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Emerging Technologies for Second Language Learning in Secondary Education: An Umbrella Review

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Emerging technologies are transforming education, especially in foreign language learning, by evolving to meet changing needs. Key tools include artificial intelligence (AI), machine learning (ML), virtual reality (VR), augmented reality (AR), and natural language processing (NLP), which enhance engagement and personalize instruction. The objective of this paper is to analyze and describe quantitatively and qualitatively the emerging technologies for second language learning in secondary education, grouping them by technology area and comparing the methods. To achieve this, we conducted a systematic review of meta-analyses published in Scopus and Web of Science, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, to ensure transparency and reproducibility. Each selected paper was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system. In total, we included 12 meta-analyses that involve five technologies: (1) chatbot-assisted, (2) robotics, (3) gamification, (4) mobile devices, and (5) virtual reality. For each category, we obtained an effect size estimate using the Generalized Least Squares (GLS) method. The technologies with the largest effects were gamification ($g = 0.890$, 95% CI [0.450, 1.333]), chatbots ($g = 0.740$, 95% CI [0.584, 0.990]), and robots ($g = 0.694$, 95% CI [-0.692, 2.08]).

Keywords: emerging technologies, foreign language learning, second language acquisition, artificial intelligence (AI), machine learning

INTRODUCTION

Emerging technologies (ET) are evolving tools and innovations designed to improve sectors like education. These technologies are not always entirely new, but their dynamic development ensures they remain at the forefront of efforts to enhance learning experiences. As educational technologies evolve, they often follow a pattern known as a

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"hype cycle", where initial high expectations are followed by a more realistic assessment of their actual value in practice (Veletsianos, 2010). Regardless of this process, emerging technologies have the potential to fundamentally reshape how we approach learning and teaching by offering innovative solutions, improving existing processes, and broadening access to resources. They provide new ways to engage learners, personalize instruction, and address diverse learning needs, which is especially crucial in the field of foreign language acquisition. These technologies enhance language learning through engagement and interactive tools while offering scalable solutions for diverse contexts.

These technologies play an important role in education, especially in second language learning (L2). Language learning is complex and requires motivation, support, and interaction. Traditional methods help some learners but do not meet the needs of all students, especially in large classes or online settings. New technologies offer more personalized and engaging learning. Artificial intelligence (AI), the Internet of Things (IoT), machine learning (ML), virtual reality (VR), and augmented reality (AR) make learning more adaptive and immersive. For example, VR can create real-world language environments, and AI chatbots can give students instant practice and feedback.

Emerging technologies also matter for policymakers in education. Governments and institutions want to improve learning outcomes. These technologies can help solve problems in language education, such as lack of access, unequal resources, and limited personalized support. Policymakers can use them to build fairer and more effective systems. For example, AI platforms can reduce the gap between urban and rural students by offering high-quality instruction on demand. Mobile learning apps can also bring language education to remote or under-resourced areas. This makes learning more inclusive and gives all students a chance to succeed.

Moreover, the adoption of emerging technologies can provide policymakers with valuable data on student performance, engagement, and learning preferences, helping to inform more evidence-based educational policies. Machine learning algorithms can analyze this data to identify patterns in student achievement, predict learning outcomes, and suggest targeted interventions for struggling learners. By using such data-driven insights, policymakers can design more responsive education systems that meet the evolving needs of students. In addition, virtual and augmented reality tools can facilitate professional development for teachers, enabling them to incorporate technology-enhanced instruction effectively and adapt their teaching strategies to better support language learners.

This paper focuses on how these emerging technologies are specifically being used to improve outcomes in foreign language learning within secondary education settings. Van Mechelen, et al., 2023 highlighted the relevance of technologies such as AI, IoT, ML, VR, and AR in K-12 education, demonstrating their capacity to enrich the learning process. Other important technologies that warrant attention include natural language processing (NLP), mobile learning, personalized learning, and gamification (Martin et al., 2020), all of which have shown potential to transform second language instruction. These technologies not only enhance language acquisition through increased engagement and interactive learning but also provide scalable solutions that can be implemented across various educational contexts.

As education systems continue to evolve in response to the demands of the 21st century, it is essential for policymakers, educators, and researchers to understand the role of these emerging technologies in shaping the future of language learning. By adopting a forward-thinking approach, stakeholders can harness the power of these tools to create more inclusive, effective, and equitable education systems.

Objective. The aim of this study is to identify emerging technologies examined through meta-analyses in secondary school foreign language education and to evaluate their learning outcomes. By analyzing the effectiveness of these technologies, we can provide valuable insights for educators and policymakers seeking to enhance learning outcomes in this critical area.

To achieve this, a systematic review methodology was employed, focusing on peer-reviewed meta-analyses published in the past decade. Relevant studies were identified through searches in databases such as Scopus and Web of Science. To assess the quality and strength of the evidence, the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system was applied. This framework enabled a structured evaluation of the certainty of the evidence by considering factors such as study design, risk of bias, inconsistency, indirectness, imprecision, and publication bias. For transparency, the review protocol is presented in the following section.

A meta-analysis is a research method that combines the results of multiple studies on the same topic to identify patterns, trends, and overall effects. By synthesizing data from various studies, a meta-analysis enhances statistical power and provides more comprehensive and reliable conclusions than individual studies alone.

The protocol presented in this paper is an *umbrella meta-analysis*. This is a type of research synthesis that examines and summarizes findings from multiple meta-analyses on emerging technologies in second language learning. This approach provides a broader understanding of how these technologies affect language learning and offers insights into their effectiveness. The RQ of interest in this review is,

> *Which emerging technologies applied in teaching foreign languages in secondary school have been examined through meta-analyses, and what are their learning outcomes*?

This paper follows the PRISMA 2020 structure for reporting systematic reviews (Page, et al., 2021). The rest of the paper is organized as follows: The *Methods* section defines the eligibility criteria for selecting meta-analyses, describes the databases and sources used, and explains the search strategy and screening process. It also outlines how data were extracted, how effect sizes were synthesized, and how the certainty of evidence was evaluated using the GRADE framework. The *Results* section starts with a summary of the study selection process, followed by a description of the included studies and their characteristics, and the results of the GRADE assessment. It then presents the main findings, the overall synthesis, and. Finally, the Discussion section interprets the results and links each technology to relevant educational theories.

METHOD

Eligibility criteria. The subset of articles considered in this review must meet the following inclusion criteria:

I1. Articles written in English, and

I2. Articles published after 2010.

We excluded articles that did not meet the criteria I1–I2. In the second stage, we selected articles focusing on the problem defined in the Introduction section.

The following criteria describe this constraint:

E1. Specifically focus on meta-analyses that examine L2 teaching at the secondary level.

E2. Provide sufficient data to be included in the meta-analysis (e.g., study level as moderator, learning outcomes, etc.).

Articles that did not meet these criteria were also excluded.

Information sources. To address the research question, we searched two electronic databases: Scopus and Web of Science. The final search was conducted on August 25, 2025. No additional sources, such as grey literature or reference lists, were used.

Search Strategy. The specific search terms, listed in Table 1, were derived from key concepts in the field and aligned with the objectives of the review. These terms encompass the meta-analysis design, emerging technologies used in interventions, and the target population, defined as middle school students learning a second language (L2). Multiple pilot searches were conducted to fine-tune the keywords in the search string through a process of trial and error. The terms whose inclusion did not yield additional articles in the automatic search were removed. We observed that including the outcome significantly reduced the number of retrieved papers, so this term was excluded from the final search string, as shown in search string of Table 1.

Selection process. The first two authors of this paper did the selection process. They first looked at the titles and abstracts to find studies that might be relevant. Then, they read the full texts to check if the studies met the inclusion criteria. If they did not agree on a study, they discussed it until they reached a decision. A third person was available to help if needed, but this was not necessary.

Table 1
Elements to delineate the search strategy

Key Components of the Search	
Design	meta-analysis
Intervention	“Artificial intelligence” OR “internet of things” OR “machine learning” OR “Virtual reality” OR “Augmented reality” OR “Natural language processing” OR “game-based” OR “video game” OR “Gamification” OR “digital technology” OR “Internet of things” OR “technology-assisted” OR “mobile learning” OR “digital technology” OR “e-learning” OR “Interactive learning” OR “Personalized learning” OR “Online Courses” OR “Machine learning” OR “Natural language processing”
Population	“Middle school” OR "Junior high school" OR “Secondary education” OR “Teenagers”
Outcome	Proficiency Gains in L2 Learning
Search Strings	
SCOPUS	TITLE-ABS-KEY (“technology-assisted" OR "game-based" OR "mobile learning" OR "videogame" OR "digital technology" OR "artificial intelligence" OR "e-learning" OR "Interactive learning" OR "Gamification" OR "Virtual reality" OR "Augmented reality" OR "Personalized learning" OR "Online Courses" OR "Machine learning" OR "Natural language processing”) AND ALL (("second language" OR "foreign language" OR "L2") AND ("Middle school" OR "Junior high school" OR "Secondary education" OR "Teenagers”)) AND TITLE("meta*")
Web of Science	(ALL=(meta-anal*) AND ALL=(“artificial intelligence” OR “internet of things” OR “machine learning” OR “Virtual reality” OR “Augmented reality” OR “Natural language processing” OR “game-based” OR “video game” OR “Gamification” OR “digital technology” OR “internet of things” OR “technology-assisted” OR “mobile learning” OR “e-learning” OR “Interactive learning” OR “Personalized learning” OR “Online Courses” OR “Machine learning” OR “Natural language processing") AND ALL=(“second language” OR “foreign language” OR L2))

Data collection process. Data extraction was carried out by the first two authors. Each author extracted the data independently, and then they compared the results. If there were any differences, the study was reviewed again until agreement was reached. The extracted data included the study name, year of publication, type of technology, effect size, sample size, educational level, and main outcomes.

Data items. For each eligible meta-analysis, we extracted the effect sizes and their corresponding 95% confidence intervals (CIs), restricted to studies involving secondary school students or participants of comparable age. When available, we also recorded indicators of heterogeneity (e.g., I^2 statistic, Q-test). In addition, we documented the type of emerging technology applied in the classroom setting. Data extraction was conducted independently by two reviewers, with any discrepancies resolved through discussion or, if necessary, consultation with a third reviewer.

Synthesis methods for the certainty of evidence. We evaluated the certainty of evidence for each outcome using the GRADE *(Grading of Recommendations Assessment, Development and Evaluation)* framework, adapted for umbrella reviews. GRADE classifies evidence into four levels: High, Moderate, Low, and Very Low, reflecting decreasing confidence that the estimated effect is close to the true effect. Each outcome began with an initial certainty rating based on study design (High). The certainty was then adjusted according to the following domains:

> *Risk of bias:* Downgrading occurred when ≥50% of the primary studies in a meta-analysis were rated as unclear or high risk of bias, or when the meta-analysis did not report any formal quality assessment.
>
> *Inconsistency* (⊖IC): We downgraded the evidence when statistical heterogeneity was high ($I^2 > 50\%$ or Cochran's Q test $p < .10$) or when heterogeneity was not reported.
>
> *Indirectness* (⊖IN): A downgrade was applied when the populations, interventions, comparators, or outcomes (PICO) in the included meta-analyses did not match those specified in this umbrella review. For instance, studies reporting on K–12 learning were downgraded because this review focuses on secondary education.
>
> *Imprecision* (⊖IM): Certainty was downgraded when pooled confidence intervals included the null effect (e.g., g = 0, OR = 1) or when the total sample size across included studies was <400 participants, following GRADE guidance for optimal information size.
>
> *Publication bias* (⊖B): We downgraded when funnel plot asymmetry, Egger's test ($p < .05$), or small-study effects were reported, or when <10 studies were available in a meta-analysis, limiting reliable assessment of publication bias.
>
> We also upgraded (⊕LE) when there was evidence of a large or consistent magnitude of effect (e.g., standardized mean difference $g \geq 0.80$).

Each outcome was assigned one of four certainty levels—**high, moderate, low, or very low**—and results were summarized in a table.

Synthesis of effect sizes across multiple meta-analyses. The overlap among the included reviews was assessed using the Corrected Covered Area (CCA) method. A CCA of 100% indicates that all reviews in the umbrella review included the exact same single reviews, whereas a CCA of 0% indicates that each review contained completely unique single reviews. The following thresholds were applied to interpret the CCA: 0–5%, slight overlap; 6–10%, moderate overlap; 11–15%, high overlap; and >15%, very high overlap (Pieper, et al., 2014).

We use the Generalized Least Squares (GLS) pooling of meta-analyses (Bom & Heiko, 2020). To model overlap between meta-analyses, we calculated pairwise Jaccard indices

J_{ij}, representing the proportion of shared primary studies between meta-analyses i and j. The covariance between effect sizes was then estimated as

$\mathrm{Cov}(g_i, g_j) = J_{ij}\sqrt{v_i v_j}$.

Where v_i is the variance estimate of the i—th study. The pooled effect size $\hat{\mu}$ was computed as:

$$\hat{\mu} = \frac{1^{\top} V^{-1} g}{1^{\top} V^{-1} 1}$$

with variance:

$$\mathrm{Var}(\hat{\mu}) = \frac{1}{1^{\top} V^{-1} 1},$$

where g is the vector of effect sizes and V is the variance–covariance matrix built with Jaccard correlations. Weighted mean differences (WMDs) with 95% confidence intervals (CIs) were used to synthesize continuous outcomes (Zhang, Yu, & Yu, 2021).

FINDINGS

Figure 1 describes the search strategy as suggested by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) (Page, et al., 2021). The database search produced 180 results (124 for Scopus and 56 for WoS). After removing the duplicate papers, we obtain a total of 170 papers. In the first selection stage, 134 articles are related to education. After a complete review of these articles in the second stage, 12 articles remained for the synthesis.

Emerging technologies for L2 in Secondary Education

Table 2 categorizes the reviewed papers. The technologies identified through secondary studies (meta-analyses) include chatbots, robots, gamification, mobile devices, and adaptive learning. The following paragraphs describe these technologies.

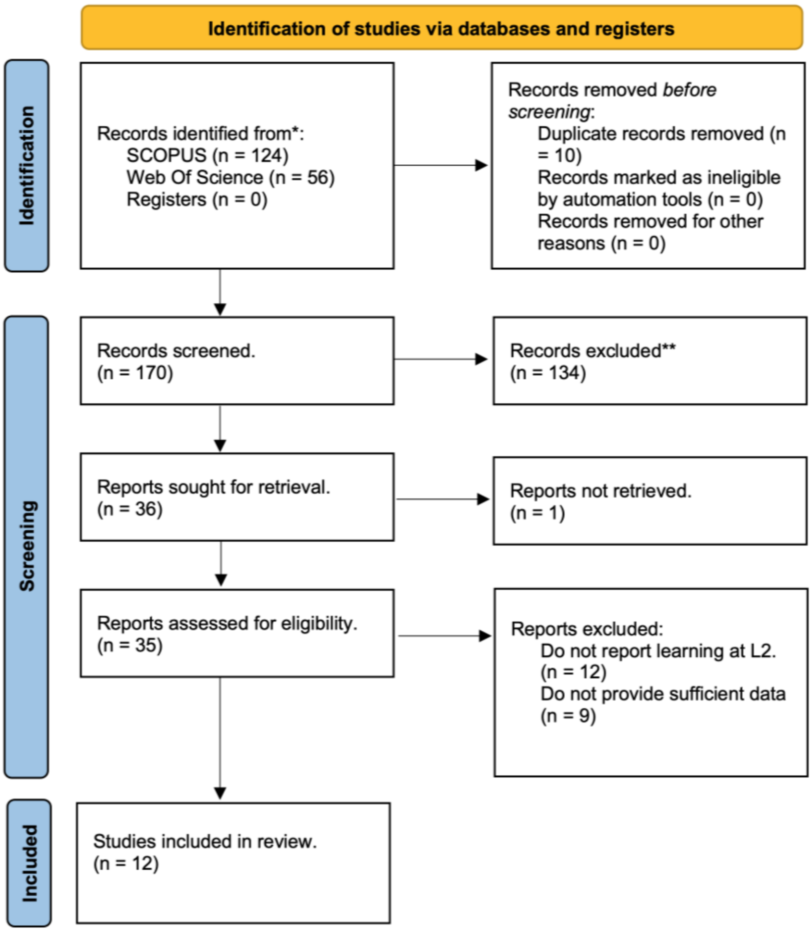

Figure 1
Flow diagram for the search and inclusion of studies

Table 2
Outcomes and evidence grading for each study/category

STUDY	n	Effect size	95% CI		*Heterogeneity (I or Q)*	Quality of evidence (GRADE)
Chatbots						
(Zhang, Shan, Lee, Che, & Kim, 2023)	20	g=0.786	[0.472,	1.101]	-	LOW ⊖IC ⊖IM
(Wu & Yu, 2024)	24	g=0.214	[-0.608,	1.036]	I^2 = 88.1	LOW ⊖IC ⊖IM
(Wu & Li, Unraveling Effects of AI Chatbots on EFL Learners' Language Skill Development: A Meta-analysis, 2024)	10	g=0.833	[0.406,	0.891]	Q = 82.9	HIGH ⊖IC ⊕LE
(Lyu, Lai, & Guo, 2025)	11	g=0.639	[0.355	0.923]	-	VERY LOW ⊖IC ⊖IN ⊖IM
Robots						
(Wang & Cheung, 2024)	18	g=0.290	[0.004,	0.533]	-	LOW ⊖IC ⊖IM
(Wu & Li, Effects of robot-assisted language learning on English-as-a-foreign-language skill development, 2024)	6	g=1.098	[0.580,	1.617]	Q = 87.9	HIGH ⊖IC ⊕LE
Gamification						
(Wu, Zhang, & Wang, 2020)	14	g=0.890	[0.450,	1.33]	-	HIGH ⊖IC ⊕LE
(Liu, Zhang, & Dai, 2025)	8	g=1.768	[0.792	2.744]	-	HIGH ⊖IC ⊕LE
Mobile devices						
(Sung, Chang, & Yang, 2015)	44	g=0.488	[0.307,	0.670]	Q = 338.2	MODERATE ⊖ IC
(Garzon, Lampropoulos, & Burgos, 2023)	21	g=0.800	[0.563,	1.037]	I^2 = 80.8	HIGH ⊖IC ⊕LE
Virtual Reality						
(Chen, Wang, & Wang, 2022)	8	g=0.845	[0.429,	1.262]	I^2 = 75.5	HIGH ⊖ IN ⊕LE
(Qiu, Shan, Yao, & Fu, 2024)	4	g=0.911	[0.417,	1.406]	Q=121.56	MODERATE ⊖ IN ⊖ IM[1] ⊕LE

[1] because of the number of studies included

Learning outcomes for emerging technologies

The overlap across the different research areas shows differences in the Corrected Covered Area (CCA). In Gamification, the CCA reached 77.06%, indicating a very high degree of overlap among the included reviews. The area of Chatbots also showed considerable overlap with a CCA of 52.78%, reflecting a moderate to high concentration of shared studies. By contrast, the studies that use Robots and Mobile Devices show complete independence between the studies included (CCA = 0).

The evaluation results of the selected twelve papers using GRADE are presented in Table 2. Calculated pooled outcomes are shown in Table 3. Three key technologies (Gamification, Chatbots, and Robots) demonstrated substantial effects on learning outcomes. Using Generalized Least Squares (GLS) pooling of meta-analyses, the estimated effect sizes were g = 0.890 for Gamification, g = 0.740 for Chatbots, and g = 0.694 for Robots, indicating consistently positive impacts across these interventions. However, the 95% confidence interval for using robots ([-0.692, 2.080]) includes zero, which means that the effect is not statistically conclusive. These findings provide a more precise synthesis of the evidence compared to individual meta-analyses.

Table 3
Comparison of emerging technologies for L2 in secondary education

Category	Pooled g	95% CI	*Pooled SE*
Gamification	g = 0.890	[0.450, 1.333]	SE ≈ 0.225
Chatbots	g = 0.740	[0.584, 0.990]	SE ≈ 0.081
Robots	g = 0.694	[-0.692, 2.080]	SE ≈ 0.707
Virtual Reality	g = 0.488	[0.307, 0.670]	SE ≈ 0.162
Mobile devices	g = 0.457	[0.221, 0.692]	SE ≈ 0.120

DISCUSSION

We can state that the use of technology in English as a second language (ESL) education has expanded significantly, with gamification, robots, virtual reality, and chatbots emerging as prominent tools It is interesting to compare these three leading technologies. Table 4 maps technologies against the educational theories.

Table 4
Educational technologies mapped to learning theories

Technology	Learning Theory	Rationale
Gamification	Humanism	ESL games use autonomy/mastery to motivate reluctant learners (Elaish, Ghani, Shuib, & Al-Haiqi, 2019).
	Sociocultural	Social dynamics enhance engagement and learning; besides students improve social skills without the help of their instructor (Couture-Matte, 2022).
	Behaviorism	Reward systems (points, digital badges, progress bar) employ conditioning principles to reinforce desired behaviors. (Zhang & Hasim, 2023)
Chatbot-assisted	Constructivism	Students can receive personalized language learning materials based on their previous interaction with chatbots (Huang, Hew, & Fryer, 2021)
	Humanism	Personalized interactions support self-paced learning and intrinsic motivation, which is a key to humanistic approaches (Huang, Hew, & Fryer, 2021)
Robots	Constructivism	Provides practice with immediate feedback (Gong, 2024).
	Sociocultural	Leverage social interaction and peer scaffolding, mirroring Vygotsky's principles (Rohlfing, et al., 2022)
	Behaviorism	Repetitive coding of English instructions reinforces vocabulary/grammar (Rohlfing, et al., 2022)
Mobile Devices	Sociocultural	Mobile learning enables collaborative, context-rich experiences through social apps and shared digital spaces (Andujar, 2016).
	Humanism	Increases the engagement from students' perception (Al-Bogami & Elyas, 2020)

As can we observe, Gamification is based mainly on Humanism, Sociocultural an Behaviorism theories. Zulkefly & Razali (2018) suggest that students recognize the importance of the English language but do not perceive an immediate need to use it as a medium of communication, particularly when interacting with peers who share the same mother tongue, as using their native language feels more effective and inclusive. In this context, gamification emerges as an important strategy to motivate reluctant learners (humanism). Furthermore, they can practice English with other in the gameplay (sociocultural). Babacan & Acat (2023) emphasize that students who engage with English beyond the classroom and cultivate diverse skills, in addition to linguistic ones, are more likely to develop strong holistic learning tendencies. This suggests that integrating the foreign language into different aspects of learners' lives plays a key role in fostering a more comprehensive learning orientation.

Wu & Li (Unraveling Effects of AI Chatbots on EFL Learners' Language Skill Development: A Meta-analysis, 2024) showed that chatbots are effective for english learners, with significant effects observed over short (≤ 1 week) and intermediate (> 1 week, ≤ 4 weeks) intervention durations. Chatbots are generally more suitable for older learners, such as adults, who can effectively engage in text-based or voice-based conversational practice. These tools offer flexibility, allowing learners to practice at their convenience, which is especially beneficial for remote or self-paced learning.
Chat-based technology for English as a Second Language (ESL) is highly adaptive, aligning closely with the principles of humanism in education. Humanistic theory emphasizes self-directed learning, personal growth, and intrinsic motivation. In this context, personalized interactions offered by chat systems enable learners to progress at their own pace, fostering autonomy and supporting internal motivation. For instance, Benek (2025) found that the 50.7% of students perceived these technologies as highly adaptable, while an additional 32.4% regarded them as moderately adaptable, highlighting their effectiveness in addressing diverse learner needs.
The digital nature of chatbots allows for easy integration into existing educational environments, making them highly accessible. Chatbots, being software-based, are generally more cost-effective and easier to scale. They can be deployed across multiple platforms, making them widely accessible to learners from various socioeconomic backgrounds. This accessibility makes chatbots a practical solution for language practice, particularly in remote or resource-constrained settings.

Wang and Cheung (2024) describe that robot-assisted language learning (RALL) is highly effective for learners in basic education and, unlike chatbots, produces stronger effects over intermediate and long intervention durations. Lampropoulos & Papadakis (2025) states that "… (Robots') ability to act as intelligent human-like tutors to offer personalized learning experiences that take students' unique characteristics, needs, knowledge, and preferences into account emerged. As a result, social robots have the potential to improve students' learning outcomes, engagement, and motivation, improve their academic performance, and increase their social skills."

Robots offer a tangible experience, and their ability to express emotions through facial expressions, body language, and gestures that enhances learner engagement (Du & Daniel, 2024) making them especially effective for younger learners. Educational robots help reduce affective filters, such as anxiety, during the learning process (Alemi, Meghdari, & Ghazisaedy, 2015). As learners interact with these robots, they serve as engaging partners, providing a safe, structured environment for practicing both social and linguistic skills. This interaction reinforces the notion that learning is a collaborative, social process. By promoting social interaction, robots embody key aspects of Lev Vygotsky's sociocultural theory. Garzon, Lampropoulos, & Burgos (2023) state that collaborative learning as the most beneficial approach in English education.

Additionally, studies show that the use of gestures by robots positively impacts long-term word memorization (de Wit, et al., 2018). This finding aligns with the idea that presenting information through both auditory and visuospatial channels enhances learning. According to Cognitive Load Theory (Sweller, 1988) presenting information across multiple channels, such as visual and auditory cues, reduces the cognitive burden on working memory.

Unfortunately, the hardware requirements and the need for a physical learning environment make RALL less accessible compared to chatbot-based systems. However, the immersive experience provided by robots may justify the higher costs in certain contexts, particularly when long-term engagement and interaction are crucial for learner success.

The Virtual Reality (VR) technology also presents information through multiple channels. But it can create immersive environments; then, it enhances constructivist learning by enabling students to engage in authentic, real-world contexts without leaving the classroom. In addition, VR creates an environment where learners are emotionally invested, aligning with humanism, as it promotes a deep connection to the language through highly engaging and realistic contexts.

Pomat, Jannok, Buripakdi, and Wilang (2024) emphasize that students seek a holistic approach to language learning, one that integrates immersive environments, practical resources, peer interaction, and supportive materials in both English and their native language. This perspective suggests that emerging technologies must be designed to support such a comprehensive model of learning. The TPACK framework (Mishra & Koehler, 2006) provides a useful lens for this integration, as it unifies content knowledge, pedagogical knowledge, and technological knowledge to guide the design of effective technology-enhanced learning experiences. In particular, linking pedagogical knowledge (PK) with technological knowledge (TK) within TPACK allows for a clearer understanding of how selected technologies embody learning theories, thereby aligning digital tools with the holistic needs of learners.

CONCLUSION

This review includes twelve studies that meet the established inclusion criteria, providing valuable insights into the role of emerging technologies in education. The findings address the initial research question and reveal that existing reviews primarily focus on technologies such as gamification, chatbots, robots, virtual reality, and mobile devices.

In response to the research question, gamification, chatbots, robots, virtual reality, and mobile devices were identified as emerging technologies with notable effect sizes. Gamification demonstrated the largest effect size ($g = 0.890$, 95% CI [0.450, 1.333]), followed by chatbots (g = 0.740, 95% CI [0.584, 0.990]). Robots showed a moderate effect size (g = 0.694), but the confidence interval was very wide (95% CI [-0.692, 2.080]), making their effect unclear. Virtual reality (g = 0.488, 95% CI [0.307, 0.670]) and mobile devices (g = 0.457, 95% CI [0.221, 0.692]) also demonstrated positive effects. These results highlight the need of additional secondary studies to evaluate how robotics have impacted learning outcomes in recent years.

These findings emphasize the importance of continued research and implementation of these technologies in educational settings. We urge educators, policymakers, and researchers to engage with these findings and consider their integration into teaching practices and educational policies to enhance learning outcomes and support future innovations in the field. In addition to the emerging technologies already discussed, such as virtual reality, chatbots, and robots, future research should also explore the integration of adaptive learning systems to enhance educational content delivery; hence, improving the content knowledge in the TPACK framework. Adaptive learning technologies, which tailor learning experiences to the unique needs of individual students, considering factors such as their proficiency levels, cultural backgrounds, and geographic locations. This could provide a more holistic approach to language learning, ensuring that content is continuously adjusted to the learner's proficiency level.

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