INTERNATIONAL CALL RESEARCH CONFERENCE

https://doi.org/10.29140/9780648184485-45

Synthesizing the Use of Augmented Reality in Technology-Enhanced Language Learning Contexts: A 15-year Systematic Review

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Abstract

The rise of Augmented Reality (AR) has provided second language (L2) educators and learners with new pathways for teaching and learning, leading researchers to investigate its impact in the field of technology-enhanced language learning (TELL). The current study adopted a systematic review methodology to synthesize AR research in TELL contexts in terms of educational technology features and language acquisition results. Three academic databases (i.e., Web of Science, Scopus, and ScienceDirect) were accessed, and two predefined sets of search terms about AR and language learning, respectively, were used to retrieve relevant studies for this review. Following the screening with a predetermined set of inclusion criteria, 42 empirical articles published in the Social Science Citation Index (SSCI) or Arts and Humanities Citation Index (AHCI) journals in the past 15 years (2009–2023) were identified. The included studies were then systematically analyzed using a coding scheme developed in this review, and the results were presented under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Major findings revealed that: (1) Handheld displays or smartphones were the most popular devices for enabling image or marker-based AR technology via various software, and such applications are frequently used for AR-enhanced content presentation, AR gaming, and AR-integrated learning tutorial in support of

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In Y. Wang & M. S. Cárdenas Claros (Eds.), Proceedings of the XXIInd International CALL Research Conference, 2024 (pp. 301–308). Castledown.

L2 learning; (2) The majority of the reviewed studies showed promising outcomes of AR use in TELL contexts, with improved vocabulary acquisition being the most frequently reported benefit, whereas some aspects of language acquisition remained under-explored. Based on the review results, several suggestions for applying AR in L2 education are discussed to help TELL educators with their future practices.

Keywords: Augmented Reality (AR), Technology-Enhanced Language Learning (TELL), Systematic review methodology

Introduction

In the past decades, there has been a growth of studies examining the effectiveness of emerging technologies in language education. Among various types of technologies, Augmented Reality (AR) has gradually broadened over time and become a significant area of interest for educational researchers (Garzón et al., 2020). AR is seen as a technology that integrates real-world experiences with virtual information, enabling users to view both the physical and superimposed virtual objects. Several educational benefits of AR have been claimed in recent research (López-Belmonte et al., 2023), such as enhancing learning performance (Fidan & Tuncel, 2019), promoting motivation (Chen et al., 2022), and increasing positive perceptions (Koç et al., 2022). However, there are still some challenges regarding educational applications of AR, such as expensive costs of AR display devices (Sırakaya & Sırakaya, 2022) and difficulties in designing AR content (Fidan & Tuncel, 2019). While the use of AR for educational purposes reveals both benefits and challenges, it is crucial to understand how AR is currently implemented in supporting language learning and then to provide pedagogical guidelines for teachers and researchers in their future teaching and research.

Therefore, the current review aims to synthesize AR studies in Technology Enhanced Language Learning (TELL) contexts that have been published in the past 15 years (2009–2023). The following two research questions are addressed in this review:

1. What educational technology features have been identified among the reviewed studies in terms of hardware, software, recognition techniques, and implementation strategies?
2. What language acquisition results have been reported among the reviewed studies?

Methodology

The methodology and procedure of this review study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), consisting of three major stages: identification, screening, and inclusion (Page et al., 2021), as shown in Figure 1. Three databases (i.e., Web of Science, ScienceDirect, and Scopus) were used as the major sources to retrieve journal articles published in the educational field. Two sets of keywords relating to AR and language learning, respectively, were developed to identify as many relevant studies as possible. Next, the pool of studies was examined based on the following inclusion criteria to ensure that the selected studies were relevant to the research questions of this review:

- Criterion 1: Studies that concern AR and its educational applications in language learning contexts.
- Criterion 2: Studies that involve L2 learners as the primary participants and measure their language acquisition outcomes.
- Criterion 3: Studies that provide empirical evidence.
- Criterion 4: Studies that are published as journal articles and are included in Social Science Citation Index (SSCI) or Arts and Humanities Citation Index (AHCI).

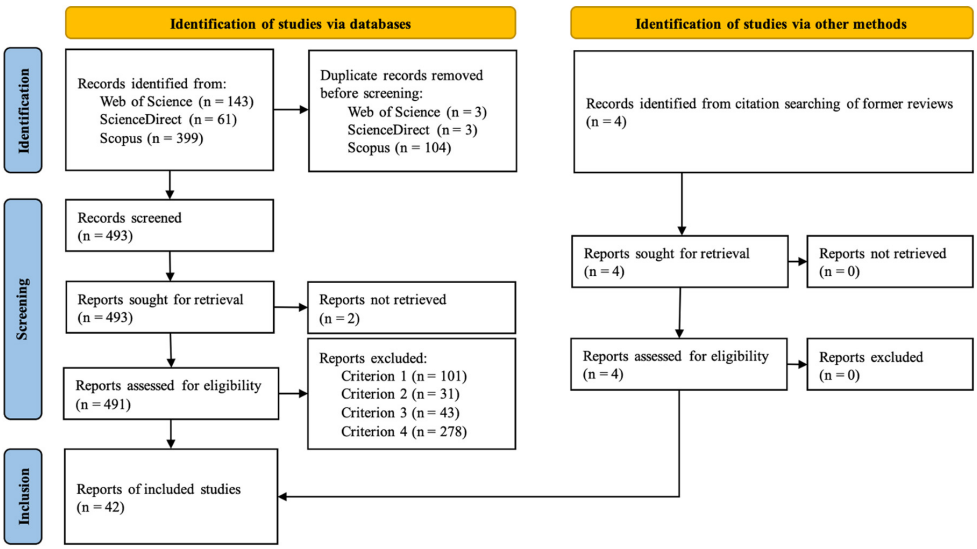

Figure 1. PRISMA flowchart of the data selection process for this review.

The search and screening process resulted in 42 AR-enhanced language learning studies being included in this review.

In terms of data coding and analysis, this review developed a coding scheme with two clusters of categories based on the two research questions (i.e., educational technology features and language acquisition results). To enhance review reliability, two coders independently analyzed the studies for initial coding and then collectively resolved coding disagreements through discussions in order to reach an inter-coder agreement.

Results and Discussion

The distribution of the 42 studies over the past 15 years (2009–2023) shows a notable increase (see Figure 2). The number of published studies rose sharply in recent years, with 18 published between 2021 and 2023. This trend is likely due to the maturity of AR-enabling hardware and the increasing prevalence of its recognition techniques and software, making AR technology more appealing and accessible for use in language learning settings (Zhang & Zou, 2022).

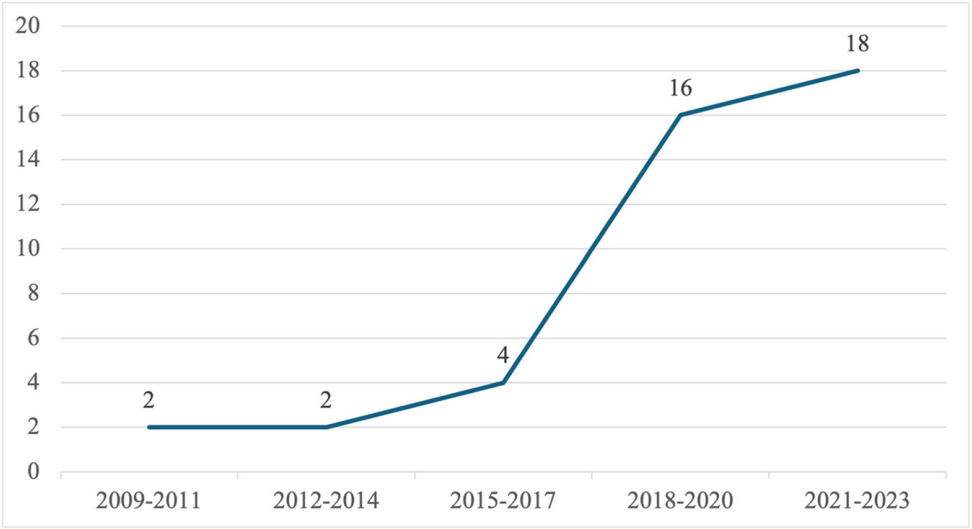

Figure 2. Number of the reviewed studies published in three-year intervals over the past 15 years.

Analysis of Educational Technology Features

The analysis concerning AR-enabling hardware indicates that handheld display (HHD) devices (93%) were the most commonly used, followed by head-mounted display (HMD) devices (5%), whereas one study (2%) did not specify its AR-enabling hardware. Since enabling AR with HHD is more accessible and allows for individual ownership by students compared to HMD, this likely explains the higher frequency of AR display with HHD (Garzón & Acevedo, 2019).

The findings regarding AR recognition techniques reveal that most studies (79%) employed marker-based AR, followed by location-based AR (16%) and markerless-based AR (5%). Marker-based AR uses images or visual markers like QR codes that the system can easily recognize, which ensures better stability in the precise placement of augmented content (Bacca et al., 2014) and thus, a better learning experience with AR for students. This likely explains marker-based AR's widespread use as compared to the other two AR recognition techniques.

The most commonly implemented AR software or programs in the reviewed studies were HP Reveal (9%) and Unity (9%), followed closely by Vuforia (8%), and ARIS (6%). Other software was rather scarce, appearing in only one or two studies, such as HELLO and EduAR. Notably, HP Reveal's popularity stems from its reported enhancement of students' learning outcomes through 3D images with sound and movement (Huang et al., 2021).

As for AR implementation strategies, most researchers adopted AR-enhanced content presentation (38%), followed by AR gaming (33%), and AR-integrated learning tutorial (29%). This trend may be due to the relative ease of designing AR-enhanced materials with marker-based AR recognition, which is accessible to educators with limited or even no coding knowledge (Costuchen et al., 2021; Danaei et al., 2020).

Analysis of Language Acquisition Results

Among the 42 AR studies, 32 investigated language acquisition effects and directly measured students' skill-based language learning outcomes. The coding categories in this review included four basic language skills (i.e., listening, speaking, reading, and writing), three specific areas (i.e., vocabulary, grammar, and pronunciation), and mixed language skills. The review results showed that vocabulary (56%) was the most targeted aspect, followed by writing (13%) and reading (6%). Additionally, several studies adopted mixed language skills (19%). Of the AR-enhanced vocabulary learning studies, 13 out of 18 (72%) reported positive effects of AR. The effectiveness may be attributed to AR's affordances

to transform abstract text-based content into various visual representations, such as 3D animations, providing students with multiple cognitive resources to process and understand abstract language meanings (Fan et al., 2020).

Conclusion

The significance of this review lies in its contribution to transitions in technologies through the exploration of AR and its applications within the context of language education, highlighting AR's potential to shape L2 teaching and learning practices. Specifically, this review synthesized 42 AR studies in TELL contexts over the past 15 years. Based on the findings, several suggestions are presented below for language educators. Concerning educational technology features, teachers can adopt AR-enhanced content presentation strategies using marker-based AR to create interactive learning environments. Smartphones, given their widespread availability, are recommended as cost-effective AR-enabling hardware, with free software like HP Reveal facilitating virtual content development. Regarding language acquisition, AR has been shown to be particularly effective in scaffolding students' vocabulary learning. However, limitations must be considered in view of the present review findings; for example, the selective focus on educational technology features and language acquisition outcomes may inadvertently neglect to consider other important aspects. Further reviews are still warranted to provide synthesized evidence and comprehensive insights into the use of AR in TELL contexts.

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