levels, and educational contexts, would help ensure that the findings are generalizable. Longitudinal studies could also be conducted to evaluate the long-term retention of vocabulary and other language skills acquired through ARAL. Finally, researchers could examine the integration of ARAL with other technological tools, such as voice

recognition for pronunciation practice or digital reading platforms, to create a holistic, interactive learning experience.

Bio-data

First Author: Designed and conducted the procedures, reviewed the final draft and made necessary revisions

Second and Third Author: Collected the data and wrote the first draft. Designed and conducted the procedures.

Funding: This research received/ did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest: The authors declare that they have no competing interests.

References

Alahmadi, A., Shank, C., & Foltz, A. (2018). Vocabulary learning strategies and vocabulary size: Insights from educational level and learner styles. *Vocabulary Learning and Instruction, 7*(1), 1-21. https://doi.org/10.7820/vli.v07.1

Alemi, M., & Khatooni, S. (2021). The impacts of virtual reality on young EFL learners' pronunciation. *Language Related Research, 11*(6), 449-480.

Alemi, M., & Khatooni, S. (2020). Virtual reality assisted pronunciation training (VRAPT) for young EFL learners. *Teaching English with Technology, 20*(4), 59-81.

Alfadil, M. (2020). Effectiveness of virtual reality game in foreign language vocabulary acquisition. *Computers & Education, 153*, 1-47. https://doi.org/10.1016/j.compedu.2020.103893

Altinpulluk, H. (2019). Determining the trends of using augmented reality in education between 2006-2016. *Education and Information Technologies, 24*(2), 1089-1114. https://doi.org/10.1007/s10639-018-9806-3

Altinpulluk, H., Kesim, M., & Kurubacak, G. (2020). The usability of augmented reality in open and distance learning systems: A qualitative Delphi study. *Open Praxis, 12*(2), 283-307. https://doi.org/10.5944/openpraxis.12.2.1017

Altınpulluk, H., & Yıldırım, Y. (2023). The bibliometric analysis of the augmented reality research carried out with the experimental method published in Scopus between 2012-2022. *Turkish Online Journal of Distance Education, 24*(3), 39-59. Retrieved from https://dergipark.org.tr/en/pub/tojde/issue/78845/1168110

Ary, D., Jacobs, L. C., Irvine, C. K. S., & Walker, D. (2018). *Introduction to research in education* (10th ed.). Cengage Learning.

Castillo-Montoya, M. (2016). Preparing for interview research: The interview protocol refinement framework. *The Qualitative Report, 21*(5), 811-831. https://doi.org/10.46743/2160-3715/2016.2337

Chen, C. M., & Wang, H. P. (2021). Enhancing English as a foreign language learning through a digital escape room game. *Educational Technology Research and Development, 69*(1), 135-161. https://doi.org/10.1007/s11423-020-09857-9

Chen, M. P., Wang, L. C., Zou, D., Lin, S. Y., Xie, H., & Tsai, C. C. (2022). Effects of captions and English proficiency on learning effectiveness, motivation and attitude in augmented-reality-enhanced theme-based contextualized EFL learning. *Computer Assisted Language Learning, 35*(3), 381-411. https://doi.org/10.1080/09588221.2019.1704787

Derakhshan, A., & Khatir, E. D. (2015). The effects of using games on English vocabulary acquisition. *Journal of Applied Linguistics and Language Research, 2*(3), 39-47.

Dünser, A., & Hornecker, E. (2007). Lessons from an AR book study. In *Proceedings of the 1st international conference on tangible and embedded interaction* (pp. 179-182). ACM. https://doi.org/10.1145/1226969.1227006

Ebadi, S., & Ashrafabadi, F. (2022). An exploration into the impact of augmented reality on EFL learners' reading comprehension. *Education and Information Technologies*, 1-21. https://doi.org/10.1007/s10639-022-11021-8

Eren, Ö. (2020). The path to digitalisation in ELT classes: An insight into the social nature of web-based language learning. In M. Montebello (Ed.), *Handbook of research on digital learning* (pp. 160-172). IGI Global.

Fathi, J., & Ebadi, S. (2020). Exploring EFL pre-service teachers' adoption of technology in a CALL program: Obstacles, motivators, and maintenance. *Education and Information Technologies, 3*(1), 1-21. https://doi.org/10.1007/s10639-020-10146-y

Greene, M., & Jones, W. (2020). Towards a critical conceptual framework for technology integration in professional development for English language teachers. *Journal of Educational Multimedia and Hypermedia, 29*(2), 113-132. https://doi.org/10.26634/jsch.14.2.14926

Hanafi, H. F., Abd Wahab, M. H., Wong, K. T., Selamat, A. Z., Adnan, M. H. M., & Naning, F. H. (2020). Mobile augmented reality hand wash (MARHw): Mobile application to guide community to ameliorate handwashing effectiveness to oppose COVID-19 disease. *International Journal of Integrated Engineering, 12*(5), 217-223. https://doi.org/10.30880/ijie.2020.12.05.028

Hsu, T. C. (2017). Learning English with augmented reality: Do learning styles matter?. *Computers & Education, 106*, 137-149. https://doi.org/10.1016/j.compedu.2016.12.007

Ibrahim, A., & Alshami, H. (2022). Vocabulary learning strategies frequently used by Sudanese EFL learners at the tertiary level to strengthen their vocabulary knowledge. *Journal of English Language Teaching and Applied Linguistics, 4*(1), 37-43. https://doi.org/10.32996/jeltal.2022.4.1.4

Ibrahim, A., Huynh, B., Downey, J., Höllerer, T., Chun, D., & O'Donovan, J. (2018). Arbis pictus: A study of vocabulary acquisition with augmented reality. *IEEE Transactions on Visualization and Computer Graphics, 24*(11), 2867-2874.

Ji, H. E., & Shin, H. W. (2019). Young foreign language learners' engagement and motivation in augmented reality-based vocabulary acquisition. *Multimedia-Assisted Language Learning, 22*(3), 9-31. https://doi.org/10.1109/TVCG.2018.2868568

Khatoony, S. (2019, December). An innovative teaching with serious games through virtual reality assisted language learning. In *2019 International Serious Games Symposium (ISGS)* (pp. 100-108). IEEE. https://doi.org/10.1109/ISGS49501.2019.9047018

Khatoony, S., & Altınpulluk, H. (2021). Exploring Iranian and Turkish faculty members' views toward using augmented reality English trainer (ARET) application for educational purposes: A comparative study in different university faculties. *AJELP: Asian Journal of English Language and Pedagogy, 9*(2), 128-152. https://doi.org/10.37134/ajelp.vol9.2.10.2021

Khezrlou, S., Ellis, R., & Sadeghi, K. (2017). Effects of computer-assisted glosses on EFL learners' vocabulary acquisition and reading comprehension in three learning conditions. *System, 65*, 104-116. https://doi.org/10.1016/j.system.2017.01.009

Khoshnevisan, B. (2021). Technology-enhanced language education revisited: A developmental perspective. *Dual Language Research and Practice Journal, 1*(1), 5-13. https://doi.org/10.21423/dlrpj-v4.a15

Kljun, M., Geroimenko, V., & Pucihar, K. Č. (2020). A review of augmented reality in education and its effectiveness in the delivery of learning content. In *2020 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)* (pp. 320-323). IEEE. https://doi.org/10.1109/AIVR50618.2020.00065

Kljun, M., Geroimenko, V., & Pucihar, K. Č. (2020). Augmented reality in education: Current status and advancement of the field. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 3-21). Cham: Springer.

Lee, H., Warschauer, M., & Lee, J. H. (2019). Advancing CALL research via data-mining techniques: Unearthing hidden groups of learners in a corpus-based L2 vocabulary acquisition experiment. *ReCALL, 31*(2), 135-149. https://doi.org/10.1017/S0958344018000162

Lee, S. M. (2022). A systematic review of context-aware technology use in foreign language learning. *Computer Assisted Language Learning, 35*(3), 294-318. https://doi.org/10.1080/09588221.2019.1688836

Legault, J., Zhao, J., Chi, Y. A., Chen, W., Klippel, A., & Li, P. (2019). Immersive virtual reality as an effective tool for second language vocabulary acquisition. *Journal of Languages, 4*(1), 2-32. https://doi.org/10.3390/languages4010013

Lin, Y. J., & Wang, H. C. (2022). Applying augmented reality in a university English class: Learners' perceptions of creativity and learning motivation. *Innovation in Language Learning and Teaching*, 1-15. https://doi.org/10.1080/17501229.2022.2040513

Luck, J., Gosling, N., & Saour, S. (2021). Undergraduate surgical education during COVID-19: Could augmented reality provide a solution? *British Journal of Surgery, 108*(3), e129-e130. https://doi.org/10.1093/bjs/znaa159

Mehri Ghahfarokhi, M., & Tavakoli, M. (2020). The effect of technology-mediated reading comprehension tasks on autonomy and metacognitive strategy use by Iranian EFL intermediate learners. *Journal of Modern Research in English Language Studies, 7*(3), 45-69. https://doi.org/10.30479/jmrels.2020.11739.1459

Min, H. T. (2008). EFL vocabulary acquisition and retention: Reading plus vocabulary enhancement activities and narrow reading. *Language Learning, 58*(1), 73-115. https://doi.org/10.1111/j.1467-9922.2007.00435.x

Naderiheshi, A. (2022). Review of literature on teaching English vocabularies through games to young language learners. *Journal of Language Teaching and Research, 13*(1), 12-19. https://doi.org/10.17507/jltr.1301.02

Nejati, E., Jahangiri, A., & Salehi, M. R. (2018). The effect of using computer-assisted language learning (CALL) on Iranian EFL learners' vocabulary acquisition: An experimental study. *Cypriot Journal of Educational Sciences, 13*(2), 351-362. https://doi.org/10.18844/cjes.v13i2

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.

Pan, X., & Gan, Z. (2020). Perceiving technology-based professional development practices for teachers: Accounts from English as a foreign language (EFL) teachers in China. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 10*(2), 40-58. https://doi.org/10.4018/IJCALLT.2020040103

Parmaxi, A., & Demetriou, A. A. (2020). Augmented reality in language learning: A state-of-the-art review of 2014–2019. *Journal of Computer Assisted Learning, 36*(6), 861-875. https://doi.org/10.1111/jcal.12486

Plonsky, L., & Ghanbar, H. (2018). Multiple regression in L2 research: A methodological synthesis and guide to interpreting R^2 values. *The Modern Language Journal, 102*(4), 713-731. https://doi.org/10.1111/modl.12509

Pujolà, J. T., & Appel, C. (2020). Gamification for technology-enhanced language teaching and learning. In *New Technological Applications for Foreign and Second Language Learning and Teaching* (pp. 93-111). IGI Global.

Shadiev, R., & Yang, M. (2020). Review of studies on augmented reality-based language learning. *Computer Assisted Language Learning, 33*(7), 811-836. https://doi.org/10.1080/09588221.2019.1640745

Song, Y., Wen, Y., Yang, Y., & Cao, J. (2022). Developing a 'Virtual Go mode' on a mobile app to enhance primary students' vocabulary learning engagement: An exploratory study. *Innovation in Language Learning and Teaching*, 1-10. https://doi.org/10.1080/17501229.2022.2047693

Sydorenko, T. (2010). Modality of input and vocabulary acquisition. *Language Learning and Teaching, 14*(2), 50-73.

Tayyebi, G. (2021). The vocabulary learning strategy use of Iranian elementary EFL learners. *Contemporary Educational Researches Journal, 11*(4), 147-160. https://doi.org/10.18844/cerj.v11i4.5711

Tnomat, D., Billik, M. O., & Banu, T. B. J. (2022). The implementation of short English movie to improve students' vocabulary mastery in interpretive listening class. *SAGA: Journal of English Language Teaching and Applied Linguistics, 3*(1), 59-68. https://doi.org/10.21460/saga.2022.31.121

Tomlinson, S. B., Hendricks, B. K., & Cohen-Gadol, A. A. (2020). Innovations in neurosurgical education during the COVID-19 pandemic: Is it time to reexamine our neurosurgical training models? *Journal of Neurosurgery, 133*(1), 14-15. https://doi.org/10.3171/2020.4.JNS201012

Wen, Y. (2021). Augmented reality enhanced cognitive engagement: Designing classroom-based collaborative learning activities for young language learners. *Educational Technology Research and Development, 69*(2), 843-860. https://doi.org/10.1007/s11423-020-09893-z

Yilmaz, R. M., Topu, F. B., & Takkaç Tulgar, A. (2022). An examination of vocabulary learning and retention levels of pre-school children using augmented reality technology in English language learning. *Education and Information Technologies*, 1-29. https://doi.org/10.1007/s10639-022-10916-w

Zhang, D., Wang, M., & Wu, J. G. (2020). Design and implementation of augmented reality for English language education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 103-112). Cham: Springer.