

PAPER

Enhancing Language Learning Experience with Augmented Reality Games: A Systematic Review of Empirical Studies from 2019–2023

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ABSTRACT

This systematic review study synthesizes and presents research findings relevant to the instructional application of gamified augmented reality (AR) tools in language learning from 25 peer-reviewed research from 2019 to 2023 with preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. The review purpose was to identify: (1) the commonly adopted AR games in language classrooms; and (2) students' perceptions of learning languages with AR games. The main study findings suggest the focus of the past research efforts was placed mostly on self-designed AR games while there is a relative lack of research interest in premade or existing games for language learning. In terms of students' perceptions, the findings indicate that students generally have positive perceptions toward AR games in the language learning experience. Moreover, games that feature a combination of 3D models and animations, including peer collaboration and competition, seem to be the favorite for digital native students. The findings also reported concerns from the students such as the need for more assistance from the instructors. Suggestions for modification of instructional design and future research in the field of AR-integrated language learning are also provided.

KEYWORDS

augmented reality (AR), AR games, game-based learning, language learning

1 INTRODUCTION

Digital game-based language learning (DGBLL) [1] is an established instructional approach that utilizes video games to support English language learning by maximizing students' interest in the process of mastering language proficiency. As noted by contemporary authors [2], instructional designers, teachers, and language learners often view video games as an interactive, multimodal assistance media in language learning. Yang and collaborators [3] argue that DGBLL has the potential to boost motivation for learning, offer instant feedback, cultivate advanced

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problem-solving abilities, and improve overall educational outcomes. As noted by Cakici [4], these games integrate thinking and action into meaningful activities to achieve specific objectives. Learners may benefit from the experience of playing games while learning because they are acquiring target knowledge in an interactive manner that is also motivating [5]. Furthermore, some authors suggest [6] that DGBLL also improves confidence and reduces anxiety when learning a language. Educational games serve as powerful learning instruments, providing students with a simulated setting where they can experiment with different choices without fearing failure.

In recent years, the DGBLL approach has been strongly infused with AR technologies, which combine virtual elements such as 3D modeling and auditory immersion including sensing with the real world [7], allowing users to see their environmental surroundings with computer-generated objects in the real context [8]. In essence, AR technology provides a real-time direct or indirect view of a physical real-world environment that has been enhanced augmented by adding virtual computer-generated information to it [9]. The instructional value of DGBLL is routed in constructivism, which emphasizes the role of contextual input for facilitating the meaningful process of constructing knowledge based on students' own experiences [10]. According to Zhao and collaborators [11], as a sub-theory of constructivism, Situated Cognition Theory is closely related to AR in the education context, which does not only refer to concrete learning in localized situations but also emphasizes the interconnection of social and activity systems within authentic environments. Therefore, through interaction with virtual objects and environmental surroundings, students can learn more efficiently with AR [12].

2 BACKGROUND

2.1 Literature review

As an already mature technology, AR has attracted significant attention among contemporary authors. The review of the existing body of literature revealed a rich tradition of utilizing AR technologies and game-based learning in a language curriculum [13]–[18]. AR game-based platforms consist of highly distinguished instructional features such as interactivity, multimodal input (textual, auditory, visual, haptic, and other cues), and a combination of a real-time view of a physical, real-world environment with a graphic overlay providing additional information that further explains the meaning of the real-world content. Given the affordances AR game-based apps offer, this technology strongly supports a variety of language learning strategies, facilitating both affective and cognitive aspects of learning across K-12, higher education, and informal learning settings [19], [20], [21].

Although its origins date back to the late 1960s [22], the use of AR-based instructional strategies has been identified as a rising educational trend in the past two decades [23]. For instance, in *Time* magazine, author Fletcher [24] noted that AR is not a conceptual novelty, but integrated with today's omnipresent development of mobile devices (smartphones, tablets, etc.), it has gained tremendous popularity among educators and the general public. From the language learning standpoint, one among a number of prominent characteristics of AR game-based platforms refers to its possibility to facilitate a better understanding of abstract concepts by providing visual cues associated with a learning context in real-time [25], [26]. Equally valuable is the collaborative nature [27], [28] of AR game-based platforms, which offer students a multitude of opportunities for situated or contextual social interaction

centered around on the given learning topic. Yang [29] further elaborated the notion that being exposed to the immediate social environment, culture, or a target language community tremendously adds to the language learning experience via augmented reality.

Beyond providing an inspiring environment for dynamic interaction with educational content and overall student engagement, AR game-based platforms are exceptionally valuable for amplifying motivation, including positive learning attitudes. There is a significant body of research [30], [31] highlighting motivation as a pivotal component of the successful language learning process. As noted by prominent contemporary authors Marrahi-Gomez & Belda-Medina [32], AR in language teaching is often implemented on a mobile device, providing an everydayness that cannot be replaced with any other element. Such an effect creates a sense of familiarity in the learner that leads to an increased motivation, as they can learn through a familiar element.

Another measurable benefit of integrating AR game-based instructional strategies points to increased self-efficacy of learners [33], [34], and [35]. Given the widely adopted definition of self-efficacy in learning [36] as a student's belief in self-regulation, especially belief in self-capabilities to organize and execute actions, including the necessity of investing effort to achieve a learning goal, the integration of this particular instructional strategy seems appropriate and supportive. Motivation, attitudes, and self-efficacy are often explored in conjunction [37] as they are related to learning contracts that play a significant role in foreign language acquisition.

2.2 Previous reviews

Applying AR games in language learning has been a research focus in the past few decades. Previous systematic reviews have explored mostly all types of AR tools in language learning; however, limited attention has been paid to learning foreign languages specifically with AR games. For example, Pinto et al. [38] investigated how virtual reality (VR) gamification can be integrated into language learning but omitted the role of AR technology in this subject matter. Similarly to Pinto and collaborators' study, Majid and Salam [39] examined AR applications in language learning but did not focus on AR games, only on AR general platforms. However, there is a myriad of authors, such as Fortaris et al. [40] and Alper et al. [41], who focused their exploration on AR game-based learning in education overall but did not focus on language learning *per se*. On the other hand, Hung et al. [42] focused on digital games in language learning but not specifically on AR games. Notably, a recent review by Lin and Wei [43] investigated the application of VR and AR games in vocabulary learning but did not explore learners' perceptions or other language skills except vocabulary learning.

These reviews highlight the need for a systematic review that focuses specifically on foreign language learning with AR games. Therefore, this systematic review intends to determine what AR games are generally adopted and what the advantages and disadvantages of AR game-based language learning are based on students' perceptions of the AR games and teaching strategies, which can guide future research and practice in this field.

2.3 Research questions

Considering the purpose of this study, identifying which specific AR games are most applied in language learning may offer significant benefits not just to education

practitioners but also to researchers who intend to address gaps in the current body of literature. As a proven effective instructional strategy, gamified AR supports teachers' decisions in crafting the learning environment, including a selection of teaching methods to meet students' needs as well as learning objectives for the given unit. Moreover, students' perceptions of these AR tools are a crucial factor to consider in the instructional design process. Students' learning experience and learning outcomes are often directly linked to how effectively the tools are integrated into the learning environment. Incorporating students' feedback on how gamified AR tools impact their language learning journey is essential for shaping a learner-centered teaching approach. Therefore, the following research questions guide the authors' efforts in conducting the present systematic review:

Research question 1: What gamified AR tools were applied in language learning?

Research question 2: What were students' perceptions of integrating gamified tools into language learning classrooms?

3 METHODOLOGY

To answer the research questions with the most relevant and recent studies, this systematic review is conducted on peer-reviewed articles published between 2019–2023 which focused on the application of AR games in language learning with the preferred reporting items for systematic reviews and meta-analyses guidelines (PRISMA) [44].

3.1 Search strategy

The comprehensive search of the articles was conducted with four prominent electronic databases, including Web of Science, Scopus, Academic Search Premier, and Education Source. The following search strings were utilized: “AR” OR “Augmented Reality” AND “language” OR “language learning” OR “second language learning” OR “foreign language learning” AND “game-based learning” OR “educational games” OR “video games” OR “computer games.”

3.2 Eligibility criteria

All the articles addressed in the research were selected based on the inclusion/exclusion criteria in Table 1.

Table 1. Inclusion and exclusion criteria of the review

Inclusion	Exclusion
The study must be conducted with a specific AR tool	Any study that used other tools
The study must use a game-based learning strategy	Any study does not use a game-based learning strategy
The study must be an empirical study	Any study that does not contain empirical study
The study must be related to language learning	Any study that is not related to language learning
The study must include students' perceptions of the teaching methods and gamified AR tools	Any study that does not include students' perceptions of the teaching methods and gamified AR tools
The study must be published in English	The study was published in other languages
The articles must be peer-reviewed	Any study is not peer-reviewed
The full text of the articles must be available online	Any study does not have access

3.3 Article selection

This initial search yielded 1071 studies with 11 duplicates that were removed immediately. Based on a thorough screening of the study titles and abstracts for appropriateness, the researchers excluded 965 articles, while 95 articles remained to be reviewed in the full text. The full-text review followed the proposed criteria, which resulted in excluding 70 articles. Therefore, 25 articles were included for an in-depth analysis of the study at last [45]–[69]. The PRISMA process is summarized in Figure 1.

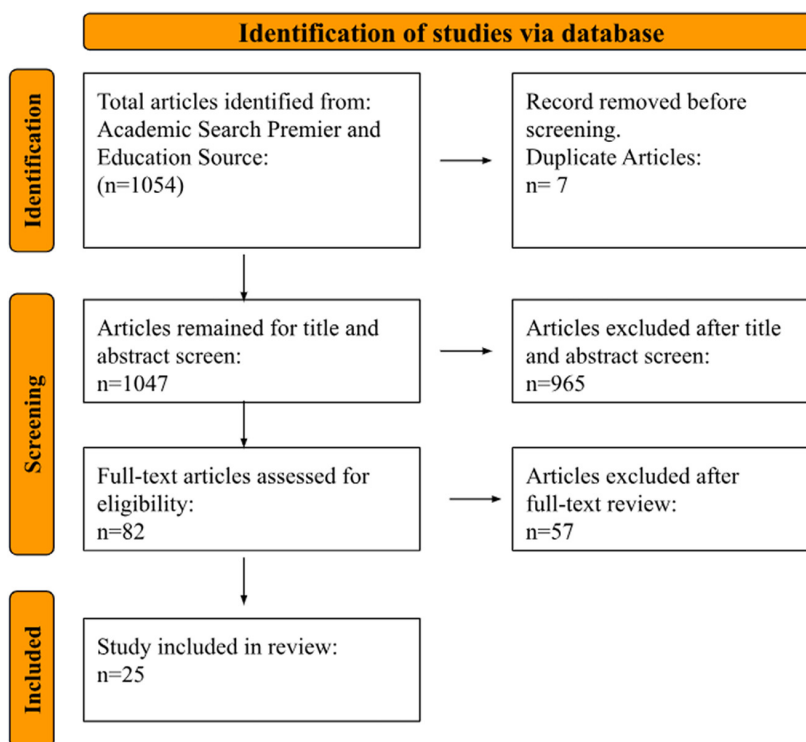


Fig. 1. PRISMA chart for the screening process

3.4 Coding process

The authors employed a content analysis method for textual analysis [70] in order to code the 25 articles included in this study. First, the coding categories of the basic study facts were constructed in a Google spreadsheet with learners’ age group, first language, target language, language skills, and AR games applied. This approach allowed authors not only to answer the first research question but also to provide an overview of the studies. To address the second research question, each author read the 25 articles, independently summarized the findings on students’ perceptions, and categorized the themes of what factors affect students’ perception of the AR games and instructional strategies. After this process was completed, the authors were involved in an in-depth discussion focused on coding discrepancies and finally confirmed the coding interpretations.

3.5 Demographics of the articles included

Relevant factors such as students’ first language, the language being taught, contexts, and language skills explored are fully addressed, which supported the

researchers in their efforts to provide an overview of the basic features of the studies on AR games in language learning. This approach also was instrumental in assessing background and major trends in the field.

Year of publication. During 2019–2023, there were eight articles published in both 2020 and 2023. Three articles were published in 2019, and five were published in 2022, with only one article published in 2021. The year of publication results are demonstrated in Table 2.

Table 2. Year of publication

Year	Number of the Studies
2019	3
2020	8
2021	1
2022	5
2023	8

Target language in the study. Concerning the language being taught to the students via AR gaming platforms, English appears to be the dominant target language in this study. 23 articles of the 25 articles included aimed to explore how AR games were applied in language learning. The other two articles focused on the target languages of Persian and Chinese. The results of the target language in the studies are shown in Table 3.

Table 3. Target languages in the studies

Target Languages	Number of the Studies
English	23
Chinese	1
Persian	1

Students' first language. Regarding the first language (L1) of the students, Chinese accounts for nine of the 25 studies. Turkish is the second-most L1 for the students, with 5 studies included. For other students' L1, Persian, Korean, English, Indonesian, Malay, and Spanish are also included. The results of students' L1 included in the studies are summarized in Table 4.

Table 4. Students' first languages

Learners' First Language	Number of the Studies
Chinese	9
Turkish	5
Persian	3
English	2
Korean	2
Indonesian	2
Malay	1
Spanish	1

Context of education. Ten of the studies included in this analysis were conducted in the higher education context. Six studies were conducted in elementary schools, with five of them in preschool context, and four of them in middle/high school. Table 5 Displays how the studies were divided into different contexts of education.

Table 5. Context of education in the studies

Learning Context	Number of the Studies
Higher Education	10
Elementary School	6
Preschool	5
High/Middle School	4

Instructional content. Among the 25 articles reviewed, eight studies concentrated on vocabulary acquisition, while seven were dedicated to content-based language learning, which refers to learning languages based on class content such as culture, medicine, and biology. Of the remaining 10 articles, two did not target a specific language skill, whereas the others addressed various aspects of language instruction, including teaching reading, writing, speaking, pronunciation, word roots and affixes, and orthographic knowledge. Notably, no studies were identified that focused on listening skills. The distribution of instructional content covered in these studies is illustrated in Table 6.

Table 6. Teaching content

Teaching Content	Number of the Studies
Vocabulary	8
Content-based Language Learning	7
Pronunciation	2
Speaking	2
Reading	1
Writing	1
Affixes and Word Root	1
Orthographic Knowledge	1
No Specific Skills	2

4 FINDINGS

The study findings are organized and presented in a manner of answering the proposed research questions. As such the author first addressed gamified AR tools, and then the focus was shifted to student perceptions.

Research Question 1: What gamified AR tools were applied in language learning?

By analyzing the 25 articles, the gamified AR tools were identified. The major gamified AR tools were self-designed games by the researchers, with 16 articles related to this type of tool. AR flashcards and AR paper games ($n = 6$), *Pokémon Go!*

($n = 2$), and 7 Scenes ($n = 1$) are also popular games/tools for language education. The summary of the AR games/tools in the studies is displayed in Table 7.

Table 7. Summary of the AR games/tools

AR Games/Tools	Number of the Studies
Self-Designed AR Game	16
AR Flashcards and AR paper games	6
<i>Pokémon Go</i>	2
7 Scenes	1

Among the 16 studies with self-designed AR games, the games/tools were developed with different software, including unity 3D combined with Vuforia ($n = 7$), ARIS ($n = 2$), HP Reveal, also known as Aurasma ($n = 2$), ARCore ($n = 1$), unite AR ($n = 1$), and Metaverse studio ($n = 1$). Two studies did not mention which software was used to design the game. The details of the development tools used for designing AR games are summarized in Table 8.

Table 8. Development tools for self-designed/custom AR games

Development Tools for Self-Designed/Custom AR Games	Number of the Studies
Unity 3D with Vuforia	7
HP Reveal (Aurasma)	2
ARIS	2
AR Core	1
Unite AR	1
Metaverse Studio	1
Not mentioned	2

Research Question 2: What Were Students' Perceptions on Integrating Gamified AR Tools into Language Learning Classrooms?

The findings in 25 studies explicitly stated that students had generally perceived learning languages with gamified AR tools positively. The major contributors to students' positive perceptions are the fun and interesting characteristics of the AR games, [52], [57], [59], [61], [62], [64], [67], [69], feelings of engagement and motivation [45], [47], [52], [53], [54], [55], [56], [58], [62], [63], [65], [68], easy access to the AR games [48], [51], [55], [60], [67], [69], collaboration and competition with peers [47], [50], [54], [66], [67], [68], interaction with the environment and context [46], [58], [60], [61], and increased curiosity [45], [53]. Several studies reported students' favorite features or functions in AR games, which are 3D images or 3D models, animations, popup pictures, and sounds [49], [52], [63], [65], [67], and [69]. Some learners also expressed their belief that they can learn a language in a self-paced method with AR games, such as taking notes [52].

Graphic representation, as shown in Figure 2, emphasizes the major elements of student perception that have been identified in the analyzed publications. Specifically, the presented graphic shows two general types of AR games: a) self-designed AR games and b) AR flashcards and paper games. Following the analysis results, it is

apparent that two specific AR games (*Pokémon Go* and *7 Scenes*) stood out as one of the most attractive AR applications that have drawn researchers’ attention since 2019. Consequently, the conducted analysis resulted in identifying eight main areas of student perception with dominant categories such as engagement, motivation, or entertainment.

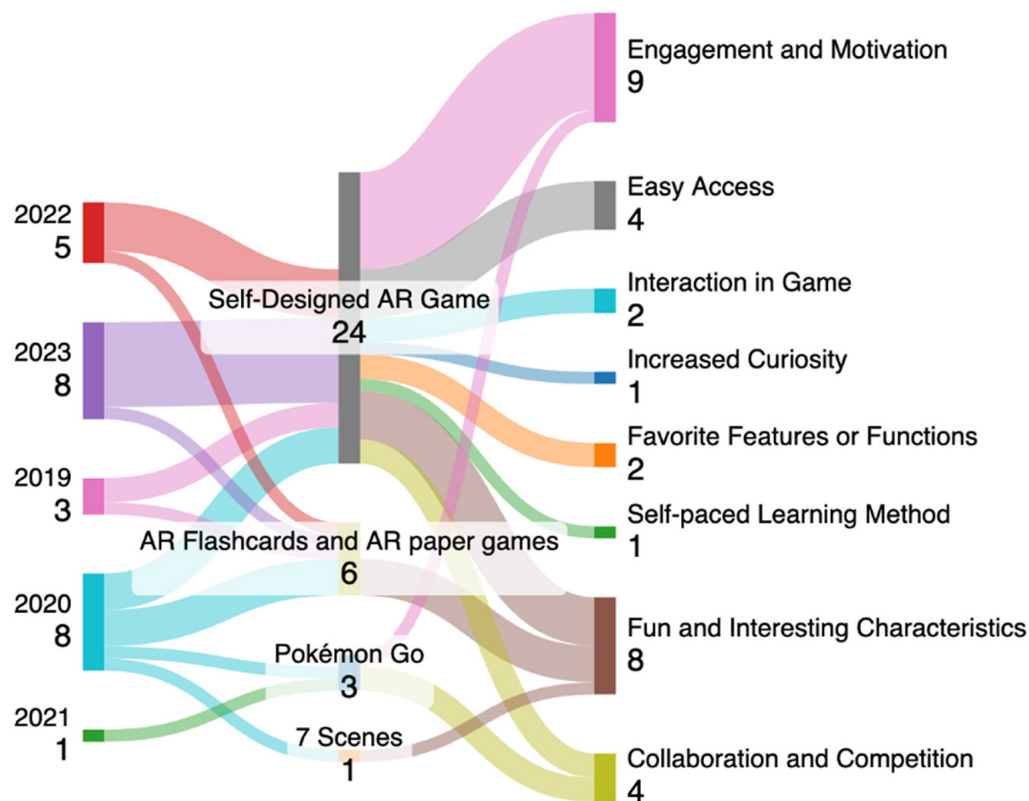


Fig. 2. The Relation among articles, AR tools or games and students’ perception

It is worth mentioning that learners also reported their concerns and negative perceptions toward learning languages with AR games as well. For example, when a location-based AR game was applied in the study, the detection of location may be inaccurate due to the weak Internet connection [57]. Also, certain comments from the participants indicated concerns such as AR being harmful to the eyes and distractions from the moving pictures [65]. Moreover, some students mentioned that they did not feel confident when using the AR applications alone and they needed more assistance from the instructors [49].

5 DISCUSSION

5.1 Characteristics of the studies

Integration of AR games in language learning gains momentum in the field of technology-integrated language learning. The number of articles related to this topic has continued to soar during the past five years, especially in 2023. This proliferation of research appears to be attributed to the popularity and development of AR in recent years [23]. The results of this study suggest the dominant presence of the

English language in the analyzed articles, which undoubtedly further reflects the current trends in language positioning worldwide as well as learners' interests in studying foreign languages [71]. Regarding students' L1, Chinese accounts for the most in the 25 studies, due to China's largest population of English language learners worldwide.

Although the present research encompasses all educational levels, higher education is the major context in which the studies were conducted. This echoes the findings from Hein et al. [72] that most of the studies related to VR/AR in education were in higher education. A possible reason is that adults or college students are more familiar with digital devices and games than students in K-12 contexts. Moreover, the flexibility of the curriculum and the rich resources of different technologies made it easier for researchers to conduct studies in higher education contexts [73]. Ethical concerns also influence research related to AR games in language learning since studies on younger students may require more ethnicity, like parents' consent [74].

As Peixoto et al. [75] mentioned. AR has the potential to improve students' different types of language skills; the current review also indicated the diverse language skills explored in the studies. More specifically, most of the studies focused on vocabulary learning. This is not a surprising finding considering the abundant evidence of the positive effects of integrating technology into vocabulary learning in recent years and the importance of vocabulary in language learning. Content-based language learning is also a main language skill in the 25 studies included, in which researchers applied AR games to teach both languages and contents such as cultural knowledge [60] and biology [47].

5.2 The AR games addressed in the studies

The AR games included in the current systematic review can be primarily categorized into two types as follows: a) existing (premade) games and b) self-designed games. Among the 25 included studies, self-designed games count for nearly half of the studies, which include 11 different existing AR games that were presented. This suggests the lack of a universally adopted AR game used for language learning. The current trend may also indicate that designing custom AR games is relatively accessible for language educators, as AR development software allows for game creation with minimal coding expertise. Nevertheless, the current review describes both categories of AR games included to provide language educators with a more comprehensive understanding of AR games in language learning.

Existing AR games included. The most commonly utilized existing AR games are AR flashcards and paper games. AR flashcards enable learners to scan a marker using their smartphones or tablets, which then displays a 3D model and animation of the word on the screen while simultaneously providing its pronunciation. AR flashcards are predominantly employed in early language learning settings, particularly for vocabulary acquisition. Their dual-channel approach, incorporating both visual and auditory stimuli, serves to enhance student engagement and motivation by making the learning process more interactive and enjoyable. According to Yilmaz et al. [69], AR flashcards have been shown to not only improve learning outcomes but also bolster retention rates, with students retaining newly learned vocabulary for extended periods. Chen [47] investigated the use of a video-based flashcard in a biology class, where tablets were used to scan models of insects and display educational AR videos containing fundamental information about these insects. This study

integrated AR videos with various interactive elements, including quizzes and scavenger hunts, to provide students with greater intrinsic motivation and improved content comprehension.

The body of literature reveals that some authors, such as Wen [67], use AR paper games for teaching Chinese character composition. Similar to AR flashcards, a paper-based type of AR game requires students to use a mobile device to scan cards featuring Chinese characters. Students work collaboratively to examine the composition of these characters and attempt to identify them independently. This specific AR paper game represents a valuable tool for teaching languages that involve complex characters, such as Chinese, Korean, and Japanese, by enhancing students' orthographic knowledge.

The primary advantage of AR flashcards and AR paper games in language learning lies in their user-friendliness, as students can engage with these tools without requiring extensive prior knowledge of AR technology. Nonetheless, the application of these tools is generally restricted to early language education contexts. AR videos, on the other hand, offer broader applicability in various educational settings, though it is advisable for educators to integrate AR videos with diverse interactive activities to optimize their effectiveness.

As a widely recognized location-based AR game that has maintained popularity for nearly a decade, *Pokémon Go* has found diverse applications in educational settings. The game's incorporation of engaging elements and cartoon characters has proven effective in capturing students' attention and enhancing their learning experiences. Additionally, *Pokémon Go* offers various avenues for improving students' language skills. For instance, Wu [68] utilized the game to teach students about word roots and affixes, as the names of the game's creatures serve as illustrative examples of prefix and suffix combinations with root words. Similarly, Halaczkiwicz [50] employed *Pokémon Go* as a medium for developing students' English writing proficiency, requiring them to document their game experiences in online "game journals." Unlike other AR games, *Pokémon Go* not only merges virtual elements with reality but also enjoys widespread appeal among young language learners due to its association with a well-known franchise. Furthermore, with one of the largest player bases globally, *Pokémon Go* offers a practical tool for both educators and learners in the instructional process due to people's familiarity with the game.

7 Scenes, a location-based AR tour application, was applied by Lee and Park [57] to facilitate college students creating gamified digital stories. This application not only enables students to engage with various game formats but also allows them to craft diverse narrative genres—such as detective, fictional, guide, and mystery—using the target language. The use of *7 Scenes* demonstrates that location-based AR games can provide students with opportunities to employ the target language in authentic contexts, thereby enhancing their productive language skills. Furthermore, the capacity for students to design and create their own games underscores the versatility of this AR tool, making it suitable for learners across different age groups.

Development software for self-designed AR games. Among the 16 studies that utilized self-designed AR games, Unity 3D with Vuforia, HP (Reveal, formerly known as Aurasma not available any longer), and ARIS emerged as the most frequently employed development platforms. This observation corroborates findings from previous reviews [71], [76], [77]. In particular, Unity 3D, when combined with Vuforia, has garnered significant attention for AR game development. This integration leverages Unity 3D's extensive capabilities in 3D modeling and animation with Vuforia's advanced tracking and recognition functionalities, enabling developers to create AR applications that enhance environmental interactivity and offer

a more engaging learning experience. Additionally, two relatively recent AR game development platforms, Metaverse studio and unite AR, were featured in the studies [45], [55]. However, Metaverse studio ceased operations as of February 2024, thereby removing it from the list of available tools for language educators and researchers interested in AR game development. Conversely, unite AR, which was introduced around 2020, has gained popularity due to several factors: it is user-friendly and does not necessitate programming skills, supports the creation of AR applications for both iOS and Android platforms, and offers a wealth of resources applicable to education, advertising, and events. Notably, in the context of self-designed AR games, key game elements frequently utilized include quizzes, scavenger hunts, and team challenges. It is advisable for language educators to not only focus on designing 3D models and animations but also to carefully consider the integration of these game mechanics into their game designs. Incorporating such interactive elements can enhance the educational value and engagement of AR applications, thereby fostering a more effective and stimulating learning environment.

Implications for AR games applied in language learning classrooms. The use of AR games in language learning provides valuable insights for future studies and practice. One of the key trends is the increasing use of interactive, user-friendly AR flashcards and paper games, which are particularly effective in early language learning environments. These tools engage students through dual-channel learning [78], incorporating both visual and auditory elements, which improves students' retention level and engagement. Games such as *Pokémon Go* and *7 Scenes* also highlight the potential for location-based AR applications to promote authentic language use and enhance productive language skills through context-rich activities. Furthermore, the adoption of development platforms such as unity 3D with Vuforia and Metaverse Studio has made it easier for educators to design tailored AR games, enabling more personalized and immersive learning experiences.

However, there are notable limitations in the current AR games in language learning. AR flashcards and paper games are mainly restricted to vocabulary learning and are less frequently utilized for more complex language skills such as reading or writing in higher education contexts. Additionally, although the use of premade games such as *Pokémon Go* offers a significant boost for students' learning experience, the reliance on pre-existing game structures may limit educators' flexibility since teachers have to adjust the class activities based on the functions of the games. For self-designed AR games, not only teachers' basic coding knowledge is required when using specific designing platforms, but also the discontinuation of platforms such as Metaverse Studio further highlights the inconvenience of designing an AR game by language teachers.

Considering most of the studies applied a self-designed AR game, it is necessary for educational application developers to create an AR-enhanced language learning tool that can be widely used in the language learning context. Also, future research and practice should focus on how to make AR development tools more accessible for educators with limited coding experience, which allows teachers to create customized AR games to better fit the learners' needs and teaching objectives.

5.3 Learners' perceptions of AR games in language learning

The integration of AR technology and game-based pedagogical strategies in educational settings has demonstrated a positive impact on students' performance across various disciplines. Consequently, language educators and researchers have

shown considerable interest in examining the efficacy of gamified AR tools and software in enhancing students' language skills, including vocabulary acquisition, communication abilities, and reading proficiency. According to feedback from previous studies, AR games were predominantly described by students as “interesting,” “accessible,” “effective,” “motivating,” and “engaging,” which aligns with the findings from Dhimolea et al. [79]. Notably, students favored the 3D animations and the elements of collaboration and competition with peers inherent in AR games. This preference can be attributed to AR's core feature of blending virtual objects with real-world environments, thereby facilitating content knowledge acquisition through enhanced interaction with dynamic elements and surroundings, as supported by situated learning theory. Additionally, constructivist principles suggest that peer communication can enhance learning outcomes, elucidating why aspects of collaboration and competition in game-based learning are favored. Despite these positive aspects, participants in earlier studies also reported concerns such as inaccuracies in location detection and potential visual strain. These issues are primarily associated with the functionality of the AR tools rather than the pedagogical strategies employed. Furthermore, a minority of students indicated a need for more instructional support with AR tools, likely due to unfamiliarity with the technology rather than its inherent complexity.

Perceptions of AR games in language learning vary across different tools, age groups, proficiency levels, and learning environments. While AR flashcards and AR paper games are highly engaging for early language learners, they may not be as effective for more advanced students who require more complex, content-driven experiences. For instance, location-based AR games offer interaction and the opportunity for collaborative language use, which are more appealing to older or more proficient learners. Younger students often prefer the fun and competitive elements of AR games. The learning environment also significantly impacts perceptions of AR tools. Location-based AR tools may be better suited for outdoor, experiential learning, where students can physically interact with the environment, whereas classroom-based tools such as AR flashcards are more effective for controlled, indoor settings. Collaborative tools tend to foster greater engagement in group-based tasks, while individual tools may feel isolating for some students.

Negative perceptions of AR games in language learning include technical limitations, user experience issues, and different levels of familiarity with the technology. One of the most commonly cited concerns is location inaccuracies in mobile-based AR applications, such as those relying on GPS. This issue can cause frustration for students, particularly in areas where GPS signals may be weak or unreliable. Such technical flaws can disrupt the learning experience, especially when students cannot interact with the AR content as normal. Additionally, visual fatigue is a significant issue, especially for prolonged use of small screens, which can lead to discomfort and reduce students' focus. More attention needs to be paid to this issue, as eyesight is important for children's physical health. Future studies should explore the most reasonable durations for AR game usage in language classrooms to balance better learning experiences with preventing potential harms to visual health. Moreover, students may feel that AR tools require more instructional support, especially if they are not familiar with how to navigate the technology. This lack of familiarity may contribute to a sense of confusion, particularly for students who do not have a high level of digital literacy. Teachers must ensure that students receive clear instructions and practice with the tools before fully integrating them into the classrooms. Additionally, some students may find basic AR games such as flashcards less engaging as their language proficiency improves, which could result in lower effectiveness than before.

To address these concerns, future experiments of AR in language classrooms should focus on improving technical accuracy, providing customizable features to reduce eye strain, and offering thorough training to ensure both students and educators feel comfortable with the technology. By addressing these negative perceptions, educators can enhance the effectiveness and inclusivity of AR games for language learning.

The perceptions of both educators and learners regarding technologies like AR games are critical to their successful integration into language classrooms [80], underscoring the importance of research into perceptions. Teachers can adapt their pedagogical approaches and the implementation of AR games based on these insights. This review offers several recommendations for language instructors, based on learners' feedback on AR game integration. First, educators developing their own AR games should consider incorporating additional 3D animations. Second, when organizing AR-based classroom activities, it is advisable to divide students into groups for collaborative and competitive tasks. Additionally, teachers should provide comprehensive introductions to AR games prior to activities and offer continuous support throughout. Lastly, preemptive testing of AR games is recommended to assess network connectivity and software functionality, thereby ensuring the effectiveness of the instructional strategies employed.

6 RESEARCH GAPS

As emphasized in the current study, the predominant target language explored in language learning with AR games was English. Only two articles in this study focused on learning languages other than English, highlighting a clear gap in studies on applying AR games to learning languages other than English. This imbalance may rise from the global status of English as a lingua franca, leading to greater research funding, institutional interest, and accessibility to AR-based educational resources in English-learning contexts [81]. To date, a myriad of commercially available AR language-learning tools has been developed with English learners in mind, further reinforcing this trend. Future research should prioritize the study of AR games in diverse linguistic contexts to assess their applicability across different language structures and cultural settings.

Additionally, several studies have recommended investigating the long-term effects of AR on language learning and students' retention rates post-intervention [46], [69]. While many studies report short-term improvements, few have examined whether AR-assisted learning leads to sustained proficiency gains over time. Longitudinal studies are needed to determine how AR tools contribute to durable language development and whether their benefits persist after learners' transition to traditional learning methods. In terms of language skills, the majority of research focused on vocabulary learning, and there is a lack of studies on other skills, especially reading and writing. This may be due to the nature of current AR applications, which predominantly focus on visual and auditory interaction rather than textual or composition-based tasks.

Expanding AR game designs to include interactive storytelling, augmented writing prompts, and immersive reading activities could provide more comprehensive support for language learners. While many studies focused on language learners' perceptions, only a few studies explored instructors' or school administrators' perspectives on the integration of AR technologies, which are pivotal in modifying teaching strategies. Thus, it is recommended that future research invite stakeholders as participants. Moreover, most existing literature explored the effectiveness of

AR games in language learning overall without distinguishing the varying impacts of different components in the AR games on learning outcomes. Future studies should address this gap by comparing the effects of specific AR game elements on language learning.

7 STUDY LIMITATIONS

One of the principal limitations of this study refers to the impacts of AR games on a specific language skill in a particular context, such as applying AR games in a college English-speaking classroom. In other words, most of the studies were focused on the English language, while other major languages were not subjects of investigations. Another limitation is related to the scope of this review, which was restricted to studies involving AR games alone. Given the interrelation between AR and VR, future research could benefit from conducting a comparative systematic review of both AR and VR games in language learning. Such studies would allow educators to better understand the relative advantages and disadvantages of these technologies, as well as students' perceptions of each, thereby providing valuable insights for refining instructional strategies.

8 CONCLUSION

In summary, this systematic review analyzed 25 AR game-based language learning studies from 2019 to 2023. The results revealed that the current body of research in the field of language education indicates that AR technology holds significant potential for providing effective support in enhancing language abilities [41]. The findings suggest that AR technology has a strong impact on motivation and engagement, the interactive and gamified elements, such as 3D models, animations, and peer collaboration, making language learning more immersive and enjoyable. However, its effectiveness varies depending on the language skill targeted; while vocabulary acquisition is the most frequently studied and positively impacted skill, fewer studies have explored AR's role in developing reading, writing, and communication abilities. The review also underscores practical challenges such as accessibility issues, the need for teacher training, and the lack of standardized AR games designed specifically for language learning. These findings reveal the innovative and varied approaches to integrating AR technology in language learning, reflecting both the adaptability of AR tools and the creativity of researchers in using these technologies to enhance learning outcomes.

From a pedagogical perspective, educators can maximize AR's benefits by incorporating diverse interactive elements, designing structured learning activities that blend AR with traditional methods, and providing students with clear guidance on using AR tools effectively. Additionally, collaborative and competitive tasks should be intentionally integrated into AR-based instruction to enhance engagement and peer interaction. To address technical and accessibility barriers, institutions should invest in teacher training programs and explore cost-effective AR solutions that do not rely on expensive hardware.

Overall, the high diversity and adaptability of gamified AR tools in language education demonstrate their potential to significantly enhance language learning outcomes. These findings strengthen the importance of continued exploration and development of AR technologies to further enrich educational experiences and support effective language acquisition. Looking ahead, further research should explore

AR's long-term effects on language retention, investigate its application across different proficiency levels and learning environments, and assess how various AR game mechanics contribute to skill development. Collaboration between educators, developers, and researchers will be essential in designing more effective, scalable, and inclusive AR-based learning solutions that go beyond engagement to foster deeper language proficiency.

9 DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT in order to improve readability and grammar. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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