International Journal of Linguistics Studies
ISSN: 2754-2599
DOI: 10.32996/ijls
Journal Homepage: www.al-kindipublisher.com/index.php/ijls

IJLS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

From Markers to Dynamic Augmentation: Modalities and Outcomes of AR in Language Teaching

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| ABSTRACT

This review synthesises post-2020 empirical research on augmented reality (AR) in foreign and second-language education to identify prevailing trends, modalities, pedagogical outcomes, and barriers to classroom integration. Following PRISMA-guided selection, 25 peer-reviewed experimental studies with a minimum of 50 participants each were analysed from ERIC and Web of Science. Results indicate that AR is primarily implemented as marker/vision-based experiences but also appears in NFC, location-based, and emerging dynamic-augmentation formats. Across educational stages, AR consistently enhances student motivation, engagement, and positive attitudes toward language learning; evidence for reliable short-term gains in specific linguistic outcomes is mixed, though several studies report improved vocabulary retention and promising applications in phonetics and discipline-specific contexts. Key research foci include general learning effects, vocabulary acquisition, teacher and student perceptions, pedagogical proposals, and methodological innovation such as AR-supported storytelling and CLIL-integrated gamification. Major obstacles to effective adoption are limited teacher digital competence, device and connectivity constraints, potential mobile-device distractions, and heterogeneity in study designs and intervention duration. The review concludes that AR holds pedagogical promise as a multimodal, situated learning tool but requires targeted teacher training, institution-level resourcing, and more rigorous, longitudinal research comparing AR modalities and isolating pedagogical variables. Recommendations include expanding studies on location-based and dynamic augmentation, exploring AR for specific competences (e.g., pronunciation, ESP), and prioritising scalable teacher-development pathways.

| KEYWORDS

Augmented Reality; Language Education; Educational Technology; Multimodal Learning; Teacher Digital Competence

| ARTICLE INFORMATION

ACCEPTED: 12 October 2023 **PUBLISHED:** 28 October 2025 **DOI:** 10.32996/ijls.2025.5.4.1

1. Introduction

In today's globalized society, learning foreign languages has become an essential skill for both personal growth and professional development. Yet, language instruction still largely takes place within traditional classroom settings (Lamb, 2017), where conventional methods may fall short of creating sufficiently interactive or context-rich learning environments (Wang, 2022). Augmented Reality (AR) has emerged as a promising tool to address these limitations, as it can bridge the physical and digital worlds, foster student engagement, and promote more meaningful learning experiences (AlNajdi, 2022).

There are four main types of AR, each interacting with the physical and digital worlds in distinct ways (Edwards-Stewart et al., 2016). The first is marker-based AR, also referred to as vision-based AR, in which the digital content is projected onto a predefined image or marker. The second type is location-based AR, which is triggered when the user reaches a specific geographical point and requires a device equipped with GPS functionality. The third category, dynamic augmentation, enables the system to track moving or changing objects in real time. Finally, complex augmentation combines features of both location-based and dynamic AR, offering a more sophisticated form of interaction between the real and virtual environments.

Although the concept of AR dates back to the 1960s (Sutherland, 1968), technological limitations delayed its development for several decades. It was not until 1995 that AR began to take the form in which it is recognized today (Kancherla et al., 1995). Since then, educators' interest in the pedagogical potential of AR has grown steadily, and it accelerated markedly from 2020 onward as the COVID-19 pandemic pushed schools toward remote and hybrid models and increased demand for tools that connect physical and digital learning (Batool, 2022). These shifts make a focused synthesis of post-2020 applications in language education both timely and necessary to identify challenges and opportunities. For this reason, the present study aims (1) to explore the potential of AR in language teaching through a review of the existing literature and (2) to identify the main lines of **research that have emerged in recent years.**

2. AR in Education

2.1. Benefits and Challenges

The cognitive development of children, adolescents, and adults cannot be directly compared, as each stage involves distinct brain processes, developmental priorities, and ways of interacting with the environment. For this reason, the effects of using AR should be examined separately for each stage, since its implications vary according to cognitive maturity and the specific challenges associated with each phase.

In early and primary education, several benefits have been documented, including greater learner autonomy (Motahar et al., 2018), increased motivation, engagement, and attention span (Basumatary & Maity, 2023; Tutkun, 2024), as well as enhanced opportunities for collaborative learning and improved knowledge retention and memorization (Basumatary & Maity, 2023). Furthermore, preschool teachers interviewed by Tutkun (2024) highlighted the usefulness of AR in explaining abstract concepts. However, they also expressed concern about the potential negative effects of excessive reliance on technology during early childhood education.

AR has also been incorporated into secondary education curricula across various subjects (Burson & Yilmaz, 2019; Schmidthaler et al., 2023; Stoyanova & Raykova, 2016), consistently demonstrating positive effects. Research conducted at this educational level reports improvements in overall learning outcomes and increased motivation (Schmidthaler et al., 2023; Stoyanova & Raykova, 2016), greater collaboration among students (Schmidthaler et al., 2023), and reading comprehension (Burson & Yilmaz, 2019).

At high school level and its equivalents, the use of AR also appears to foster higher motivation (Amores-Valencia et al., 2023) and better academic performance (Akhmalludin & Ayu, 2019). Similarly, AR applications have been well received by university students, who report that they facilitate the acquisition of new knowledge (Blas Padilla et al., 2019). Overall, AR seems to support learning in one way or another across all educational stages. Its impact has been so significant that some authors have even proposed considering AR as a new pedagogical methodology rather than merely an instructional tool (C. Chen et al., 2018).

However, the implementation of AR also presents several challenges. Among the main issues to consider are teachers' lack of preparation to work with this technology (Tutkun, 2024), the limited availability of electronic devices in schools, and connectivity problems that hinder access to AR resources (Schmidthaler et al., 2023). In addition, there remains a general lack of awareness regarding the potential benefits of integrating AR into educational practice (C. Chen et al., 2018).

2.2. Learning Theories Supporting the Use of Augmented Reality

On one hand, AR aligns closely with connectivist theory (Zhao et al., 2020), which posits that learning operates as a network and develops through the interaction between its various nodes (Gutiérrez, 2012). AR can contribute to the expansion of these networks by linking space, technology, people, and systems of knowledge, thereby facilitating interaction among nodes (Zhao et al., 2020). Techakosit and Wannapiroon (2015) support this perspective, arguing that AR fits well within a connectivist methodology, as it fulfils the four characteristics of an effective learning environment proposed by Smeets (2005).

On the other hand, AR is also closely related to situated learning theory (Zhao et al., 2020). This theory posits that effective learning can only occur when it takes into account the real contexts in which the acquired knowledge will be applied (Sagástegui, 2004). By overlaying digital elements onto the real world, AR brings authentic situations into the classroom, thereby facilitating the real-world connection necessary for meaningful knowledge construction (Zhao et al., 2020). However, the effectiveness of this approach has shown mixed results when applied to language learning (Chew et al., 2018) and STEM disciplines (Kulkarni et al., 2024), which may be attributed to differences in the methodological designs employed across studies. It is therefore essential to consider the methodological implications of AR when adapting it to specific educational fields.

Furthermore, Qarshiyeva (2024) highlights the role of AR within Dual Coding Theory. This theory posits that learning occurs through the combination of verbal and non-verbal stimuli, such as the integration of text and imagery (Clark & Paivio, 1991). By

overlaying real-world visuals with digital images to support teachers' explanations, and by allowing text to be embedded directly within the projection, AR serves as an ideal complement to instructional approaches grounded in dual coding.

3. Objectives and Method

AR has proven to be a highly valuable tool in the educational field. In the context of language teaching and learning, however, there remains a need for a detailed analysis of the existing literature to gain a deeper understanding of the advantages and limitations associated with its use. Such an analysis is essential to assess how these characteristics may vary across different stages of the learning process, from beginner to advanced levels.

Accordingly, the present study aims to compile and identify the main lines of research on the use of AR in language teaching over recent years. To achieve this, a review has been conducted with the goal of identifying key patterns and trends in research on AR and language education. This analysis not only seeks to provide a comprehensive overview of the current state of the field but also to highlight unexplored areas that may represent opportunities for future research.

Furthermore, the study seeks to address four Research Questions (RQ) designed to guide and frame the analysis of AR in language pedagogy:

RQ1. What are the main research focuses on the application of AR to language teaching?
RQ2. What are the effects of AR use on language teaching and learning across different stages of the learning process?
RQ3. Which types of AR are most commonly used in language teaching and learning?
RQ4. What are the main challenges hindering its integration into the curriculum?

Regarding methods, this study follows the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and adopts a qualitative approach, as it aims to understand and interpret the information on AR in language education gathered from recent research and experiments. The collection of studies was carried out through a systematic search in two internationally recognized academic databases: the Education Resources Information Center (ERIC) and Web of Science (WoS). These repositories were selected for their high impact and the strong relevance of the articles they index in the fields of education and technology, making them particularly suitable for the purposes of this study.

To filter the most relevant results, a single search string was applied and adapted to the specific requirements of each database. The search string used was: "Augmented reality" AND ("language learning" OR "CALL" OR "Computer-Assisted Language Learning" OR "MALL" OR "Mobile-Assisted Language Learning"). This formulation was chosen to capture a broad spectrum of terms related to AR and its application in language learning. It was designed to yield a comprehensive and representative collection of studies on the topic.

Additional inclusion criteria were also applied. Only articles published between January 2020 and October 2024, the date of the search, were considered. This time frame was selected deliberately to encompass the period in which AR research in education experienced its most rapid growth and pedagogical consolidation. The COVID-19 pandemic catalysed a profound digital transformation in education, prompting the exploration of immersive and remote learning tools such as AR (Batool, 2022). The years following 2020 marked a turning point, as the global shift toward digital learning environments accelerated the exploration and integration of immersive technologies in teaching. Studies published during this period show a notable increase in the adoption and evaluation of AR across diverse educational contexts, reflecting both technological advancements and evolving pedagogical practices (Al-Ansi et al., 2023). Setting the cut-off in October 2024 ensures that the analysis encompasses this mature and well-documented stage of AR development, while avoiding the methodological instability associated with ongoing or recently published 2025 studies.

Moreover, only peer-reviewed journal articles were included if they reported an experiment involving AR in the context of foreign or second language learning. These studies were required to include at least fifty participants and to be published in English. Conversely, other types of works, such as literature reviews, were excluded. This search yielded 555 articles in WoS and 128 in ERIC. After eliminating duplicates, the total number of studies found was 633. The application of criteria took part in two stages. First, the titles of the articles were checked to eliminate papers relevant to this review. The full papers of the remaining 84 studies were then sought. However, 9 of them could not be retrieved. Following the application of these criteria, a total of 25 studies were selected. This process is illustrated in Figure 1. Figure 2 presents the distribution of these articles by year of publication.

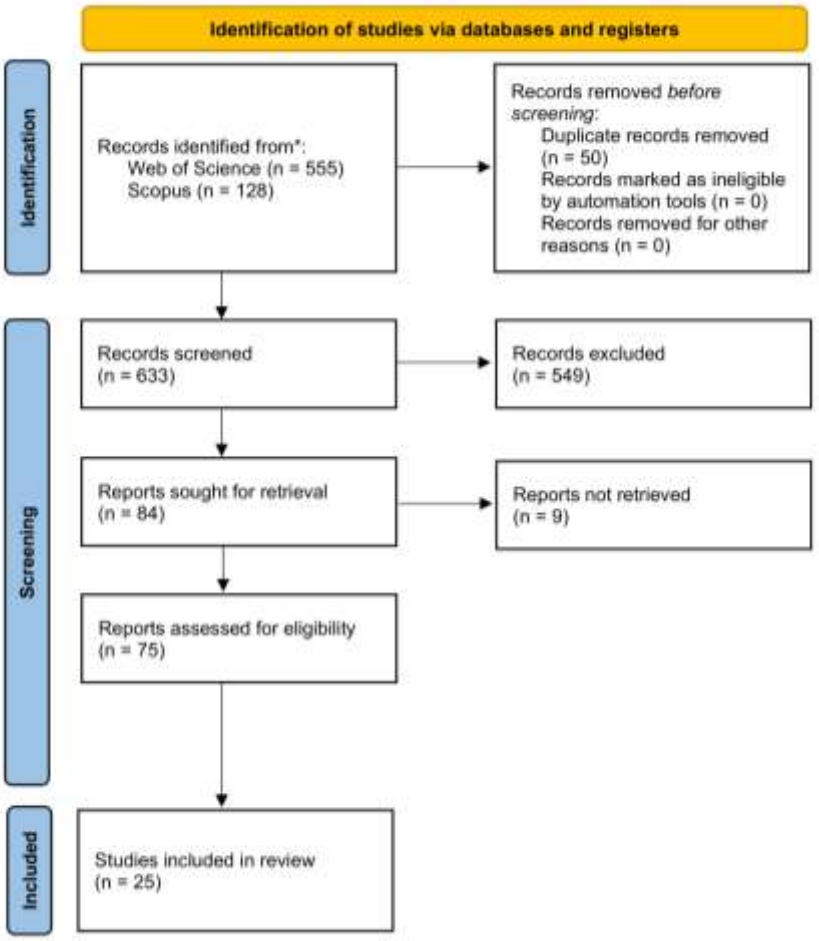

Figure 1. PRISMA diagram

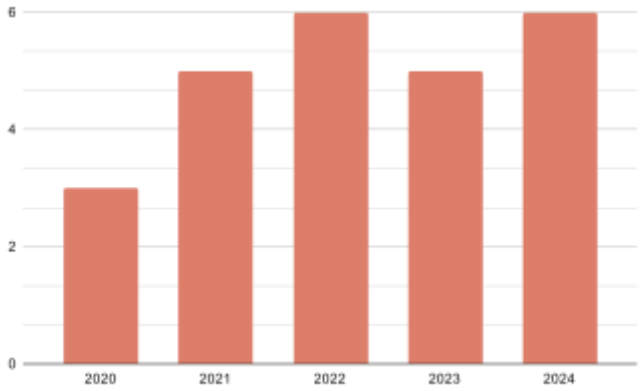

Figure 2. Distribution of articles by year

4. Results

The articles analysed in this review explore various dimensions of AR in language education, including its effects on learning outcomes (Belda-Medina & Marrahi-Gomez, 2023; Çelik & Yangin Ersanli, 2022), motivation (Binhomran & Altalhab, 2021), and perceptions of both teachers (Kaplan-Rakowski et al., 2023) and students (Tolba et al., 2024). The studies also cover a wide range of educational levels, from early childhood (Redondo et al., 2020) to adulthood (Fuccio et al., 2024), and predominantly employ mixed-method and quasi-experimental designs. The results and discussion are organized around the previously formulated RQs.

The main authors identified within the selected corpus include Belda-Medina, who appears once as a sole author (Belda-Medina, 2022) and three times as a co-author (Belda-Medina & Calvo-Ferrer, 2022; Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024); Marrahi-Gomez, who co-authored two of those studies (Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024); and Yangin Ersanli, who appears both as a sole author (Yangin Ersanli, 2023) and as a co-author (Çelik & Yangin Ersanli, 2022).

4.1. Research focuses

Of the twenty-five articles analysed, twenty-one address the use AR directly with students, while three focus on teacher preparation for implementing this technology, and one exclusively explores teachers' perceptions of AR. Among the twenty-one student-centred studies, nine primarily examine the overall effects of AR on the teaching–learning process without targeting any specific skill or area in their research questions. Seven studies focus specifically on vocabulary acquisition, while the remaining works address various other linguistic areas and competences. Table 1 presents the frequency with which each research focus was identified, noting that some articles investigated more than one focus.

Table 1. Frequency of research focus

Focus	Number of studies
Effect on Learning	9
Student Perceptions	7
Teacher Perceptions	7
Vocabulary Learning	7
Pedagogical Proposal	6
Motivation	5
Phonetics	2
Reading	2
Speaking	2
Grammar	1
Listening	1
Specific Communicative Task	1
Ease of Development	1
Ease of Implementation	1
Content-Language Integrated Learning (CLIL)	1
Teachers' Digital Competence (AR)	1

4.1.1. General Effects of AR on Language Learning

A significant body of research has examined the overall impact of AR on language education.

- **Primary education:** Aldossari and Alsuhaibani (2021) explored teachers' perceptions of AR in English instruction and its influence on learners' autonomy among primary school children. Similarly, Redondo et al. (2020) analysed AR's impact on early language learning and collected teachers' views on its classroom use.
- **Higher education:** Fuccio et al. (2024) designed an AR-based application to evaluate its effects on foreign language learning and cultural knowledge acquisition among university students.
- **Comparative and contextual studies:** Hung et al. (2023) examined and compared the effects of both Virtual Reality (VR) and AR in language classrooms, using the Attention, Relevance, Confidence, Satisfaction (ARCS) motivation model with primary school learners. Along the same lines, Liao et al. (2024) measured the effects of the AR application developed by Lin and Tsai (2021) on learning English as a foreign language and compared learning outcomes between students from urban and rural areas. Additionally, Zuo et al. (2022) created an AR-based educational game for teaching mathematics and English to primary learners.

4.1.2. AR and vocabulary acquisition

Vocabulary acquisition may be one of the most common lines of research, with 7 studies focusing on it. Findings have been summarised below.

- **Secondary education:** Belda-Medina and Marrahi-Gomez (2023) analysed students' perceptions and measured AR's effects on both vocabulary acquisition and motivation among secondary learners.

- **Primary education:** Binhomran and Altalhab (2021) studied AR's influence on vocabulary learning and motivation among primary school students, while Dalim et al. (2020) used AR to teach lexical items such as shapes, colors, and spatial vocabulary to young children.
- **Higher education and specialized contexts:** Khazaie and Derakhshan (2024) examined robot-assisted AR for English for medical purposes in university settings within a flipped classroom framework. Similarly, Larchen Costuchen et al. (2021) demonstrated that AR-based vocabulary learning can be effective even in low-resource environments in higher education.
- **Innovative methodologies:** At the primary level, Yangin Ersanli (2023) combined AR with storytelling to enhance vocabulary acquisition and retention, while Reyes-Ruiz (2022) implemented AR in a flipped classroom to teach abstract vocabulary to public school learners in Mexico. Finally, Wen (2021) expanded this line of research to Chinese character learning, showing AR's potential beyond English language contexts.

4.1.3. AR for Grammar, Competences, and Methodological Innovation

Several studies have used AR to develop grammatical knowledge and broader communicative competences.

- **Gamified and CLIL-based approaches:** Çelik and Yangin Ersanli (2022) integrated AR into a CLIL framework enriched with gamification to examine its effects on secondary learners' performance. Likewise, Chen (2020) investigated and designed an AR-based system scaffolding tool for primary education..
- **Game-based and formal instruction:** Khodabandeh (2023) developed an Augmented Reality Game for primary students to practice communicative functions such as asking for and giving directions. Marrahi-Gomez and Belda-Medina (2024) adopted a more formalist perspective, using AR to teach English grammar, specifically comparative and superlative structures, to secondary students.
- **Integrated skill development:** Pena-Acuna and Martinez-Sala (2022) merged storytelling and AR to foster reading and writing skills in English among primary learners.

4.1.4. AR for Phonetics and Pronunciation Instruction

Although to a much lesser extent, the implementation of AR in phonetics and pronunciation teaching programs has also been explored.

- **Adult learners:** Tolba et al. (2024) incorporated AR in teaching phonetics and pronunciation, while Wen et al. (2023) developed an AR-based model that provides real-time videoconference feedback on tongue and lip positioning during the production of English sounds.

4.1.5. Teachers' Perceptions and Integration of AR Technologies

Lastly, it is essential to assess teachers' ability to implement these technologies and to gather their perceptions regarding their use.

- **Pre-service teacher training:** Belda-Medina (2022) investigated pre-service teachers' capacity to integrate AR into their lessons and collected their perceptions after a trial period.
- **Digital competence and attitudes:** Belda-Medina and Calvo-Ferrer (2022) examined future teachers' digital competence and their attitudes toward AR use in the classroom.
- **AR-supported teacher education:** Lin and Tsai (2021) proposed an AR-supported language learning application and gathered feedback from university students preparing to become language teachers.
- **Extended Reality (XR) perspectives:** Kaplan-Rakowski et al. (2023) explored teachers' perceptions and use of Extended Reality (XR), a term encompassing Virtual Reality (VR), AR, and Mixed Reality (MR), providing a broader perspective on immersive technologies in education.

4.2. Effects by Educational Stage

One study (Reyes-Ruiz, 2022) was excluded from this section because it did not specify the educational stage in which AR was applied. Figure 3 displays the distribution of the selected studies according to the educational stage addressed.

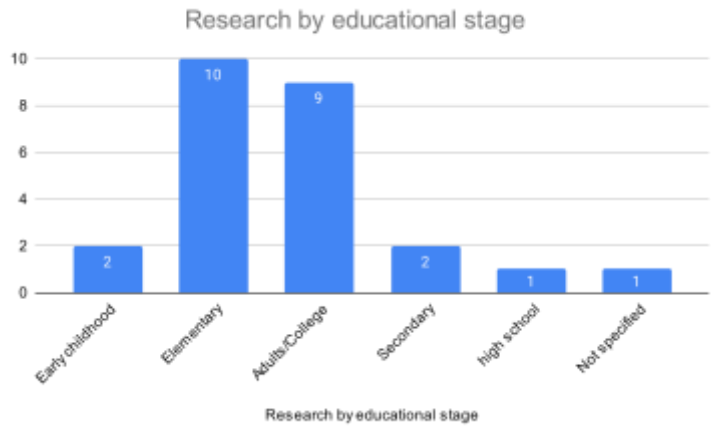

Figure 3. Number of studies by educational stage

4.2.1. Early Childhood Education

Only two studies explored the effects of AR in early childhood education (Dalim et al., 2020; Redondo et al., 2020). Both reported increased motivation and more positive attitudes toward language learning among students in experimental groups compared to control groups. However, while Redondo et al. (2020) observed a general improvement in learning outcomes, Dalim et al. (2020) did not find significant gains in vocabulary acquisition.

4.2.2. Primary Education

Ten of the twenty-five studies focused on primary education (Aldossari & Alsuhaibani, 2021; Binhomran & Altalhab, 2021; C.-H. Chen, 2020; Khodabandeh, 2023; Liao et al., 2024; Pena-Acuna & Martinez-Sala, 2022; Wen, 2021; Yangin Ersanli, 2023; Zuo et al., 2022). Their main findings are reported below:

- **Learning improvements:** Reported in teaching–learning processes (Aldossari & Alsuhaibani, 2021; C.-H. Chen, 2020; Khodabandeh, 2023; Liao et al., 2024), vocabulary learning (Yangin Ersanli, 2023), and reading/writing development (Pena-Acuna & Martinez-Sala, 2022)
- **Non-significant results:** Two studies found no significant differences between experimental and control groups (Binhomran & Altalhab, 2021; Hung et al., 2023).
- **Motivation and attitudes:** Most studies noted positive attitudes and increased motivation (Aldossari & Alsuhaibani, 2021; Binhomran & Altalhab, 2021; C.-H. Chen, 2020; Pena-Acuna & Martinez-Sala, 2022). However, Hung et al. (2023) reported no motivational improvement in the AR group.
- **Challenges:** Zuo et al. (2022) found that students' unfamiliarity with the technology caused confusion and reduced engagement.
- **Recommendations:** Teacher training in AR use was suggested to improve classroom implementation and outcomes (Aldossari & Alsuhaibani, 2021; Pena-Acuna & Martinez-Sala, 2022).

4.2.3. Secondary Education

Two studies examined secondary education (Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024)

- **Positive effects:** Increased motivation and interest (Belda-Medina & Marrahi-Gomez, 2023), and improved attitudes toward learning (Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024).
- **Non-significant results:** No measurable differences were found in vocabulary acquisition (Belda-Medina & Marrahi-Gomez, 2023) or grammar learning (Marrahi-Gomez & Belda-Medina, 2024).
- **Teacher perceptions:** Concerns were raised about mobile device distractions and lack of teacher training, leading to hesitancy in adopting AR despite its motivational benefits (Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024).

4.2.4. Post-Compulsory and Higher Education

One study addressed upper secondary (post-compulsory) education (Çelik & Yangin Ersanli, 2022), while nine focused on university or adult learning contexts (Belda-Medina, 2022; Belda-Medina & Calvo-Ferrer, 2022; Fuccio et al., 2024; Kaplan-Rakowski et al., 2023; Khazaie & Derakhshan, 2024; Larchen Costuchen et al., 2021; Lin & Tsai, 2021; Tolba et al., 2024; Wen et al., 2023). Findings have been organised by level.

- Upper secondary: Çelik and Yangin Ersanli (2022) reported positive attitudes and improved learning outcomes.
- Higher education:
    - **Improved engagement and collaboration:** AR promoted student engagement, collaborative learning, and social skill development (Fuccio et al., 2024).
    - **Discipline-specific gains:** Positive results were found in medical English instruction using AR and robotics (Khazaie & Derakhshan, 2024), and in phonetics teaching, improving phoneme differentiation and learning pace (Tolba et al., 2024; Wen et al., 2023).
    - **Vocabulary retention:** AR fostered long-term retention, even when short-term gains were not significant (Larchen Costuchen et al., 2021).
    - **Teacher and pre-service teacher perceptions:** While attitudes toward AR were generally positive (Belda-Medina, 2022; Belda-Medina & Calvo-Ferrer, 2022; Lin & Tsai, 2021), a lack of preparation, confidence, and software limitations were frequently cited as barriers (Belda-Medina, 2022; Kaplan-Rakowski et al., 2023).

4.3. Types of AR, Obstacles, and Differences by Language

Regarding the types of AR used, the majority of studies employed marker-based or vision-based AR. Only one study (Çelik & Yangin Ersanli, 2022) used location-based AR, while another combined both approaches (Belda-Medina, 2022). Additionally, one study utilized Near Field Communication (NFC)-based AR (Fuccio et al., 2024), and another implemented dynamic augmentation (Wen et al., 2023). Three studies (Aldossari & Alsuhaibani, 2021; Belda-Medina & Calvo-Ferrer, 2022; Hung et al., 2023)did not specify the type of AR used in their research.

In terms of potential obstacles to implementation, the most frequently reported challenge was the insufficient training of teachers in new technologies such as AR (Aldossari & Alsuhaibani, 2021; Belda-Medina, 2022; Belda-Medina & Calvo-Ferrer, 2022; Belda-Medina & Marrahi-Gomez, 2023; Marrahi-Gomez & Belda-Medina, 2024; Pena-Acuna & Martinez-Sala, 2022; Wen et al., 2023). However, the limited digital competence of students has also been identified as a factor that may restrict the effectiveness of AR (Zuo et al., 2022).

Moreover, while some studies have reported benefits for collaborative learning (Wen, 2021), others have identified limitations, such as reduced interaction (Wen et al., 2023). Therefore, teachers wishing to implement AR in their classrooms should make appropriate pedagogical adjustments to maximize its benefits, taking into account, for instance, the amount of time students spend daily on mobile devices (Marrahi-Gomez & Belda-Medina, 2024). Similarly, educators must ensure a fast and reliable internet connection, as several studies have noted issues related to connectivity (Belda-Medina & Marrahi-Gomez, 2023) and the lack of offline functionality in some AR tools (Wen et al., 2023).

5. Discussion

The aim of this study is to compile and identify the main lines of research on the use of AR in language education in recent years, as well as to highlight other elements relevant to the investigation of AR in classroom settings. To achieve this, four research questions were formulated to guide the structure and analysis of the results.

The first research question concerns the current research focuses in the implementation of AR for language teaching. The analysis suggests that approximately 36% of the studies collected concentrate on the general effects of AR on language learning, rather than addressing specific linguistic areas. This may be attributed to the relative novelty of the technology. However, studies focusing on more specific domains, such as phonetics (Tolba et al., 2024; Wen et al., 2023), appear to indicate that AR holds significant potential for supporting the development of skills that are typically challenging for learners of English as a foreign language.

From a theoretical perspective, these findings align closely with Connectivism (Zhao et al., 2020), as AR seems to facilitate the creation of learning networks that interconnect digital tools, real contexts, and learners themselves. This was particularly apparent in studies where AR promoted collaboration and communication, enabling students to learn from multiple nodes within their learning networks. Such outcomes appear consistent with Connectivist principles, reinforcing the notion that AR may serve as a medium for technologically mediated and socially situated learning.

Similarly, although 28% of the studies applied AR to vocabulary learning, Çelik and Yangin Ersanli (2022) demonstrated that, when integrated into CLIL, AR holds potential for both language and subject-specific vocabulary acquisition, as well as understanding of the disciplinary content with which it is combined. This finding suggests an unexplored potential for AR in English for Specific Purposes (ESP) instruction, where learners could practice language use in simulated professional environments related to their field of study.

In this regard, VR has already been established as an effective tool for training future professionals in industrial and technical fields beyond language learning (Liu et al., 2020), largely due to its capacity to simulate authentic work environments. While AR does not provide as deep an immersive experience as VR, it offers lower implementation costs and greater ease of integration (Kaplan-Rakowski et al., 2023), making it a more accessible and realistic option for educational institutions with limited budgets.

This tendency may echo Situated Learning Theory (Sagástegui, 2004), according to which learning is most effective when embedded in authentic contexts. AR allows learners to engage with linguistic content in settings that approximate real-world conditions, thereby enhancing contextualization and meaning-making. The pandemic context may have further amplified this relevance, as AR bridged the gap between the physical and virtual, restoring a sense of presence and immediacy in otherwise remote learning environments.

Regarding the integration of AR and storytelling tools, Pena-Acuna and Martinez-Sala (2022) emphasize the importance of considering both technical and methodological factors to ensure the effective application of this technology. Nonetheless, their study reported improvements in reading comprehension and written expression, as well as more positive student perceptions (Pena-Acuna & Martinez-Sala, 2022). Similarly, AR-based storytelling appears to support vocabulary learning and retention (Yangin Ersanli, 2023).

These multimodal storytelling approaches could also illustrate Dual Coding Theory (Clark & Paivio, 1991). By combining verbal input (narratives, vocabulary) with visual or spatial augmentation, AR fosters the integration of verbal and non-verbal channels, enhancing memory and retention. The prevalence of studies showing improved recall and motivation supports this dual processing effect.

Teachers could leverage this approach by adapting narratives to the specific needs of their class groups. For example, by incorporating cultural elements from the target language variety or by designing stories that visually illustrate grammatical concepts. The first approach aligns with the findings of Cheng (2023), who, although not focused specifically on language teaching, explored the use of AR in fostering cultural competence. The second approach is supported by Marrahi-Gomez and Belda-Medina (2024), who observed improvements in students' attitudes toward learning. Although their study did not find significant differences in grammatical learning outcomes, this may be due to the short duration of the intervention, which lasted only four weeks.

The second research question focuses on the effects of AR according to the learners' educational stage. In this regard, it is essential to indicate at least generally which stage students belong to, even when anonymity must be preserved to prevent participant identification. For instance, depending on the country, primary education may begin between the ages of five and seven and end between eleven and twelve. In other contexts, schooling is organized by grade level rather than educational stages, which further complicates cross-study comparisons. These contextual variations may explain some of the disparities in results between Hung et al. (2023) and other studies conducted at the same level (Peña-Acuña & Martínez-Sala, 2022; Yangin Ersanli, 2023; Zuo et al., 2022), potentially due to differences in learners' cognitive development.

However, this hypothesis is challenged by the findings of Binhomran and Altalhab (2021), who also reported no significant differences between experimental and control groups, despite working with students aged eleven to twelve, typically the final years of primary education. This suggests that the methodological approach, rather than cognitive maturity, may account for these discrepancies. Therefore, two key considerations emerge: first, teachers should analyse the needs and capabilities of their specific class groups to determine whether AR can genuinely enhance the teaching–learning process and to prevent potential confusion among learners (Zuo et al., 2022); and second, both in-service and pre-service teachers must receive adequate training in emerging technologies to ensure proper implementation (Aldossari & Alsuhaibani, 2021; Belda-Medina & Marrahi-Gomez, 2023; Pena-Acuna & Martinez-Sala, 2022; Wen et al., 2023) and to conduct accurate assessments of student needs.

Regarding the effects of AR, several consistent outcomes have been observed across different educational stages, along with some stage-specific effects. Belda-Medina (2022) and Dalim et al. (2020) both reported that AR facilitated the understanding of spatial concepts, the former among adult learners and the latter among preschool children. The impact of AR on vocabulary retention has been investigated at all educational levels, yielding mixed results even within the same stage (Belda-Medina & Calvo-Ferrer, 2022; Binhomran & Altalhab, 2021; Dalim et al., 2020; Larchen Costuchen et al., 2021; Liao et al., 2024). These variations may be attributed to differences in research methodologies or to learner-specific characteristics, such as participants' levels of digital competence. Furthermore, AR has consistently been found to enhance student motivation across all educational stages (Aldossari & Alsuhaibani, 2021; Belda-Medina & Marrahi-Gomez, 2023; Redondo et al., 2020).

The third research question addresses the types of AR employed in experimental studies. The most common form used in language classrooms is vision-based or marker-based AR, which projects an image, video, or 3D model onto a predefined

marker. However, Wen et al. (Wen et al., 2023) introduced a more innovative use of the technology through dynamic augmentation, applying it directly to students' faces to indicate the correct positions of the lips and teeth during pronunciation. The predominance of the vision-based type may be explained by its ease of implementation. Nevertheless, the limited number of studies exploring other AR modalities reveals a gap in the literature, suggesting that the full potential of AR technology in language education remains underexplored.

Finally, in response to the fourth research question, it can be concluded that the main obstacle lies in teachers' insufficient digital competence, which limits the effective integration of new technologies in educational contexts ((Aldossari & Alsuhaibani, 2021, p. 20; Belda-Medina, 2022; Belda-Medina & Calvo-Ferrer, 2022; Belda-Medina & Marrahi-Gomez, 2023; Hung et al., 2023; Marrahi-Gomez & Belda-Medina, 2024; Pena-Acuna & Martinez-Sala, 2022; Wen et al., 2023). However, several recurring issues have also been reported across different educational stages, such as technical limitations related to software, hardware, or connectivity problems (Belda-Medina, 2022; Belda-Medina & Calvo-Ferrer, 2022; Belda-Medina & Marrahi-Gomez, 2023; Wen et al., 2023), as well as distractions caused by mobile phone use, the most common device for accessing AR applications (Belda-Medina & Marrahi-Gomez, 2023; Hung et al., 2023; Marrahi-Gomez & Belda-Medina, 2024).

Nevertheless, these findings should be interpreted with caution. The present review encompasses a relatively limited number of empirical studies, and even within this corpus, results were heterogeneous: some showing clear learning gains while others reported neutral or inconclusive outcomes. This variability, coupled with differences in methodological design, participant profiles, and instructional duration, limits the generalizability of the conclusions. Hence, while the trends identified appear theoretically robust, they remain preliminary and warrant further validation through larger-scale and longitudinal research.

In this context, it is crucial that future educational policies prioritize and promote the development of teacher training programs in emerging technologies. To minimize classroom distractions, such initiatives should not focus solely on technical instruction but also on pedagogical strategies for the effective implementation of these tools, in order to maximize their educational benefits. Moreover, investing in institutional technological resources, such as Chromebooks or dedicated classroom devices, could provide viable alternatives to mobile phones, ensuring a more controlled and focused learning environment.

Overall, the post-2020 expansion of AR research may thus be viewed as a theoretically grounded yet still evolving response to pandemic-driven educational transformation, a shift toward more networked, situated, and multimodal conceptions of language learning.

6. Conclusions

The rapid advancement of Information and Communication Technologies (ICT) offers new solutions to challenges and needs within language classrooms. However, the pace at which these changes occur also poses difficulties for both educators and researchers in keeping track of and organizing information about these innovations. To address this, the present study has compiled and analyzed the impact of AR on foreign language learning, with particular attention to its effects across educational stages, prevailing research trends, the types of AR employed, and the potential obstacles to its classroom implementation.

The findings indicate that AR can have a positive impact on foreign language teaching and learning by enhancing motivation, engagement, and knowledge and vocabulary retention among students. In line with the second research question, it was found that these benefits are consistent across educational stages, though effective outcomes depend on the use of methodologies tailored to learners' specific needs. Regarding the first research question, several innovative research focuses were identified, such as the use of dynamic augmentation for phonetics instruction, which demonstrates AR's potential to target specific areas of language learning. Other applications include storytelling-based AR, which allows students to interact with narratives in immersive and meaningful ways. Furthermore, this study has identified the main types of AR used in language education.

Nonetheless, as highlighted by the fourth research question, several challenges to implementation persist. Chief among them is the lack of teacher training in the use of emerging technologies. Additional difficulties include technical limitations, such as connectivity and infrastructure issues, as well as potential distractions caused by mobile phone use, the most common device for AR access. To overcome these barriers, which currently hinder schools' ability to adapt to new technologies, it is recommended that educational institutions invest in institutional equipment and teacher training programs to promote more effective and sustainable integration of AR in the classroom.

Looking ahead, the development of innovative AR applications represents a promising direction for future research. At present, most studies focus primarily on vocabulary learning or general language acquisition, leaving a gap in the exploration of AR's potential to foster specific linguistic competences. Additionally, the predominance of marker-based AR reveals another gap in the literature, as location-based and dynamic augmentation modalities remain relatively unexplored in the context of language education.

It is important to acknowledge the limitations of this study. First, despite efforts to ensure analytical rigour, the scope of the review remains limited. The final corpus of twenty-five studies provides a focused yet relatively small sample of the broader research landscape on AR in language education. Consequently, the results should be interpreted with caution, as they may not capture the full diversity of existing work in this rapidly evolving field.

Second, the studies included in the review exhibit notable heterogeneity in terms of research design, participant profiles, instructional contexts, and duration of interventions. This variability likely contributed to the mixed results observed across the corpus and constrains the comparability of findings. Therefore, while the identified patterns appear to align with established learning theories, they should be considered indicative rather than conclusive.

Third, the review was limited to peer-reviewed journal articles published in English, which may have excluded relevant research published in other languages or disseminated through alternative channels such as conference proceedings or doctoral dissertations. Broadening the linguistic and publication scope in future reviews could yield a more comprehensive understanding of the topic.

Finally, given the fast-paced evolution of AR technologies, some of the studies analysed may rely on tools or systems that have since become outdated. As hardware and software capabilities continue to advance, future research should revisit these findings to evaluate how newer generations of AR applications influence learning outcomes.

Funding: This research was funded by Generalitat Valenciana cod. CIAICO/2022/079.
Conflicts of Interest: The authors declare no conflict of interest
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