



IMMERSIVE VIRTUAL REALITY IN FOREIGN LANGUAGE LEARNING: A SYSTEMATIC REVIEW OF IMPACT, CHALLENGES, AND RESEARCH TRENDS

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ABSTRACT

Aim/Purpose	The application of immersive virtual reality (iVR) to foreign language learning is increasing, but evidence remains dispersed across tasks, platforms, and outcomes, making it difficult for educators to determine which designs are effective.
Background	This paper addresses this problem by systematically synthesizing scattered academic evidence on high-immersion HMD iVR and bridging the gap to practice through an evaluation of currently available commercial applications.
Methodology	A systematic review was conducted following PRISMA guidelines. From an initial 2,149 records, 96 academic studies were included for analysis. Data extraction focused on educational settings, technical hardware, and learning outcomes. Concurrently, a scoping search identified six commercial iVR language-learning apps for descriptive analysis.

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Contribution	This review provides a comprehensive, trans-disciplinary synthesis of the state-of-the-art literature, offering an explicit mapping between academic evidence-based design principles and the pedagogical features of current commercial iVR tools.
Findings	Quantitatively, 67.71% of the included studies reported positive learning effects, with the strongest evidence supporting contextual vocabulary acquisition and listening comprehension among beginner and intermediate learners. A formal meta-analysis was not feasible due to profound methodological heterogeneity and pervasive reporting gaps.
Recommendations for Practitioners	Educators should avoid using iVR as a standalone novelty and instead ground it in established frameworks like Task-Based Language Teaching. Furthermore, highly accessible mobile-based VR setups (e.g., Google Cardboard) can be sufficient for achieving immersive pedagogical goals without the need for expensive PC-tethered systems.
Recommendations for Researchers	There is a need for researchers to adopt standardized reporting frameworks that detail hardware specifications, interaction types, and pedagogical settings to address current transparency issues and enable future meta-analyses.
Impact on Society	By demonstrating that affordable standalone and smartphone-based HMDs are nearly as prevalent and effective as high-end systems, this review highlights the potential for democratizing access to immersive, embodied language acquisition in low-resource educational settings.
Future Research	Future studies must transition from short-term novelty trials to longitudinal designs measuring long-term language retention. Additionally, research should expand to include understudied populations, such as K-12 learners and advanced language speakers.
Keywords	immersive virtual reality, systematic review, foreign language learning, media in education, teaching/learning strategies, serious games

INTRODUCTION

Foreign language learning is a foundational component of education that supports global communication, cultural exchange, and professional development. Traditional approaches (e.g., classroom instruction, textbooks, and multimedia) are widespread and can enhance motivation and attention when integrated thoughtfully (Andresen & van den Brink, 2002; Costley, 2014; Courville, 2011). In parallel, advances in educational technology have expanded opportunities for situated practice, supportive feedback, and authentic exposure beyond the physical classroom.

Among these innovations, Virtual Reality (VR) has emerged as a promising tool for language learning because it can situate learners in interactive, context-rich environments (Y.-L. Chen, 2016; Peixoto, Pinto, et al., 2021; Pinto et al., 2019). VR systems span non-immersive displays (desktop or mobile on a flat screen) and immersive VR (iVR), which uses head-mounted displays (HMDs) and tracking typically to create a strong sense of “being there”, or Presence (Fuchs, 2011; Slater & Wilbur, 1997; Souza et al., 2021). Beyond visual immersion, multisensory stimuli may support learning further by engaging multiple modalities (Baines, 2008; Melo et al., 2020).

BACKGROUND: WHAT PRIOR REVIEWS TELL US

Pre-2019 research and prior syntheses on iVR in language learning report positive perceptions and short-term gains, especially for vocabulary and near-term achievement, alongside encouraging signals for motivation, satisfaction, and engagement (e.g., Dhimolea et al., 2022; Melo et al., 2020; Peixoto,

Pinto, et al., 2021; and Pellas et al., 2021). Early studies identified contextualized vocabulary learning as a highly suitable use case. However, factors such as cost, availability, and user comfort (e.g., cyber-sickness) have historically constrained wider adoption in educational settings (Weech et al., 2020).

PERSISTENT GAPS: WHAT REMAINS UNCLEAR

Despite these positive signals, several gaps remain prominent in the literature, complicating the understanding of how iVR supports specific learning outcomes. First, learning outcomes are examined through short, single-session designs, with limited reporting on retention or transfer (Dhimolea et al., 2022; Peixoto, Pinto, et al., 2021). Outcome definitions vary substantially, and effect sizes are often omitted, hindering comparability. Second, motivation and engagement are gauged via unvalidated self-report instruments with little behavioural triangulation. Third, non-immersive comparators vary widely, ranging from static content (text/images/audio) to structured pedagogies (e.g., PBL); meanwhile, manipulations of iVR features (e.g., interactivity, avatar fidelity, embodied controls) are inconsistently aligned with targeted language skills.

Two cross-cutting issues further limit synthesis: pervasive reporting gaps for devices, exposure/dose, and instructional design generate “not reported” entries that impede replication; and ecological validity remains uneven, as classroom-integrated evidence using commercially available applications is sparse by comparison.

THE TIMELINESS OF THIS REVIEW

Addressing these gaps has become especially timely due to recent shifts that have altered the feasibility and scale of iVR. The onset of COVID-19 in 2020 catalysed a shift from optional pilots to necessary experimentation with digitally mediated learning (Fogg et al., 2020), making institutions more receptive to immersive options for practice and assessment. Concurrently, the emergence of affordable standalone HMDs (e.g., the Meta Quest series) reduced total cost of ownership and setup complexity relative to tethered PC rigs, lowering adoption friction (Radianti et al., 2020). In parallel, commercial content on major platforms expanded the availability of scenarios relevant to language tasks. Because more institutions can now deploy iVR and more studies are viable in authentic classrooms, it is critical to untangle the persistent heterogeneity in the literature. A comprehensive review is needed to provide educators and researchers with clear evidence on which iVR designs genuinely support language learning.

This review is limited to high-immersion iVR and synthesizes 96 empirical studies with a fixed, study-level denominator; distinguishes variable-level multi-label tabulations (skills, features, comparators) from study-level effect direction (mutually exclusive), with explicit unit/denominator notes; and complements the academic synthesis with a separate scoping of commercially available iVR language-learning applications to inform feasibility. The analysis foregrounds three decision-relevant domains, learning outcomes, motivation, and engagement, so that findings are actionable for instructors and designers.

THEORETICAL FRAMEWORKS

To establish a conceptual grounding for how iVR supports foreign language learning beyond mere novelty, it is essential to contextualize its affordances within established theoretical frameworks. First, Situated Learning Theory posits that learning is most effective when it takes place in authentic contexts. iVR provides high contextual authenticity, allowing learners to practice vocabulary and pragmatics in simulated real-world environments. This theoretical grounding underpins pedagogical approaches such as Task-Based Language Teaching (TBLT), which are widely utilized in iVR (Willis & Willis, 2013).

Second, the theory of Embodied Cognition suggests that language comprehension is tied to sensory and motor experiences. In HMD-based iVR, physical embodiment allows learners to enact verbs or

physically interact with virtual objects, strengthening memory encoding. Finally, Cognitive Load Theory (CLT) is critical when evaluating these environments (Sweller, 1988). While VR's immersive nature can reduce extraneous cognitive load by blocking out real-world distractions, poorly designed environments with overwhelming visual stimuli can overload working memory, hindering language acquisition. Understanding this balance is vital for interpreting the learning outcomes synthesized in this review.

SERIOUS GAMES

When evaluating iVR for language education, it is important to distinguish between general game-playing and serious learning. As the literature notes, whilst learning can incorporate game elements, games alone, such as standard virtual reality experiences built in engines like Unity, prove insufficient for structured language acquisition (Y.-L. Chen & Hsu, 2020). General games prioritize entertainment primarily and, at best, support only incidental vocabulary acquisition through repetition. Serious learning, however, requires explicit pedagogical intent (Michael & Chen, 2005). For foreign language acquisition in iVR to be effective, it cannot rely merely on the novelty or mechanics of a game environment; it must integrate structured linguistic input, targeted feedback, and task-based mechanics aligned with specific language competencies (Peixoto, Pinto, et al., 2021). Therefore, whilst iVR often utilizes game-based mechanics, achieving genuine language learning outcomes requires the environment to be designed as a “serious game” or a pedagogically grounded simulation.

RESEARCH QUESTIONS

Guided by the above, the primary overarching research question of this review is:

How do current pedagogical designs, technical implementations, and reported outcomes shape the effectiveness of iVR for foreign language learning across both academic studies and commercial applications?

To answer this main question systematically, the review addresses the following four sub-questions:

- (1) Which iVR conditions and non-immersive comparators are used in language-learning studies, and how are they operationalized?
- (2) Which target skills and outcomes are assessed, and how are overall learning effects classified at the study level (positive/negative/mixed/not reported)?
- (3) What platforms, devices, and in-game features are reported (and how consistently), including reporting gaps relevant to replication and adoption?
- (4) Which commercially available iVR language-learning applications exist on major platforms, and how do their designs align with the academic patterns observed?

While the first three questions focus on synthesizing the academic evidence, RQ4 extends this analysis to the commercial sphere. The rationale for evaluating commercially available applications is to bridge the gap between academic research and practical implementation. By examining this alignment, this review aims to determine whether the off-the-shelf tools accessible to educators are grounded in evidence-based pedagogical designs for language acquisition.

The remainder of the paper is organized as follows. The Methods section details the methodology used for the systematic review of academic studies and commercially available applications, including search and eligibility criteria, as well as data extraction procedures. The third section presents the results and discussion of the analysis of the selected academic studies, namely the PRISMA flow and study-level effect direction (unit = study; denominator = 96), followed by variable-level, multi-label analyses for conditions, comparators, target languages, platforms/devices, and features. The Commercially Available Apps section reports the results of the scoping search for commercial applications and evaluates their alignment with evidence-based academic design principles. The Synthesis and Implications section provides an overarching synthesis connecting the educational, technical, and

outcome dimensions, offers prioritized recommendations for practice, and discusses the limitations of the current review. The final section concludes the paper and outlines consolidated directions for future research across key pedagogical and technical themes.

METHODS

In this section, we describe the methodology employed for analysing both academic studies and commercially available applications in the context of iVR for foreign language learning.

ACADEMIC STUDIES

The systematic review of the academic studies follows the PRISMA 2020 reporting guideline for systematic reviews and meta-analyses, a well-established approach outlined by Liberati et al. (2009); the study selection process is summarized in a flow diagram (Figure 1).

Information sources and search strategy

Electronic searches covered Scopus, Web of Science, ACM Digital Library, and IEEE Xplore from inception through October 2024, with no year limits applied; database-specific Boolean strategies used the concepts “virtual reality/immersion” and “foreign/second language,” with synonyms and controlled vocabulary where available. To ensure replicability, the complete search string was: “*TITLE-ABS-KEY((“Virtual Reality” OR “VR” OR “Virtual Worlds” OR “Virtual Environments” OR “3D” OR “Virtual Classroom” OR “Metaverse” OR “Immersion” OR “Immersive” OR “HMD” OR “CAVE” OR “Head-mounted display” OR “360” OR “Cardboard”) AND (“Second Language” OR “Foreign Language” OR “English” OR “Language”))*”. This string was syntactically adapted for the other databases while maintaining the core conceptual logic.

Eligibility criteria

Inclusion criteria required: (i) immersive virtual reality in the intervention or exposure; (ii) foreign/second language teaching or learning; and (iii) empirical research articles (journal or conference). Furthermore, eligibility screening included language (publication language) limits in English, Portuguese, and Spanish, based on the team’s language competence. This criterion applies only to the language of the articles and does not restrict the target languages taught or learned in the included studies. References to languages in the Results denote the languages of instruction within the studies. Exclusions included unavailable full texts, publications in languages other than those specified, non-foreign-language topics, non-immersive VR, and non-empirical/theoretical-only reports.

Selection process

Two reviewers independently screened titles/abstracts and full texts against prespecified eligibility criteria. Inter-rater reliability during the initial title/abstract screening phase ($n = 1,375$) was exceptionally high, with 99.34% agreement (disagreements occurred on only 9 records). To maintain a conservative inclusion approach, these 9 disputed records were automatically advanced to the full-text screening stage ($n = 218$). At the full-text stage, any further disagreements were resolved by discussion.

Data extraction and synthesis

A data extraction form (codebook) was developed to standardize the collection of relevant information from the 96 included studies. The codebook was drafted based on the review’s research questions and refined through an iterative pilot testing process with a subset of five included articles to ensure clarity and consistency. Two reviewers extracted data from all studies independently using the final form. Any discrepancies in the extracted data were resolved through discussion and consensus. Disagreements during the coding of the 96 included studies were minimal and resolved between the two primary reviewers; consequently, third-reviewer adjudication was not required.

The final codebook organized extracted variables into four main domains:

- (1) **Publication Metadata:** author(s), year of publication, and publication type (journal article, conference paper).
- (2) **Educational Context:** form of instruction (formal, non-formal, informal), mode of instruction (e.g., higher education, K-12), language proficiency levels (e.g., beginner, intermediate), target language(s), pedagogical focus, learning experiences offered, teaching methods/strategies employed, and target language skills (e.g., vocabulary, listening, speaking).
- (3) **iVR System Characteristics:** platform/software used, application/content type (e.g., game, simulation), VR conditions and technologies, hardware (e.g., HMD model), level of interactivity, multiplayer/single-player mode, specific in-game features, other technological features, evaluated variables (e.g., presence, cognitive load), and feedback mechanisms.
- (4) **Outcomes and Study Constraints:** reported learning outcomes, stated user benefits, detailed learning assessment methods, session duration(s), participants' prior iVR exposure, sample size, reported disadvantages/challenges, and authors' suggestions for future research.

Data synthesis for the academic studies was primarily descriptive. Frequency counts and percentages were used to summarise the characteristics of the included studies across the coded categories.

COMMERCIALLY AVAILABLE APPLICATIONS

For the scoping review of commercial applications, a separate search and evaluation protocol was established. A manual search of prominent commercial platforms (Google Play, App Store, Steam, Oculus/Meta Quest Store) was conducted during October 2024. Search queries utilized practical adaptations of the previously established academic terms, such as “VR language learning,” “learn [language] VR,” and “immersive language app.” Rather than restricting the review strictly to top-ranked applications or conducting an exhaustive screening of entirely irrelevant outputs (e.g., low-quality or non-educational), reviewers screened results sequentially until relevance ceased. This targeted process led to the inclusion of 6 iVR applications designed specifically for foreign language learning.

A separate evaluation framework was developed to assess each tool based on publicly available information from its respective app store pages and official websites. The evaluation metrics for each application were organized into three categories. First, general information was collected, including the application name, developer, compatible platforms (e.g., Meta Quest, SteamVR, mobile), and its cost model (e.g., one-time purchase, subscription, free with in-app purchases). Second, the pedagogical design was examined, focusing on the stated target audience, the primary language skills targeted (e.g., vocabulary acquisition, conversational practice), and the core pedagogical approach (e.g., gamification or social VR). Third, key technical features were documented, including single-player or multiplayer functionality, the advertised level of interactivity (e.g., branching dialogues, object manipulation), and the use of specific technologies such as speech recognition or AI-driven NPCs. The analysis of these applications was descriptive, aimed at characterizing the landscape of commercially available tools and comparing their stated features against the trends observed in the academic literature.

ACADEMIC STUDIES: RESULTS AND DISCUSSION

Figure 1 presents the PRISMA 2020 flow diagram of identification, screening, eligibility, and inclusion. In brief, records identified ($n = 2,149$) were de-duplicated ($n = 774$), leaving $n = 1,375$ for screening; records excluded at titles/abstracts were $n = 1,157$; reports assessed at full text were $n = 218$; full-text exclusions were $n = 122$; studies included were $n = 96$. See Appendix A for the full list of included studies.

Results employ two distinct approaches. Study-level analyses use $n = 96$ studies as the denominator, with mutually exclusive categories (each study counted in only one category). Variable-level analyses allow multiple responses per study (e.g., a single study reporting both TBLT and CLT).

The eligible publications span 2016-2024. Their yearly distribution is shown in Figure 2. Most are from the past four to five years, reflecting a growing research focus on iVR in foreign language learning.

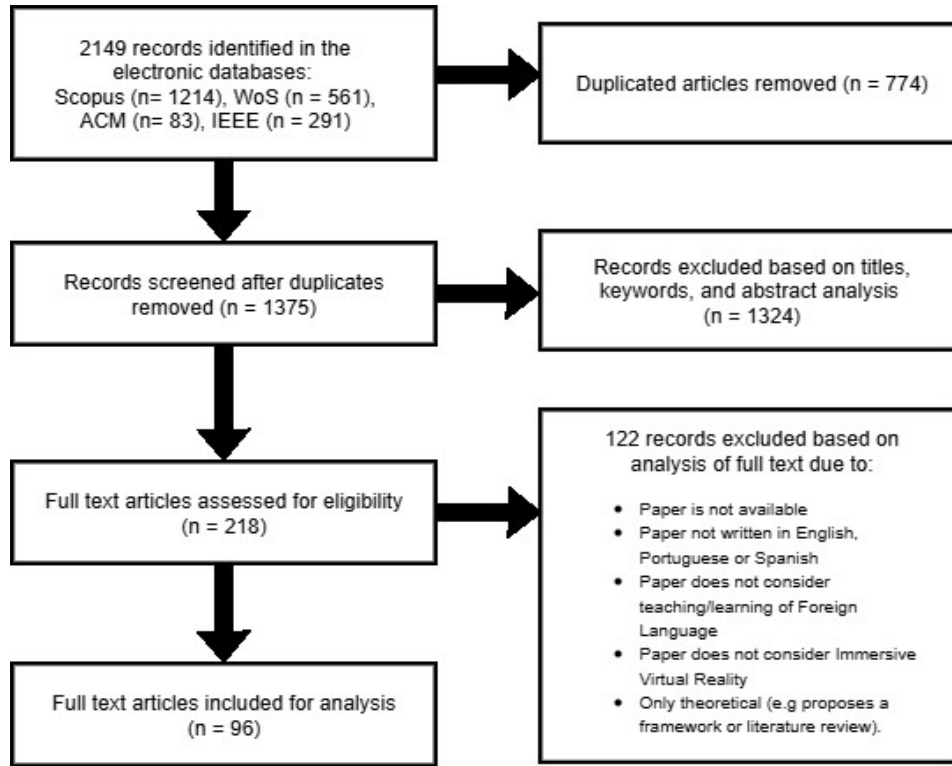


Figure 1. Flow diagram

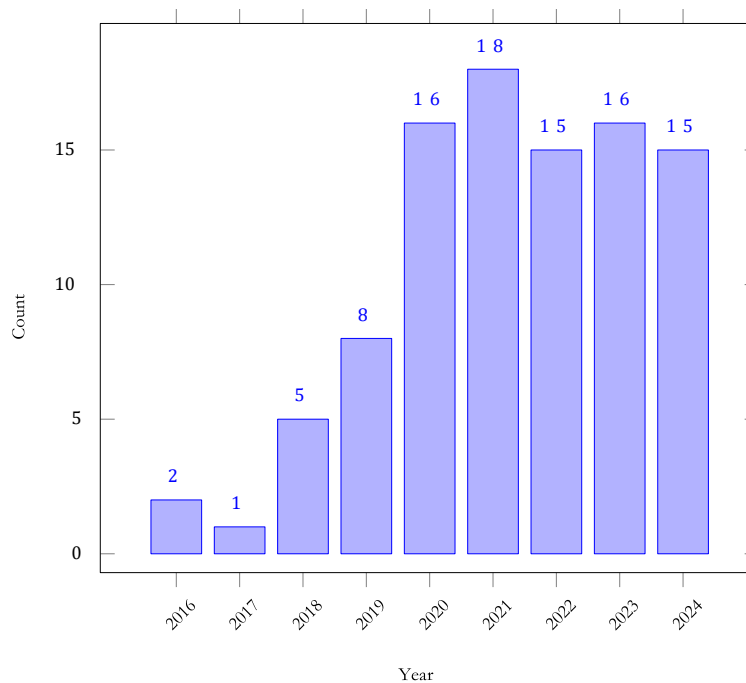


Figure 2. Year of publication

The early years, 2016 and 2017, marked the initial phase of research, with limited numbers of publications, accounting for 2.08% and 1.04% of the total, respectively. However, starting in 2018, a discernible increase in research activity became evident, with 5 papers in 2018 and 8 in 2019. By the year 2020, the landscape of research activities saw a remarkable transition. Amid a global pandemic marked by the emergence of COVID-19, research output surged, more than doubling compared to the previous year. This transition in 2020 signifies an intriguing shift in the field's focus. While the correlation with external events such as the pandemic is plausible, further analysis is required to establish causal relationships.

The trends from 2020 to 2024 show sustained, elevated research activity. In particular, the years 2020 and 2021 saw the highest concentration of publications, with 16 and 18 papers, respectively. This period of growth continued into 2022, 2023, and 2024, with publication counts remaining steady at 15, 16, and 15 papers, respectively. The trends observed in the latter part of this period underscore the growing importance of research in recent years, particularly the dynamic nature of the last few years.

EDUCATIONAL ASPECTS OF FOREIGN LANGUAGE LEARNING

Forms of instruction

This study employs the classification of education into formal, non-formal, and informal to categorize different types of instruction (Dib, 1988; Livingstone, 2001). Formal education refers to structured, institutionalized learning within schools and universities, following a set curriculum. Non-formal education encompasses organized educational activities conducted outside the formal system, such as workshops or training sessions. Informal education involves unstructured learning through daily life experiences, including self-study and community-based learning.

The analysis, as shown in Table 1, examined different forms of instruction found in the selected publications. “Formal education” was the most common, representing 56.25% of the papers. This is expected, as formal education systems often have the resources and infrastructure to incorporate new technologies such as iVR into their curricula. “Informal education” and “Non-formal education” accounted for 6.25% and 5.21%, respectively. In 31.25% of cases, the form of instruction was unspecified or unavailable. Additionally, one paper exclusively focused on “trainee Irish primary school teachers.”

Table 1. Types of instruction

Form of instruction	n studies	%
Formal education	54	56.25%
Informal education	6	6.25%
Non-formal education	5	5.21%
Not informed	30	32.00%
Trainee Irish primary school teachers	1	1.04%

Language proficiency levels

The analysis focused on language learners' proficiency levels within the Common European Framework of Reference (CEFR). The data revealed varying levels of language proficiency across the selected papers. Based on the CEFR reference, these levels were categorized into “beginner”, “intermediate”, and “advanced”. Furthermore, some studies encompassed multiple levels, reflecting a comprehensive approach to addressing learners at different proficiency levels.

While the majority of papers (26.42%) addressed “beginner” level language learners, indicating a significant focus on foundational language skills within the iVR context, a considerable number of stud-

ies addressed multiple proficiency levels. “Intermediate” level learners were also well represented, accounting for 24.53% of the analysed papers, showcasing the broader spectrum of learners targeted by virtual reality-based language learning. “Advanced” level learners, though a smaller portion, were present in 3.77% of the studies. The “not informed” category constituted 45.28% of the total, indicating that a substantial portion of the selected papers did not specify the language proficiency level of the learners.

Table 2 provides a detailed breakdown of the distribution of language proficiency levels across the analysed papers, including instances in which multiple proficiency levels were targeted. This shows a predominant focus on “beginner” and “intermediate” language learners in iVR studies, indicating a strategic emphasis on foundational language skills and a broad learner audience. For “beginner” learners, iVR offers an engaging platform for acquiring essential language foundations. “Beginner” and “intermediate” level learners likely constitute a large portion of the language learning population. Focusing on these levels allows the studies to reach a broad audience.

Table 2. Language proficiency levels addressed

Language proficiency level	n studies	% of 96
Beginner	28	29.17
Intermediate	26	27.08
Advanced	4	4.17
Not informed	48	50.00

Note: multiple responses are allowed because a single study may target more than one proficiency level, so the sum of level counts can exceed 96, and percentages can sum to more than 100%; “not informed” indicates studies that did not specify any proficiency level.

This emphasis may stem from technical considerations, as creating iVR experiences for “advanced” learners could pose challenges in simulating more complex linguistic and cultural scenarios. Additionally, motivation could also play a role. “Beginner” and “intermediate” learners may benefit more from iVR’s engaging nature to support foundational skill acquisition, whereas “advanced” learners, already possessing a strong command of the language, may not require the same level of external motivation. Furthermore, the advanced-learner demographic is relatively small, making it a less common target for iVR research. Future research should explore this potential research gap, as iVR’s experiences could significantly benefit “advanced” learners in refining their language skills to near-native levels.

Educational setting

The analysis explored the educational settings in which virtual reality-based language learning was implemented. The data were extracted based on explicit mentions in the papers or implicit indications of the educational setting. The distribution across educational settings is summarized in Table 3.

Table 3. Distribution of educational settings

Educational setting	n studies	%
Classroom	33	34.38%
Individual	19	19.79%
Both	1	1.04%
Not Informed	43	44.79%

Most studies (34.38%) focused on integrating virtual reality into traditional classroom environments. This aligns with the prevalence of formal education settings, as schools and universities often have

the infrastructure and resources to implement new technologies. Additionally, classroom-based learning offers structured instructor guidance, easing integration of iVR into existing curricula. In contrast, individual iVR learning (19.79%) may require more time and resources to support each learner, thereby challenging large-scale implementation; 44.79% of studies did not specify the educational setting, highlighting the need for clearer reporting of iVR use across learning contexts.

Modes of instruction

The analysis examined the modes of instruction covered in the selected publications. The majority of studies (58.33%) focused on face-to-face learning, indicating a predominant emphasis on traditional, in-person instructional methods. Additionally, a subset of papers explored blended learning (5.21%), incorporating a combination of face-to-face and online approaches. Distance learning, primarily online, was represented in 7.29% of the studies. However, a notable portion (29.17%) did not provide information on the mode of instruction. Table 4 presents a concise overview of the distribution of modes of instruction across the analysed papers.

Table 4. Modes of instruction

Modes of instruction	n studies	%
Face-to-face learning	56	58.33%
Distance learning	7	7.29%
Blended learning	5	5.21%
Not informed	28	29.17%

The majority of studies focused on face-to-face learning, reflecting the strong presence of iVR within traditional classroom-based instruction. This may be linked to the structured nature of in-person teaching, where educators can guide students through iVR experiences and provide immediate feedback. In contrast, distance learning and blended learning received less exploration, possibly due to the technical and logistical challenges of implementing iVR remotely, such as ensuring access to appropriate hardware and stable internet connections.

Foreign languages covered

The analysis delved into the specific foreign languages covered in the selected publications. English was the predominant focus, with 61.46% of the studies centering around this language. Mandarin/Chinese, German, and Japanese followed with 11.46%, 6.25%, and 4.17%, respectively, reflecting a diverse linguistic scope. Other languages, including French, Spanish, Italian, Korean, Irish, Filipino, Portuguese, Swedish, and Vimmi (a constructed or fictional language), contributed to the overall representation.

The distribution of languages covered aligns with global linguistic trends. English and Mandarin/Chinese are among the most spoken languages worldwide, with English having approximately 1.456 billion speakers and Mandarin Chinese around 1.138 billion speakers (Lewis et al., 2016). This prevalence is reflected in the focus of academic studies, as these languages have significant global influence and are often sought after for educational and professional purposes.

Furthermore, the prominence of English in the global language network is well-documented, with its widespread use as a lingua franca in international business, science, and diplomacy (Martins, 2017). Due to China's growing economic and geopolitical influence, Mandarin Chinese has also seen an increase in learners globally. The inclusion of German and French in the studies can be attributed to their status as influential European languages with substantial numbers of speakers and cultural impact. The prioritization of these languages in educational research is unsurprising, given their utility in global communication and the benefits of learning them. Table 5 provides a comprehensive breakdown of the distribution of foreign languages across the analysed papers, sorted by count.

Table 5. Foreign languages covered

Language	n studies	%
English	59	61.46
Chinese	11	11.46
German	6	6.25
Japanese	4	4.17
French	3	3.13
Spanish	3	3.13
Italian	2	2.08
Korean	2	2.08
Irish	2	2.08
Filipino	1	1.04
Portuguese	1	1.04
Swedish	1	1.04
Vimmi	1	1.04

Pedagogical focus

The pedagogical focus of the analysed papers varied, reflecting diverse approaches to virtual reality-based language learning. Most studies (57.29%) adopted a generic approach, encompassing a broad spectrum of instructional methodologies. Notably, two papers (2.08%) placed specific emphasis on student-centered learning, indicating a more individualized, learner-centric instructional approach. In particular, one study in this category had a distinct focus, tailoring its methodology to low-achieving students in a disadvantaged English-learning context. Table 6 provides an overview of the distribution of pedagogical focus within the selected papers.

Table 6. Pedagogical focus in VR-based language learning

Pedagogical focus	n studies	%
Generic Approach	55	57.29%
Student-Centred Learning	2	2.08%
Not Informed or Other	39	40.63%

The analysis reveals a preference for guided learning experiences in iVR foreign language studies, emphasizing structured approaches suited to learners in a new environment. Additionally, this trend may stem from iVR's predominant use in formal education settings, where structured learning is standard practice. Surprisingly, student-centered learning, known for fostering autonomy and engagement, is limited, possibly due to challenges in designing personalized iVR content, the technical expertise required (Y.-L. Chen, 2016), and the structured nature of classroom-based iVR integration. Despite these hurdles, the potential benefits of student-centered learning, including increased motivation, warrant further exploration, urging more research in iVR language learning to leverage its unique capabilities for personalized learning experiences.

Types of learning experiences

Each paper could encompass multiple types of learning experiences, contributing to a total count exceeding the number of analysed papers. Most papers (58.33%) incorporated guided learning experiences, indicating a structured and directed approach to language acquisition. Additionally, 15.63% of studies incorporated passive learning experiences in which learners played a more observational role.

Approximately 16.67% of the papers provided free learning experiences, allowing learners greater autonomy to explore and engage with the virtual environment. Notably, 19.44% of papers provided no explicit specification or implicit indications of the type of learning experience, falling into a category labeled “Not Informed.” Table 7 summarises the distribution of learning experience types across the selected papers.

Table 7. Types of learning experiences

Learning experience type	n studies	%
Guided	56	58.33%
Free	16	15.63%
Passive	15	16.67%
Not Informed	13	21.88%

Note: Percentages use n=96 studies as the denominator. Multiple responses permitted per study (e.g., guided + passive), so percentages may exceed 100%.

The data from this analysis reveal a preference for guided learning experiences. This is consistent with the pedagogical approach that emphasizes structure and direction in the learning process, which can be beneficial in a new and potentially overwhelming environment like iVR. Guided learning experiences tend to involve clear instructions, specific tasks, and structured interactions, which can help learners focus on language-learning objectives and reduce cognitive overload. This approach can be effective for beginners or less confident learners who need more support and guidance. However, the significant proportion of papers that did not specify the type of learning experience suggests that pedagogical approaches require more explicit consideration in iVR foreign-language learning research.

Teaching methods and strategies

Analysis of language-learning studies revealed the adoption of various teaching methods and strategies in virtual reality environments. The data on teaching methods were extracted from explicit mentions in the papers or, in the absence of explicit statements, from implicit indications. In cases where the information was neither explicit nor deducible, it was categorized as “Not Informed.” As shown in Table 8, the following approaches were identified.

Table 8. Teaching methods and strategies

Teaching method	n studies	%
Task-Based Language Teaching	69	71.88
Communicative Language Teaching	16	16.67
The Direct Method	5	2.21
Content and Language Integrated Learning	4	7.29
Cooperative Language Learning	2	2.08
The Natural Approach	1	1.04
Not Informed	21	21.88

Note: Percentages use n=96 studies as the denominator. Multiple responses permitted per study (e.g., TBLT + CLT), so percentages may exceed 100%.

The prevalence of TBLT in the analysis aligns with contemporary trends in language education, particularly within iVR environments. iVR’s capacity for simulation and collaborative learning enhances TBLT’s experimental nature (Smith & McCurrach, 2021). Several factors contribute to its suitability:

engagement, fostering active participation; authenticity, involving real-world tasks; and effective communication, which iVR facilitates through immersive interaction (Bryfonski, 2020; González-Lloret, 2017). Moreover, TBLT's structured, task-based approach aligns with guided learning in iVR studies (see Section III-A7), in which clear instructions and objectives help learners navigate virtual environments effectively.

The other approaches highlight the versatility of iVR for foreign language learning. Communicative Language Teaching focuses on real-world communication, making iVR's immersive environments a natural fit. Content and Language Integrated Learning integrates language and subject learning, benefiting from iVR's ability to create context-rich scenarios. The Direct Method, emphasizing immersion and spontaneous interaction, aligns with iVR's potential for intuitive, speech-driven learning. The dominance of TBLT suggests its compatibility with iVR's structured, interactive, and task-oriented nature. Unlike more traditional methods, TBLT's focus on learner engagement, real-world application, and guided learning aligns well with iVR's strengths, reinforcing its widespread adoption in this field.

Language skills addressed in learning

Table 9 provides an extensive breakdown of the language skills addressed in the analysed papers, reflecting the multifaceted nature of language learning within virtual reality environments. Grammar and vocabulary (24.00%) are among the primary language skills targeted, and this is also true in traditional language learning methods. These skills can be incorporated into a variety of iVR experiences by integrating them into interactive tasks that address other language skills, such as listening. Speaking (19.79%) is another prominent skill addressed in iVR, often incorporated through tasks that allow learners to practice speaking without relying on advanced speech recognition or synthesis. Implementing speech recognition technology would add complexity and require additional hardware, potentially limiting its use in some studies. However, in this literature review, most studies addressing speaking focused on providing opportunities for users to practice speaking skills in more basic forms, without the added complexity of speech recognition. This likely contributes to the relatively high prevalence of speaking activities in iVR studies. While listening tasks are a common feature in iVR (12.50%), they are relatively easy to implement and often involve passive environments where learners listen to audio or dialogue in a virtual space. This makes it easier to design and implement listening tasks than more interactive or dynamic language skills like speaking. Writing is an infrequent focus in iVR, possibly due to the current technological limitations in providing realistic and practical writing tasks in virtual environments.

Table 9. Language skills addressed in learning

Language skills	n studies	%
Grammar/Vocabulary	31	24.00%
Speaking	19	19.79%
Listening	12	12.50%
Not Informed	18	18.75%
Writing	4	4.17%
... (full list truncated) ...		

Note: A single study may address multiple skills (e.g., speaking and vocabulary), so percentages may exceed 100%.

Synthesis of educational approaches

Synthesizing the findings across these educational variables reveals a distinct pedagogical profile for current iVR language learning. The data indicate that the predominant design of iVR interventions targets Beginner and Intermediate learners (Table 2), whose primary focus lies in acquiring founda-

tional Grammar/Vocabulary and Speaking skills (Table 9). To deliver these foundational skills effectively within an immersive environment, researchers show an overwhelming reliance on TBLT (Table 8). This trend highlights iVR's current primary use case: providing lower-proficiency learners with low-risk, highly contextualized simulated environments to practice basic vocabulary and communicative tasks. On the other hand, Advanced learners and complex productive skills (such as Writing) remain an unexplored area in the literature, likely due to the technical challenges of simulating advanced, open-ended linguistic tasks in current iVR applications.

KEY FEATURES

Platform/software used for iVR

The studies employed various platforms and software to create iVR experiences. The data extracted includes both the development platforms and tools researchers used to create their own iVR experiences, as well as pre-existing applications and software already available on the market. A summary of the most frequently used platforms and software (4 or more) is presented in Table 10.

The data reveal a diverse range of platforms and software, with Unity, a widely used game engine, serving as the primary tool for creating iVR language-learning experiences. Recognized for its accessibility to developers of all levels, Unity stands out for its multiplatform support, making it easy to reach a broad audience across various iVR devices (Sinha, 2017). The platform's interactive capabilities, aligned with active-learning pedagogy, enhance language-learning experiences (Lee, Wang, et al., 2024). Furthermore, the platform's extensive community and abundant learning resources solidify its popularity among educational content creators (Unity Technologies, 2021).

Table 10. Commonly used platform/software for iVR ($n \geq 4$)

Platform/Software	Count	%
Unity (game engine)	27	28.13
Immersive VR	6	6.25
Google Expeditions	4	4.17
Mondly VR	4	4.17
YouTube VR / 360 Video	4	4.17
EduVenture VR	4	4.17
Not Informed	16	16.67

Note: The table lists only platforms/software that appear in ≥ 4 studies; if a study used multiple platforms/software, it may be counted in multiple rows, so totals across platforms may exceed 96.

While Unity enables the creation of fully interactive iVR experiences, other platforms like Immerse VR, Mondly VR, and YouTube VR serve primarily as content delivery tools rather than development environments. Notably, YouTube VR and 360° video-based platforms focus on passive learning experiences, where users are immersed in a virtual scene but have limited interaction. In contrast, 3D iVR environments, using readily available iVR applications, support active learning by allowing users to manipulate objects, navigate freely, and engage in scenario-based interactions.

The widespread use of Unity highlights an important challenge, as many studies require researchers to develop custom iVR experiences from scratch. This reflects a lack of readily available, robust platforms dedicated to language learning. The need for bespoke development may also act as a barrier to adoption, particularly for educators and researchers without programming expertise. Future advancements in iVR for language learning should explore the development of user-friendly, customizable platforms that facilitate interactive learning while reducing the technical burden of content creation.

Type of application

The virtual reality language learning studies varied in the type of applications employed, distinguishing between mobile iVR applications and PC-powered iVR applications. Some studies utilized both types of applications. The distribution of these application types is summarized in Table 11. The distribution of application types in virtual reality language learning studies, with a nearly equal split between mobile and PC-powered iVR applications, reflects the dynamic landscape of immersive technologies.

Table 11. Type of application in iVR language learning studies

Type of application	Count	%
Mobile	51	53.13
PC-powered	37	38.54
Not Informed	13	13.54

Note: A study may employ both mobile and PC-powered iVR

Mobile iVR applications, used with devices like Google Cardboard or mobile iVR glasses, offer portability and accessibility. They allow learners to use their smartphones to engage with iVR content, making iVR experiences more accessible to a broader audience.

On the other hand, PC-powered iVR applications, which run on headsets connected to a computer (such as the HTC Vive or Oculus Rift), provide high-quality graphics and a more immersive experience. These setups are often preferred for complex simulations or when high levels of detail and interactivity are required (Nicolaidou et al., 2023).

Notably, the rise in popularity of devices like the Oculus Quest models, which combine mobile-powered and PC-powered iVR capabilities, could contribute to the balanced distribution observed. This trend highlights the evolving nature of iVR, where the adaptability of mobile solutions and the immersive potential of PC-powered applications coexist, reflecting the diverse preferences and technological advancements in the field.

Type of content presented

The virtual reality language learning studies featured various types of content presentation, with distinctions between 360-degree videos, virtual environments, and instances where both were utilized. The distribution of content presentation types is summarized in Table 12.

Table 12. Type of content presented

Type of content	n studies	%
Virtual Environment	64	66.67
360-degree Video	31	32.29
Not Informed	7	7.29

Note: A single study may employ both a virtual environment and a 360-degree video

Traditionally, 360-degree videos were popular in iVR and foreign language learning studies, offering realistic portrayals of real environments that heightened the sense of presence and immersion. This approach, while effective, has seen changes in recent trends. The current shift toward virtual environments indicates a preference for greater flexibility and customization, allowing creators to design specific scenarios or interactions aligned with learning objectives. Virtual environments, with their enhanced interactivity, have the potential to foster greater learner engagement and facilitate active learning. While 360-degree videos provide a sense of realism, they also require less technical expertise and quicker production, making them a viable alternative for specific applications.

Comparison of different iVR conditions and technologies

Virtual reality language learning studies often compare iVR conditions against traditional methods or other non-immersive content. Table 13 summarises the distribution across these comparators. Notably, 22.92% compared different iVR conditions (e.g., avatar fidelity, interactivity), 22.92% used traditional text/image/audio controls, 9.38% used 2D video, and 41.67% made no specific comparison.

Table 13. Comparators and study design for iVR evaluations

Comparator/design type	n studies	%
Different iVR Conditions	22	22.92
Traditional (text/images/etc.)	22	22.92
Video (non-immersive)	9	9.38
Non-Immersive Content (excluding video)	7	7.29
No Comparison Made	40	41.67

Note: A single study may include more than one comparator type (e.g., iVR vs traditional and iVR vs 2D video)

Traditional: As summarised in Table 13, 22 studies used “traditional” comparators that delivered content without immersive affordances, typically via text, slides, static images, or established classroom pedagogies such as Problem-Based Learning (C.-H. Chen et al., 2021; Ma, 2021). Overall, iVR showed consistent advantages over static controls (particularly for vocabulary and listening tasks), though benefits were more mixed against highly interactive pedagogies. For comprehensive examples, see List B1 in Appendix B.

Non-Immersive Content: Non-immersive content primarily consists of 3D environments or educational games viewed on a computer monitor or smartphone (Johnson et al., 2020; Nersesian et al., 2018). This category underscores the flexibility of technology-assisted language learning beyond fully immersive HMD environments. Detailed comparisons of annotation styles and 3D desktop environments are provided in List B1.

Video: Within the category of non-immersive content, 2D and 360° videos offer a distinctive avenue, leveraging established technologies to deliver dynamic visual stimuli on flat-screen displays (H.-W. Huang et al., 2023; Ji et al., 2019). This approach accommodates various instructional methods while maintaining high accessibility. Further details on video-based methodologies are available in List B1.

Different iVR Conditions: Several studies have explored the impact of manipulating specific iVR conditions to isolate active-learning ingredients. Five consistent takeaways emerge from these manipulations: (i) higher avatar fidelity aligns with stronger presence (Peixoto, Melo, et al., 2021); (ii) greater scene realism tracks with higher engagement (Sun et al., 2020); (iii) captions scaffold comprehension (Yang et al., 2020); (iv) interactivity helps when goal-relevant (Harris & Sun, 2022; Peixoto et al., 2023); and (v) embodied controls improve memorisation without adding cognitive load (Ratcliffe & Tokarchuk, 2020a). An extended review of these individual condition studies is located in List B1.

Hardware utilized in virtual reality language learning studies

Collecting detailed information on the hardware used in virtual reality language learning studies was challenging due to variations in reporting and multi-device use across studies. The primary hardware categories include HMDs, controllers, computer peripherals, and CAVE (Cave Automatic Virtual Environment). Additionally, some studies utilized various other hardware, as outlined in Table 14.

Table 14. Hardware used in iVR language learning studies

Hardware type	Count	%
Head-mounted display	88	91.67
Controllers	39	40.63
CAVE	4	4.17
Computer Peripherals	3	3.13
Other	14	14.58
Not Informed	3	3.13

Note: A single study may use multiple hardware types (e.g., HMD and controllers)

The “Other” category includes hardware such as eye trackers, Google Home, hand-tracking devices, HMD microphones, Kinect, Leap Motion Controller, mind mapping-based VR systems, Myo arm-band, VIVE MAG P90 Gun, various EEG systems, and panoramic scenes displayed on a 360° cylindrical panoramic screen. Due to the complexity of hardware configurations and reporting inconsistencies, some studies may not provide detailed information, resulting in the “Not Informed” category.

The predominance of HMDs and controllers in the data underscores their central role in the virtual reality infrastructure. Their widespread use may be attributed to their immersive capabilities and intuitive interaction mechanisms, which are fundamental to effective language learning in a virtual environment. However, the presence of a diverse array of additional hardware in the “Other” category highlights the innovative approaches researchers are taking to enhance the iVR language learning experience. The “Not Informed” category, albeit small, serves as a reminder of the challenges in standardizing hardware reporting in such a rapidly evolving field. This diversity in hardware utilization not only reflects the dynamic nature of iVR technology but also suggests a promising future for iVR in language learning, where customized hardware configurations could cater to specific learning objectives and learner preferences.

The specific HMDs reported in the studies are outlined in Table 15. An important consideration is that some studies employed multiple HMDs or used different devices throughout the research. A common trend is the frequent use of Generic Smartphone VR and Google Cardboard, with a combined total of 29 instances. This underscores the accessibility and widespread adoption of smartphone-based iVR experiences in language-learning research. Notably, Google Cardboard, although listed separately in the table, is often grouped with Generic Smartphone VR because it is a platform that transforms smartphones into basic iVR devices.

Table 15. HMD models used

HMD model	n studies	Type
Generic Smartphone VR	17	Smartphone-Powered
Google Cardboard	12	Smartphone-Powered
Oculus Quest 2	12	Standalone & PC-Powered
Oculus Rift	10	PC-Powered
HTC Vive†	9	PC-Powered
HTC Vive Pro 2	4	PC-Powered
Oculus Rift S	4	PC-Powered
Oculus Quest	2	Standalone & PC-Powered
HTC Vive Focus Plus	1	Standalone & PC-Powered
Lenovo Mirage Solo	1	Standalone
Oculus Go	1	Standalone

HMD model	n studies	Type
Oculus Rift CV1	1	PC-Powered
Oculus Rift DK2	1	PC-Powered
Pico Neo	1	Standalone
Pico Neo 3	1	Standalone & PC-Powered
Not Informed or N/A	22	N/A

Note: A single study may use multiple HMD models (e.g., Oculus Rift and HTC Vive). †One HTC Vive setup included an SMI eye-tracking module.

Furthermore, PC-powered HMDs, including various Oculus and HTC models, appeared collectively 31 times. In contrast, Standalone HMDs, such as the Oculus Quest 2, showed a growing presence, with 17 instances. This diversity highlights the adaptability of virtual reality technologies across different setups, meeting varied preferences, technological needs, and accessibility requirements.

Level of interaction

The level of interaction varied across the analysed studies, providing insights into the nature of participant engagement. In 70.83% of the studies, participants actively engaged with the virtual environment in a hands-on manner. Approximately 12.50% of the studies involved passive interaction, where participants played a more observational role. An additional 5.21% of the studies incorporated both active and passive forms of interaction, and these were not included in the percentages for active or passive interaction alone. The level of interaction was neither explicitly stated nor deducible in 11.46% of cases. The active involvement of participants in hands-on interactions constituted the majority, aligning with the established notion that interactive learning experiences often yield positive educational outcomes (Molina Roldán et al., 2021). However, practical constraints such as hardware limitations, the complexity of interaction design, and the learning curve associated with iVR controllers may make interactivity unfeasible or unnecessary, allowing passive engagement as an option. In classroom settings, where multiple learners share the same physical space, passive approaches can also mitigate logistical challenges, including limited movement space and the risk of accidental collisions. Additionally, some language learning tasks may not require extensive interaction to be effective, such as vocabulary exposure exercises, where immersion in context-rich environments alone can contribute to learning outcomes. While high interactivity is often beneficial, passive approaches may provide a more accessible alternative in certain scenarios.

Single-player vs multiplayer

Of the analysed studies, 45 (46.88%) were designed for single-user experiences. In contrast, 16 (16.7%) studies incorporated multiplayer elements. Notably, in the multiplayer category, 5 studies (5.21%) described collaborative settings. Two of these collaborative studies presented scenarios where one user engaged with iVR through an HMD, while other participants interacted using traditional methods such as paper-based materials or verbal communication.

The predominance of single-user experiences suggests that many iVR language learning applications are designed for individual use. This aligns with the pedagogical approach of personalized learning (Coleman & Money, 2020), where learners can progress at their own pace and receive immediate, individualized feedback. On the other hand, the incorporation of multiplayer elements in 16.7% of the studies indicates an acknowledgment of the benefits of social interaction in language learning. Collaborative learning in virtual environments can offer opportunities for authentic communication, peer feedback, and the co-construction of knowledge (van der Meer et al., 2023).

However, it is worth noting that most studies did not incorporate multiplayer elements. One reason for the predominance of single-user experiences could be the greater complexity of programming required to synchronize multiple users in a virtual environment. Ensuring smooth and synchronized interactions in a multiplayer setting can be technically challenging and resource-intensive. Another

factor could be space constraints in traditional classrooms, which may limit the feasibility of implementing multiplayer iVR experiences. For studies focusing on specific variables or equipment, the emphasis on single-player experiences may be due to the simpler control over experimental conditions. Single-player setups allow researchers to isolate and test specific factors without the added complexity of multiple participants. This could suggest an area for further exploration, given iVR's ability to facilitate immersive, interactive social experiences.

In-game features

The studies employed various in-game features to enhance immersion and support task-based language practice. Table 16 summarises the features observed across the studies. Interaction (46.9%) and avatars (34.4%) were the most prevalent features. The high rate of the “Not Informed” category (34.4%) indicates that many specific features (e.g., teleportation mechanics) were often underreported, highlighting a need for more comprehensive documentation in future research.

Table 16. In-game features

Feature	Count	%
Interaction	45	46.9
Avatars	33	34.4
Other	12	12.5
Not Informed	33	34.4

Note: A single study may include multiple in-game features (e.g., interaction and avatars), so percentages may exceed 100%.

Regarding specific technological features, speech recognition was mentioned in 6.67% of the studies. Researchers employed innovative approaches to enhance interaction; for instance, Peixoto, Melo, et al. (2021) demonstrated how avatar lip-sync and body animations enhanced presence and retention, whilst Harris and Sun (2022) incorporated highly interactive virtual characters within city environments. Furthermore, unique features leveraged iVR's physical tracking affordances, such as Cheng et al. (2017), implementing a bowing mechanic for cultural learning using HMD head tracking. For a comprehensive, detailed breakdown of all reported in-game and technological features, including eye-tracking, voice recognition, hand-tracking, and gamification elements, see List B2 in Appendix B.

Evaluated variables

The analysis of 112 variable instances coded across 96 studies revealed key focuses, with multiple responses allowed per study (e.g., learning outcomes, user feedback, test scores, motivation, presence, cybersickness). Predominantly, studies assessed learning outcomes (45 occurrences), user feedback (37 occurrences), test scores (20 occurrences), motivation (17 occurrences), presence (16 occurrences), and cybersickness (14 occurrences). Other significant variables included anxiety, engagement, enjoyability, user satisfaction, usability, and perceived usefulness, each appearing 7 to 11 times. For a visual representation, refer to the generated word cloud in Figure 3.

The prevalence of learning outcomes, as a primary focus, aligns seamlessly with the fundamental objectives of language learning in an iVR context. As the central goal of acquiring a foreign language is proficiency and effective communication, it is natural that studies prioritize the assessment of learning outcomes. Additionally, a notable focus on other mediating variables, such as cybersickness, presence, and anxiety, emphasizes the importance of understanding not only whether iVR can improve learning outcomes, but also how these other factors contribute to the learning process. These variables may play a crucial role in shaping the effectiveness of iVR language learning environments, highlighting the need for a deeper investigation into the paths through which iVR influences learning.

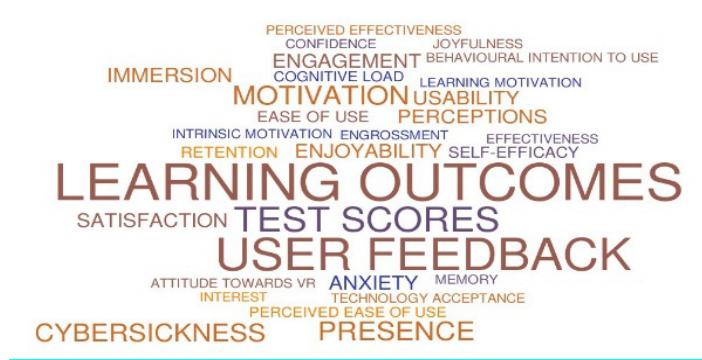


Figure 3. Evaluated variables word cloud

Feedback during iVR experience

In 22 studies (22.92%), participants received feedback during their iVR sessions, enhancing their engagement and interaction. However, in most studies (74 cases, 77.08%), either no feedback was provided, or the information was not stated. The analysis indicates that feedback during iVR sessions is uncommon across most studies. This is surprising given that feedback is a crucial component of effective learning, particularly in virtual environments. Feedback can enhance user engagement, interaction, and learning outcomes (Berger et al., 2022).

BENEFITS AND LIMITATIONS

Direction of learning effects

At the study level, each included paper was classified into a single overall effect direction (positive, negative, mixed/inconclusive, or not reported); counts and percentages are shown in Table 17. Most studies reported positive learning effects, highlighting the potential benefits of integrating iVR into language education. In contrast, one study indicated negative results, suggesting challenges or drawbacks associated with the iVR approach. In 11 cases, the findings were inconclusive, indicating a need for further investigation or varied results. Significantly, 19 studies provided no explicit information on general learning outcomes.

Table 17. Overall study-level effect direction

Effect direction	n studies	%
Positive	65	67.71
Negative	1	1.04
Mixed/Inconclusive	11	11.46
Not Informed	19	19.79

User benefits of iVR in language learning

The integration of iVR in language learning studies demonstrated various user benefits, as shown in Table 18. The analysis identified a total of 168 instances of user benefits across the 96 papers. Predominantly, iVR contributed to enhanced learning outcomes (46.88%), increased motivation (34.38%), improved engagement (16.67%), and heightened enjoyment (11.47%). Other reported benefits included a decrease in anxiety (9.38%), increased immersion (4.17%), and positive attitudes (5.21%). Specific user benefits lacked explicit information in several cases (11.46%).

Integrating iVR into foreign-language learning studies revealed a diverse range of user benefits. Notably, iVR emerged as a potent catalyst for enhanced learning outcomes, as evidenced in studies such as Y.-L. Chen's (2016) exploration acknowledged iVR as a substantial learning facilitator. Moreover,

Cheng's work showcased iVR's capability to heighten participants' sense of cultural involvement, emphasizing its potential impact on cultural education (Cheng et al., 2017). Legault et al. (2019) examined the differential benefits of iVR platforms, revealing their optimal impact on less successful second-language learners.

Table 18. User benefits in iVR language learning studies

User benefit	n studies	%
Learning Outcomes	45	46.88
Motivation	33	34.38
Engagement	16	16.67
Enjoyment	11	11.47
Decrease Anxiety	9	9.38
Positive Attitude	5	5.21
Immersion	4	4.17
Not Informed	11	11.46

Note: A single study may report multiple benefits (e.g., learning outcomes and motivation), so percentages may exceed 100%.

Y. Xie, Ryder, and Chen's (2019) investigation emphasized how immersion into realistic scenes and virtual tutor guidance facilitated active and discovery learning, resulting in notable improvements in participants' vocabularies. Furthermore, it demonstrated the positive outcomes of using embodied controls and spoken production in an immersive virtual environment, supporting the effectiveness of embodied cognition-based learning in iVR (Ratcliffe & Tokarchuk, 2020a).

Engagement, a crucial aspect of learning, was explored in Nicolaidou et al.'s (2023) study, which provided preliminary empirical evidence that iVR applications can engage learners, though not conclusively superior to mobile versions. Tai and Chen's (2021) research underscored the motivation for and benefits of using iVR in English-as-a-Foreign-Language listening, emphasizing its positive impact on preparation for real-world communication.

Y.-J. Lin and Wang's (2021) exploration illuminated how iVR technology enhanced students' self-efficacy for creative thinking, thereby establishing its feasibility and value in creative training and language learning within second-language education. The study by Hung et al. (2023) investigated the effects of iVR-based wearables, revealing positive correlations with learning performance, comprehension, and a sense of accomplishment, particularly in comparison to traditional learning methods. Additionally, Lan and Tam's (2023) research aimed to understand the impact of iVR on the writing skills of Chinese as a Second Language beginners, demonstrating significantly higher composition scores in the experimental group compared to the control group.

While several studies highlight the pedagogical benefits of using iVR in language learning, iVR can be seen as a complementary or facilitating tool rather than a replacement for traditional methods (C. Chen & Yuan, 2025). Moreover, the study acknowledges the potential influence of individualized learning, as the experimental group had the flexibility to learn at their own pace. This flexibility allowed for more repetition and exposure to key terms, which may have influenced the observed results. The study emphasizes the importance of considering individualized learning experiences as a potential confounding variable in interpreting findings.

In addition to learning outcomes, iVR demonstrates its value in addressing psychological aspects of language learning. Y.-H. S. Wu and Hung (2022) suggest that iVR has the potential to reduce speaking anxiety, providing particular benefits for individuals with a typical experience of higher anxiety levels when learning English. This reduction in anxiety is particularly significant, indicating that iVR environments can create a supportive, less intimidating space for language learners. By alleviating

speaking anxiety, iVR contributes to a more positive and comfortable learning experience, fostering an environment conducive to language acquisition and the development of communication skills.

The analysis of user attitudes and perceptions towards iVR in foreign language learning studies emphasized key aspects, with notable occurrences in enjoyment, engagement, motivation, ease of use, usefulness, and positive attitudes toward using iVR. For instance, studies have found that the higher the reality of the virtual environment's scene, the greater the learner's engagement in learning. In high-reality scenarios, there is a significant correlation between learning engagement and effectiveness (Sun et al., 2020). These findings collectively highlight the positive impact of iVR on various user experiences, ranging from enjoyment and engagement to motivation and confidence.

Detailed learning assessments in iVR studies

Analysis of detailed learning assessments in iVR studies revealed a range of outcomes. Vocabulary acquisition was a prominent focus, with 13 instances highlighting its significance in language learning within iVR. For instance, Collins et al. (2020b) reported a notable increase in participants' attitudes towards learning Irish, coupled with a 20% improvement in vocabulary retention for Irish-language items in the game. Knowledge acquisition and retention were also substantial, with eight occurrences each. In the study by Tai and Chen (2021), iVR was found to facilitate EFL learners' listening comprehension and retention, demonstrating its effectiveness in enhancing language skills. Additionally, communicative ability, gains in speaking proficiency, comprehension, and writing performance were among the assessed aspects, each providing valuable insights into the multifaceted impact of iVR on language learning. The comprehensive overview of these detailed assessments is presented in Table 19.

Table 19. Detailed learning assessments

Learning assessment	n studies
Vocabulary Acquisition	13
Retention	9
Knowledge Acquisition	8
Communicative Ability/Speaking	7
Comprehension	5
Proficiency Gains	4
Writing Performance	4
Listening Comprehension	3
Transfer of Knowledge	3
Other	21
Not Informed	39

Note: A single study may use multiple assessment types (e.g., vocabulary and speaking), so percentages may exceed 100%

Duration of the experiment

The duration of the experiments varied across the selected papers, providing insights into the time invested in each study. The duration of the experiments varied significantly, with the shortest being less than 15 minutes and the longest exceeding 60 minutes. This variation in duration could impact iVR's effectiveness as a learning tool (Hamilton et al., 2021; Y. Lin et al., 2020). Table 20 breaks down the duration distribution within the analysed papers, ordered from the smallest to the largest interval.

Table 20. Duration of the experiment (in minutes)

Duration	n studies	%
0-15	15	15.63%
15-30	22	22.92%
30-60	13	13.54%
60+	18	18.75%
Not Informed	28	29.17%

A shorter duration may not give learners enough time to fully engage with the material. In comparison, a longer duration could introduce challenges such as fatigue, loss of concentration, or cognitive overload (T. Xie et al., 2023), depending on the experience's intensity. The largest group of studies (22.92%) had a duration between 15 and 30 minutes. This duration might strike a balance between allowing learners sufficient time to engage with the material while minimizing potential fatigue or loss of focus (Hamilton et al., 2021; Y. Lin et al., 2020). However, a substantial number of studies (18.75%) exceeded 60 minutes, which, while potentially beneficial for deeper learning, could lead to fatigue and loss of concentration if not properly structured (T. Xie et al., 2023). Further research is needed to determine the optimal duration for iVR learning experiences, considering both the cognitive demands of the tasks and the pacing of the interaction.

Previous exposure to iVR

The analysis examined whether participants were introduced to iVR before engaging in language-learning activities. Most participants (59.38%) were either not introduced or had the information not provided ("No/Not informed"). In contrast, a large portion of participants (40.63%) reported having prior exposure to iVR ("Yes").

An acclimatization period to iVR could be beneficial for learners, allowing them to familiarise themselves with the controllers and the virtual environment. Additionally, this has the potential to mitigate the novelty effect, a psychological phenomenon in which the newness of the technology initially distracts from the learning objectives (Miguel-Alonso et al., 2023).

Sample size

The sample sizes varied across different intervals, providing insights into the distribution of participants. The distribution is summarized in Table 21, which presents the number of studies for each sample size interval. An important observation is that three studies omitted any explicit mention of the number of participants in their experiments. Determining the optimal sample size for iVR foreign-language learning studies is not inherently difficult, as researchers can calculate it based on effect size and study variables. However, securing diverse and representative samples remains challenging, as many studies rely on participants from a single class or university cohort.

Table 21. Sample sizes in iVR language learning studies

Sample size interval	Number of studies
1-10	14
11-20	8
21-30	22
31-40	12
41-50	7
51-60	3
61-70	8

Sample size interval	Number of studies
71-80	6
81-90	1
91-100	0
101+	12

Most of the studies had sample sizes under 30; caution is advised when generalizing results, as this is considered limited (Faber & Fonseca, 2014). Balancing statistical rigor with practical considerations, such as iVR equipment availability and participants' time commitments, is crucial. Some studies suggest that even with smaller sample sizes, multiple iVR sessions per participant can yield valuable insights. In essence, researchers should strike a balance between statistical robustness and practical feasibility when determining sample sizes (Hua & Wang, 2023; X. Huang et al., 2021).

Disadvantages of iVR in language learning

A breakdown of these disadvantages of iVR in language learning studies, based on the analysed papers, is presented in Table 22.

Table 22. Disadvantages reported

Disadvantage	n studies
Cybersickness/Dizziness	13
Technical Difficulties	8
Discomfort	4
Cognitive Overload	3
Higher Anxiety	2
Lower Learning Outcomes	2
Other	6
None/Not Informed	69

Note: A single study may report multiple disadvantages (e.g., cybersickness and technical difficulties), so percentages may exceed 100%.

The category “Other” encompasses various challenges reported in the studies, such as the high cost of equipment, technical complexity, and specific issues like “lack of facial expression tracking and other nonvocal paralinguistic cues for foreign language instruction.”

While iVR in foreign language learning demonstrates considerable potential, it is essential to acknowledge the challenges and disadvantages reported in the studies. A recurring concern is cybersickness or dizziness, often attributed to the weight of iVR devices and necessitating careful control of duration to mitigate discomfort (Ji et al., 2019). Technical challenges, such as the weight and complexity of iVR equipment, pose hurdles for learners (Y.-H. S. Wu & Hung, 2022). A study comparing learning outcomes with annotated 360° pictures on a desktop monitor versus iVR headsets found that participants who used the desktop monitor achieved significantly higher post-test scores. This suggests that, in certain contexts, traditional screen-based approaches may be more effective than iVR for vocabulary acquisition (Papin & Kaplan-Rakowski, 2024).

Some studies raise concerns about cognitive overload, suggesting that iVR may lead to less controlled and less accurate target-language learning than traditional classroom activities (Dooly et al., 2023). Increased cognitive load, lack of prior experience, and divided attention further highlight the importance of considering learners' familiarity with iVR when designing instructional activities (Ji et al., 2019).

Another key concern is the novelty effect; the initial excitement of using iVR may divert learners' attention from actual language learning, potentially affecting learning outcomes over time (Ebert et al., 2016). Some studies suggest that post-test scores in iVR environments may be lower due to distraction, as learners engage more with the immersive experience itself rather than the instructional content (O'Brien et al., 2009; Wickstrom & Bendix, 2000; Y.-H. S. Wu & Hung, 2022). These factors underscore the importance of careful consideration and design to mitigate distractions and enhance the effectiveness of iVR in language learning.

Challenges and limitations

While investigating the challenges and limitations of iVR in language learning, it is crucial to acknowledge not only the specific drawbacks in the learning process but also the broader technological constraints encountered in the utilization of iVR. The studies analysed revealed challenges intrinsic to iVR technologies, including equipment costs and accessibility issues, as highlighted by Yang et al. (2020). Urueta and Ogi (2021) identified difficulties with mass adoption in traditional classrooms, emphasizing the need to address practical challenges for widespread implementation. Moreover, technical barriers such as incompatibility and proprietary restrictions on iVR headset types and software, reliability issues with speech-to-text functionality and macro controls, and a steep learning curve for instructors in creating iVR content were reported. Additionally, the limited language compatibility and availability of iVR content, especially outside of English and a few other languages, pose significant challenges to the widespread adoption of iVR in language education (Urueta & Ogi, 2021). These technological challenges underscore the need for careful consideration and strategic planning when integrating iVR into language learning environments.

LONG-TERM USE OF iVR FOR TEACHING

Long-term or longitudinal studies are advocated to explore the sustained impact of iVR beyond short-term interventions and mitigate potential novelty effects (Johnson et al., 2020; Nicolaidou et al., 2023; O'Brien et al., 2009; Peixoto et al., 2023; Ratcliffe & Tokarchuk, 2020b; Tai & Chen, 2021; Urueta & Ogi, 2019, 2020). However, this literature review revealed a significant gap in the long-term use of iVR for teaching, with only nine studies (9.38%) meeting the criteria for longitudinal research. Among these, Kaplan-Rakowski and Gruber (2021) conducted five tutoring sessions over 3 weeks, during which a learner of German practiced her foreign-language speaking skills in iVR with the guidance of a tutor. The study confirmed that iVR can provide pedagogically valuable environments for developing foreign-language speaking skills.

Furthermore, three research teams (Lan & Tam, 2023; Lee, Yang, & Wu, 2024; Wang et al., 2022) conducted studies with a duration of 4 weeks each. Lan and Tam (2023) involved 36 Vietnamese students in an essay-writing course for second-language learners, with iVR sessions conducted weekly over a 4-week period. Despite the experimental group's limited use of iVR in weeks 1 and 3, results indicated significantly higher composition scores than those of the control group. Wang et al.'s (2022) experiment focused on an EFL writing course, with weekly iVR exercises conducted over 4 weeks, and found that the learning method not only provided significant enhancements to students' EFL writing performance but also increased their motivation, self-efficacy, and sense of presence while reducing their EFL writing anxiety. Similarly, Lee, Yang, & Wu (2024) explored the language-learning experiences of 25 fourth-graders in a Korean elementary school who participated in a 4-week project involving six iVR sessions (45 minutes each, twice a week). The results demonstrated a significant positive impact on students' behavioural, affective, and cognitive engagement, as well as improved learning outcomes. Teachers reported initial challenges with students' excessive excitement; however, as sessions progressed, students' behaviour improved, and their motivation and interest remained high. Teachers expressed confidence that iVR would be an effective language-learning environment in the long term, suggesting that novelty effects diminished over time.

Several studies have explored the impact of iVR over periods of six to eight weeks, offering insights into its potential while emphasizing the need for further research on longer-term effects. DeSocio's

(2024) study investigated the use of iVR in a six-week language project for small groups of students. While the findings suggested that iVR holds promise for the transmission of cultural and historical knowledge, the technology was deemed insufficiently advanced to yield significant improvements in reading and listening competencies beyond an elementary level.

In contrast, Lee, Wang, et al. (2024) conducted a six-week study with 19 Korean university students using iVR for communicative English tasks in realistic virtual environments. The results revealed that students engaged in meaningful and context-driven conversations, responding naturally to the surrounding virtual environments and communicative tasks. Furthermore, the study reported increased speaking opportunities and a strong preference for iVR over traditional methods due to its realistic and engaging contexts. However, the study noted that six weeks might still be too short to overcome potential novelty effects and called for longer-term research with diverse participant groups.

Shi et al. (2024) extended the duration to 8 weeks and compared traditional teaching, project-based learning (PjBL), iVR-supported instruction, and a combination of iVR and PjBL (PjVR) with 80 students in a Hotel English course. The PjVR group outperformed all others in oral English skills and engagement across behavioural, affective, cognitive, and social dimensions. The study highlighted the value of combining iVR with pedagogical strategies such as PjBL for contextualized learning and recommended exploring best practices and long-term impacts.

Research with longer durations, though limited, provides deeper insights into the sustained effects of iVR on language learning. One study by Y.-H. S. Wu and Hung (2022) extended the duration to 10 weeks, with both experimental and control groups undergoing two-hour lessons each week. Results demonstrated that iVR significantly increased students' grammar and lexical use in their speaking performance, although it did not affect pronunciation, fluency, or intonation. Despite the extended timeline, the authors speculated that novelty effects might still have influenced outcomes, emphasizing the need for longer-term studies.

Another study by Dooly and Vera (2024) spanned three months, with 24 students alternating weekly between iVR and non-iVR activities. The results indicated that while iVR enhanced spontaneous language use and engagement, it occasionally reduced linguistic accuracy. The study emphasized the complementary role of iVR and traditional methods in fostering active language learning.

These findings highlight the importance of exploring longer-term implementations of iVR to understand its sustained impact on language learning. While shorter interventions demonstrate promising results, extended durations provide valuable insights into mitigating novelty effects and better reflect the practical, long-term use of iVR in real educational settings. Future research should continue to expand the duration and scope of iVR studies to evaluate its long-term potential in diverse educational contexts.

FUTURE RESEARCH DIRECTIONS IN THE FIELD

As the field of iVR in foreign language learning continues to evolve, numerous studies have identified key areas for future research, aiming to enhance the effectiveness and applicability of iVR technologies. One recurrent theme is the call for a larger sample size and greater diversity to yield broader findings (Berns et al., 2018; C. Chen & Yuan, 2025; C.-H. Chen et al., 2021; Johnson et al., 2020; Lan & Tam, 2023; Maragkou & Rangoussi, 2018; Papin & Kaplan-Rakowski, 2024; Y. Xie, Chen, & Ryder, 2021). Another notable focus is improving speech and emotion recognition in iVR environments, with a move towards more natural, human-like communication (Garcia et al., 2019; Jia & Liu, 2019; Maragkou & Rangoussi, 2018). The expansion of virtual environments, new features, and more learning scenarios are highlighted to diversify the learning experiences offered by iVR (Y.-L. Chen & Hsu, 2020; Han, 2022; Urueta & Ogi, 2019, 2020). Suggestions include exploring collaborative virtual environments, repurposing existing iVR content for foreign-language learning, and creating new iVR learning environments across subjects (Y.-L. Chen & Hsu, 2020; Urueta & Ogi, 2020).

Given the low expertise and budget required, some unique proposals for future work include training students to record 360° videos to support learning approaches (Berns et al., 2018; Repetto et al., 2023). This approach aligns with the goal of empowering students to contribute actively to the content creation process, fostering a sense of ownership and engagement. Furthermore, ensuring consistency, accessibility, and affordability in delivering iVR-based education is crucial. The study by Nersesian et al. (2018) emphasizes the importance of providing a consistent, accessible learning experience for all students, regardless of their first language. Additionally, Berns et al. (2018) propose an approach focused on customizing learning content and affordability for school districts.

Moreover, researchers plan to implement adaptive learning systems, offer additional language support, and include game elements to reduce learner anxiety (Chabot et al., 2020; Y.-L. Chen & Hsu, 2020). Collectively, these future research directions provide a roadmap for advancing iVR in language learning, addressing challenges, and unlocking new potentials.

COMMERCIALLY AVAILABLE APPS: RESULTS AND DISCUSSION

Starting with the technical details of these commercially available iVR language-learning apps, Table 23 provides an overview of key features and specifications, including launch and revision years, pricing, monetization models, ratings, supported platforms, and the number of languages each app supports.

Table 23. Technical details of commercially available iVR language learning apps

App name	Launch year	Last rev.	Price	Monetization	Rating	Platforms	Languages supported
EduVenture VR	2019	2023	Free	None	n/a	iOS, Android	2
Mondly VR	2017	n/a	€14.99/mo €19.50/mo	Buy once	Mixed (Steam), 3.72 (PCVR), 4.1 (Quest)	Meta, Steam	30
Immerse Me	2020	n/a	US\$300/yr	Subscr.	n/a	WebVR	9
Noun Town VR	2022	2023	€14.99, €19.50	Buy once	3.99 (Quest), Very Pos. (Steam)	Meta, Steam	7
Language Lab	2022	n/a	Free, In-App €8.47/mo, €77.23/yr	Subscr.	3.85 (Quest), Pos. (Steam)	Meta, Steam	14
Virtual Speech	2016	2023	\$45/mo, \$399/yr	Unlock, Subscr., Per-course	n/a	n/a	1

Considering various aspects of commercially available iVR language learning apps, EduVenture VR stands out as a compelling option for users on a budget, being free of charge. Ratings for the apps that provided this information were generally positive, indicating user satisfaction with the overall experience.

Regarding supported platforms, Mondly VR, Noun Town: VR Language Learning, and Language Lab are available on the most popular iVR shops, Steam, and the Meta App Store (catering to users

of the Meta Quest series and/or the Link PC VR series). For those who prefer smartphone-powered iVR experiences, EduVenture VR is compatible with both iOS and Android. Additionally, for users interested in WebVR, Immerse Me offers an accessible option for immersive language learning.

Turning to the educational aspects, Table 24 examines the feedback mechanisms, learning content, target proficiency levels, immersive environments, and interaction types of these commercially available iVR language learning apps. The table offers insights into the personalized learning experiences each app provides, including feedback, supported language skills, target proficiency levels, learning environments, content types, modes of interaction, and the availability of personalized content.

Table 24. Educational aspects of commercially available iVR language learning apps

App name	Feedback	Learning content	Target level	Environment	Content modes	Interaction types	Personalization
EduVenture VR	n/a	Custom	Custom	360 Video, 360 Photo	Voice memos, Quiz, interaction	Selection, Voice Memos	Yes
Mondly VR	None, Sound, Visual, Text, Hints	Vocabulary, Grammar, Pronunciation, Listening, Reading, Speaking	Beginner, Intermediate, Advanced	Virtual Environment	Interaction avatars, Chatbot, speech recognition, multiplayer	Voice, Selection	No
Immerse Me	n/a	Pronunciation, Listening, Reading, Speaking, Dictation	CEFR, ACTFL levels	360 Video	Interaction	Voice, Selection	No
Noun Town VR	Sound	Vocabulary, Listening, Reading, Speaking	n/a	Virtual Environment	Interaction, Avatars, Mini-games	Voice, Selection	No
Language Lab	n/a	Vocabulary, Grammar	CEFR A1–B1	Virtual Environment	Interaction, Avatars	Selection	No
Virtual-Speech	n/a	Pronunciation, Speaking	CEFR B1–C2	Virtual Environment	Quiz, Interaction, Avatars, AI, Videos	n/a	No

EDUCATIONAL SETTINGS & KEY FEATURES

For those seeking rich learning content, Mondly VR is a comprehensive choice, offering a broad spectrum covering vocabulary, grammar, and pronunciation. Not only that, but Mondly VR also stands out as an exceptional choice for language learners seeking diversity beyond mainstream languages. With an extensive selection of 30 languages for practice, Mondly VR offers an opportunity to explore less commonly taught languages alongside popular ones. According to the official Mondly VR website (<https://www.mondly.com/vr>), users can engage in real-life conversations in 30 languages, including English, Spanish, German, French, Italian, Portuguese, Russian, Dutch, Japanese, Chinese, Arabic, Korean, Vietnamese, and Hindi. This platform stands out for offering a variety of language options and is ideal for individuals who want to explore different linguistic landscapes.

Most apps structure their teaching according to the CEFR Levels, supporting Beginner and Intermediate levels. However, for users at the Advanced level, both Mondly VR and VirtualSpeech English

for Business also offer tailored content and support. In addition, Noun Town: VR Language Learning enhances the learning experience through its gamification approach, integrating sound-based feedback, avatars, and engaging mini-games. However, evaluating this against the academic synthesis reveals a pedagogical limitation common in commercial apps: while it excels in technical immersion and interaction, its heavy reliance on gamified vocabulary drills lacks the deeper, structured framework that academic studies have proven most effective for long-term retention and complex skill acquisition.

On the other hand, for learners with specific goals, such as business English proficiency, VirtualSpeech English for Business offers tailored content and diverse interaction types. This platform is a valuable resource for new learners or professionals seeking to enhance their English communication skills in a business context, offering targeted content and interactive exercises tailored to the unique needs of business English learners. Notably, Mondly VR offers versatility, featuring many languages, extensive content, and diverse features, making it a strong choice for varied learner preferences and goals.

Regarding personalization, EduVenture VR is the only app that allows educators to create customized iVR learning environments. Described by its developers as a user-friendly platform, it enables teachers to craft personalized iVR experiences tailored to their students' needs and learning objectives. The platform's intuitive authoring web interface empowers educators to design immersive 360-degree VR environments that cater to diverse learning styles and preferences. This unique capability enables teachers to shape the iVR learning journey according to their pedagogical preferences, fostering greater student engagement and facilitating a more enriching learning experience.

COMMERCIAL APPS IN ACADEMIC STUDIES

The overall versatility of Mondly VR is further substantiated by its prominent use in academic studies, where it emerged as the most commonly used commercial app across four distinct research investigations. In the first study (Nicolaidou et al., 2023), undergraduate students engaged with the Italian language learning app, comparing the iVR group (Mondly VR) with a control group using the mobile application (Mondly). Although no statistically significant difference was found between the two conditions, the iVR participants demonstrated high engagement, engrossment, and immersion scores. In the second study (Tai & Chen, 2021), participants utilized the Mondly VR app through an HMD, while the control group watched a walkthrough video on a PC screen. The findings suggested that most of the iVR players found the experience engaging and beneficial. The third study (C. Chen & Yuan, 2025) focused on a Chinese-learning iVR app based on Mondly VR, employing Oculus Quest 2 as the iVR device. The results indicated that the iVR approach effectively facilitated vocabulary learning and retention, giving students a positive learning experience. Lastly, the fourth study (Tai, 2022) involved participants using HMDs to play the iVR app Mondly for EFL listening. The results highlighted that, for most iVR players, this approach was perceived as motivating, beneficial, and convenient. These consistent positive outcomes across diverse studies underscore the robustness and versatility of Mondly VR in supporting effective language learning experiences. EduVenture VR, a free and widely used app for academic studies, has demonstrated its effectiveness across various contexts, particularly in supporting language learning.

In a study by V. Lin et al. (2023), researchers leveraged the EduVenture VR platform to compose learning content and activities. The findings revealed that the iVR technology was easy to manipulate and a valuable tool for English classes. EduVenture VR was effective in helping participants learn about target tourist destinations by providing relevant words and phrases in tourism English. C.-H. Chen et al. (2021) used EduVenture VR with students in the experimental group to view, design, and share iVR content via spherical videos on HMDs. The results indicated that students in the experimental group outperformed those in the control group in vocabulary acquisition by a significant margin and showed greater motivation to learn English related to their future careers, demonstrating the app's positive impact on language acquisition and future-oriented language learning. In another study,

EduVenture VR was utilized as a learning tool for international high school students (Zhao & Yang, 2023). The study introduced a mind-mapping-based iVR learning system for Chinese courses to enhance learning outcomes and perceptions among students learning Chinese as a foreign language. The results demonstrated that the mind-mapping-based iVR learning system led to a significant improvement in students' Chinese learning outcomes, including vocabulary acquisition and sentence formation. The system also positively influenced problem-solving ability and self-efficacy while stimulating students' interest and participation in class. These studies underscore EduVenture VR's role in facilitating language learning across diverse settings and having a positive impact on vocabulary acquisition, motivation, and overall learning achievements.

The study evaluating ImmerseMe (Soto et al., 2020) found that the platform is ideal for enhancing English language skills, especially speaking proficiency. Considering diverse contexts, the immersive focus proved effective in developing communicative skills and encouraging interaction with native speakers. Recommendations highlight the need for active participation and motivation among teachers and students to ensure successful implementation despite associated costs. The study underscores the multiple advantages of immersing students in a second-language virtual environment. Crucially, evaluating these commercial apps systematically against the academic findings reveals a strong, yet incomplete, alignment. Commercial offerings like Mondly VR and EduVenture VR demonstrate successful implementation of the evidence-based principles of high interactivity, avatar use, and contextual vocabulary practice identified in RQ1 and RQ3. However, they are most effective academically not as standalone gamified solutions, but when educators ensure their active integration into established pedagogical frameworks, such as using EduVenture VR's customization to build specific TBLT scenarios (V. Lin et al., 2023). This indicates that while commercial platforms provide the necessary technical affordances, their ultimate efficacy depends on bridging the gap between out-of-the-box gamification and structured academic pedagogy.

SYNTHESIS AND IMPLICATIONS

CONNECTING EDUCATIONAL, TECHNICAL, AND OUTCOME DIMENSIONS

While the preceding sections detailed specific variables in isolation, an overarching synthesis across our four research questions reveals a highly cohesive and accessible profile of iVR in foreign language education. Educationally (RQ1, RQ2), the literature shows a strong orientation toward beginner and intermediate learners practicing foundational skills, primarily vocabulary and speaking. To teach these skills, researchers demonstrate an overwhelming reliance on TBLT. This pedagogical choice is enabled by the technical dimensions of iVR (RQ3), specifically the use of high-immersion environments, interactive object manipulation, and avatars. Notably, high-end equipment is not a strict requirement for achieving these immersive affordances; our analysis reveals a strong reliance on accessible hardware, with smartphone-based HMDs (e.g., Google Cardboard) appearing nearly as frequently as tethered PC-VR systems. When these educational and technical dimensions are aligned, the reported learning outcomes at the study level are exceptional, characterized by enhanced vocabulary retention, significantly increased learner motivation, and reduced speaking anxiety.

Furthermore, synthesizing these academic successes against the landscape of commercial applications (RQ4) reveals a surprisingly strong alignment between off-the-shelf tools and academic needs. Unlike early educational software that often relied on superficial gamification, leading commercial iVR applications (such as Mondly VR and EduVenture VR) demonstrate robust versatility, offering comprehensive content across multiple languages, CEFR-aligned learning structures, and high interactivity through avatars and speech recognition. The fact that these commercial platforms are actively and successfully used in academic studies underscores their pedagogical validity. Therefore, the overarching narrative of this review indicates that the technical capabilities of iVR are mature enough to support robust, embodied language acquisition, provided that interventions remain grounded in structured pedagogical frameworks like TBLT.

RECOMMENDATIONS FOR PRACTICE

To support the effective integration of iVR into language learning, the following explicit recommendations are provided, prioritized from the strongest evidence of pedagogical efficacy to emerging technical trends:

- **Pedagogical Integration:** iVR should be implemented using a learner-centered approach grounded in established methodologies like TBLT. Educators should focus iVR use on vocabulary acquisition and speaking practice, where evidence of efficacy and anxiety reduction is strongest.
- **Hardware Accessibility:** High-end, expensive PC-tethered setups are not essential. Schools with budget constraints can rely on mobile-based VR or standalone headsets, which are widespread in successful academic studies.
- **Commercial App Usage:** When utilizing commercial applications, educators must take an active role in bridging the ‘evidence-to-practice gap’ by going beyond out-of-the-box gamification and instead embedding these apps within culturally immersive, structured real-world scenarios.

LIMITATIONS

While this systematic review provides a comprehensive synthesis, it is important to acknowledge the study’s methodological limitations. First, the search was restricted to specific databases and to English-language publications, introducing potential language restrictions that may have excluded relevant studies published in regional journals. Second, the rapidly evolving nature of iVR technology means that hardware and software evaluated in earlier studies may no longer represent current state-of-the-art capabilities. Finally, a significant limitation of the current evidence base is the pervasive issue of poor reporting quality. Throughout the analysis, substantial proportions of studies were classified as “Not Informed” across key methodological variables, including learners’ language proficiency levels (50.0%), educational settings (44.8%), modes of instruction (29.2%), and specific in-game features (34.4%). Because of this missing data, the analysis was limited to a descriptive synthesis, as a robust meta-analysis was not feasible. This is framed not merely as missing data points, but as a severe methodological transparency issue that constrains interpretation, limits generalisability, and reduces the usefulness of the evidence for implementation decisions.

CONCLUSIONS AND FUTURE WORK

CONCLUSIONS

This systematic review provides a comprehensive synthesis of 96 studies, offering a unique trans-disciplinary perspective that bridges pedagogical methodologies, technical affordances, and commercial applications in iVR for foreign language learning.

The evidence overwhelmingly demonstrates that integrating iVR is a powerful tool for enhancing learning outcomes, the primary variable evaluated in 45 instances across the literature. Specifically, iVR excels in facilitating vocabulary acquisition and speaking practice, driven by high levels of active participant interaction (present in 70.83% of studies). Furthermore, the positive correlation between immersion into realistic environments and learner engagement is supported by the data, with user feedback (37 occurrences) and motivation (17 occurrences) emerging as prominent themes. Notably, the findings highlight the high accessibility of these interventions: smartphone-based VR and Google Cardboard (29 instances) were nearly as prevalent as tethered PC-VR setups (31 instances) in successfully preparing learners for real-world communication.

However, it is important to acknowledge that iVR serves as a complementary and facilitating tool rather than a replacement for traditional methods. The available evidence demonstrates iVR’s capacity

to transform foreign language learning by delivering quantifiable improvements in learning outcomes, greater engagement, and enhanced psychological well-being (e.g., reduced speaking anxiety). As language education continues to evolve, iVR represents not just a technological advancement but an evidence-based pedagogical tool capable of creating immersive, accessible, and effective learning experiences.

FUTURE RESEARCH DIRECTIONS

To address the challenges identified in this review, future research requires systematic organization across the following key themes:

- (a) *Research Design and Methodological Transparency*: A major directive for future research is the adoption of more rigorous, standardized reporting in iVR studies, ensuring that interventions, participant characteristics, and hardware/software specifications are documented to allow for practical replication. Furthermore, longitudinal studies are crucial. Many existing studies focus on single-session experiences; future research must incorporate multiple sessions to better understand language skill retention while mitigating novelty effects.
- (b) *Technical Development*: Comprehensive research is needed to assess the challenges of speech recognition in iVR environments, including accuracy, latency, and adaptability to different accents. Moreover, despite the potential benefits of integrating multisensory stimuli (e.g., haptics or olfactory cues) into immersive virtual reality (Melo et al., 2020), no studies in the sample addressed this in language learning.
- (c) *Psychological and Cultural Integration*: While iVR can reduce speaking-related anxiety, a deeper understanding of cognitive load and stress is necessary to optimize anxiety reduction while maintaining cognitive challenge. Additionally, exploring how authentic cultural immersion (e.g., bowing in a Japanese setting (Cheng et al., 2017)) influences cross-cultural competence could lead to a significant enhancement of iVR's realism.
- (d) *Understudied Populations and Equity/Access*: Future research must expand beyond the heavily studied university-level demographic to include young learners (K-12) and advanced adult learners. Furthermore, research should investigate the logistical and financial barriers to iVR adoption in low-resource educational settings and explore how accessible hardware can democratize immersive learning.

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APPENDIX A

INCLUDED STUDIES

Included Studies (n=96):

Ahlers et al., 2021; Bacca-Acosta et al., 2022; Barrett et al., 2021; Bergsma et al., 2023; Berns et al., 2018, 2020; Berti et al., 2020; Bisogni et al., 2022; Chabot et al., 2020; Chandra et al., 2022; Chang et al., 2024; C. Chen & Yuan, 2025; C.-H. Chen et al., 2021; Y.-L. Chen, 2016; Y.-L. Chen & Hsu, 2020; Cheng et al., 2017; Cho et al., 2022; Collins et al., 2020a, 2020b; Derakhshan et al., 2024; DeSocio, 2024; Ding, 2024; Dooly & Vera, 2024; Dooly et al., 2023; Ebert et al., 2016; Enkin, 2022; Feng & Ng, 2023; Feng & Ng, 2024; Figueroa et al., 2022; Garcia et al., 2019; Guo & Gao, 2022; Han, 2022; Harris & Sun, 2022; Hasan et al., 2024; Hayashida et al., 2020; Hsu, 2024; H.-W. Huang et al., 2023; Hung et al., 2023; Ji et al., 2019; Jia & Liu, 2019; Johnson et al., 2020; Kaplan-Rakowski & Gruber, 2021, 2024; Karageorgakis & Nisiforou, 2018; Lan & Tam, 2023; Lee, Wang, et al., 2024; Lee & Wu, 2024; Lee, Yang, & Wu, 2024; Legault et al., 2019; Y.-F. Li et al., 2024; Y. Li et al., 2022; Z. Li et al., 2023; Liaw et al., 2024; V. Lin et al., 2023; Y.-J. Lin & Wang, 2021; J. Liu et al., 2022; K.-Y. Liu et al., 2023; X. Liu & Hou, 2020; Ma, 2021; Macedonia et al., 2023; Maragkou & Rangoussi, 2018; Nersesian et al., 2018; Nicolaidou et al., 2023; Nobrega & Rozenfeld, 2019; O'Brien et al., 2009; Paccotacya Yanque & Ramos Lovon, 2018; Pack et al., 2020; Papin & Kaplan-Rakowski, 2024; Park et al., 2023; Peixoto, Melo, et al., 2021; Peixoto et al., 2023; Penpinun et al. (2021); Ratcliffe & Tokarchuk, 2020a, 2020b; Repetto, Di Natale et al., 2023; Sally Wu & Alan Hung, 2022; Shen et al., 2024; Shi et al., 2024; Song, 2019; Soto et al., 2020; Sun et al., 2020; Suzuki et al., 2021; Tai, 2022; Tai & Chen, 2021; Tseng & Geng, 2021; Urueta & Ogi, 2019, 2020, 2021; Wang et al., 2022; Wu et al., 2023; Y. Xie, Ryder, & Chen, 2021; Yang et al., 2020; Ye & Kaplan-Rakowski, 2024; Zhao & Yang, 2023.

APPENDIX B

DETAILED STUDY EXAMPLES

This appendix provides comprehensive examples from the analyses presented in the main text. Detailed study descriptions have been moved here to enhance readability while maintaining full transparency.

LIST B1. COMPARISON CONDITIONS AND TECHNOLOGIES

- (1) **Traditional Comparators:** As summarised in the main text, 22 studies used “traditional” comparators that delivered content without immersive affordances.
 - **Conventional Teaching:** Ma (2021) utilized conventional teaching methods with their control class. Similarly, Nersesian et al. (2018) utilized a standardized, nationally recognized textbook already used in the classroom.
 - **PBL:** Chen et al. (2021) employed a conventional PBL approach where participants collaboratively solved complex medical control system design problems.
 - **Vocabulary Association:** Legault et al. (2019) conducted a study where participants learned 30 words via traditional word-word paired association, comparing it against iVR vocabulary learning.
 - **Listening Exercises:** Peixoto et al. (2023) utilized a conventional method consisting of audio-only listening exercises.
 - **Visual Instruction:** Karageorgakis, Nisiforou, et al. (2018) employed a sequence of static images depicting famous city sights, followed by verbal descriptions in English.
- (2) **Non-Immersive Content:** This category includes non-immersive 3D environments on computer monitors or smartphones.

- **Educational Games:** Nersesian et al. (2018) utilized the 2D educational chemistry game “Collisions” by Playmada Games. Johnson et al. (2020) incorporated a control game called “This or That” that served as a digitized flashcard system.
 - **Online Platforms:** Feng and Ng (2023) implemented a control group that learned target words using online meeting software via PCs or smartphones, with instructors presenting slides through screen-sharing.
 - **Desktop Annotation:** Papin and Kaplan-Rakowski (2024) compared vocabulary annotated on 360° pictures viewed on a desktop monitor against standard 2D pictures on a monitor.
 - **Mobile Applications:** Nicolaidou et al. (2023) utilized a mobile application for learning Italian as their control group. Berns et al. (2020) investigated the “Cadiz 360°” app, mostly accessed via computers or tablets.
- (3) **Video Comparators:** Videos offer dynamic visual stimuli presented on traditional flat-screen displays.
- **Flat-Screen Video:** Ji et al. (2019) engaged their traditional group with video material on flat screens.
 - **Dubbed Content:** Y. Li et al. (2022) explored a video-based approach utilizing professionally dubbed videos with English subtitles.
 - **Introductory Video:** H.-W. Huang et al. (2023) incorporated a 2D introductory video prior to classroom discussions.
 - **Pre-Recorded Walkthroughs:** Tai (2022) implemented a non-interactive treatment wherein participants watched a pre-recorded walkthrough video of the Mondly application.
- (4) **Different iVR Conditions:** Studies manipulating internal iVR variables.
- **Avatar Fidelity:** Peixoto, Melo, et al. (2021) evaluated the effect of body animations and lip-sync across four distinct conditions.
 - **Virtual Environments:** Legault et al. (2019) compared spatial navigation between a Zoo setting (free movement) and a kitchen setting (high interaction).
 - **Scene Realism:** Sun et al. (2020) created high-reality and low-reality virtual scenes, examining the correlation between scene reality and learner engagement.
 - **Captioning:** Yang et al. (2020) investigated caption-assisted versus caption-off modes.
 - **Modality (AR vs iVR):** Hung et al. (2023) integrated both AR and iVR groups into English teaching.
 - **Interactivity Levels:** Harris and Sun (2022) compared High, Low, and No Interactivity. Peixoto, Melo, et al. (2021) compared conditions with and without object interaction. Peixoto et al. (2023) compared passive iVR against interactive iVR.
 - **Embodied Cognition:** Ratcliffe and Tokarchuk (2020a) investigated interacting using contextually accurate embodied controls.
 - **Modality (AR vs iVR):** Hung et al. (2023) integrated both AR and iVR groups into English teaching.
 - **Interactivity Levels:** Harris and Sun (2022) compared High, Low, and No Interactivity. Peixoto, Melo, et al. (2021) compared conditions with and without object interaction. Peixoto et al. (2023) compared passive iVR against interactive iVR.
 - **Embodied Cognition:** Ratcliffe and Tokarchuk (2020a) investigated interacting using contextually accurate embodied controls.

LIST B2. IN-GAME FEATURES AND TECHNOLOGIES

This list provides a detailed breakdown of the in-game features, mechanics, and technologies used across the included studies to enrich the virtual language-learning experience.

(1) Avatars, AI, and Interaction:

- **Interactive Virtual Characters:** Harris and Sun (2022) incorporated avatars and AI virtual characters within a city environment, allowing participants to move and interact freely.
- **Animations and Lip-Sync:** Peixoto, Melo, et al. (2021) evaluated the effect of body animations and lip-sync of avatars on user presence and knowledge retention.
- **Role-Playing Scenarios:** Urueta and Ogi (2019) utilized avatars for high-presence learning scenarios with roles played by students and teachers.
- **Cultural Tracking Mechanics:** Cheng et al. (2017) implemented a bowing mechanic in a Japanese teahouse setting by detecting head movement using HMD tracking (registering a successful bow beyond 22.5°).

(2) Speech and Voice Technologies:

- **Phoneme Acquisition:** Hayashida et al. (2020) used voice recognition devices to measure learners' recorded phoneme scores, providing direct feedback on learning progress.
- **Scenario Training:** Suzuki et al. (2021) focused on customer service training using voice recognition in English scenarios.
- **Conversational Applications:** Tai and Chen (2021) evaluated the Mondly VR app, which leverages spatial audio, verbal/non-verbal communication, and immediate feedback with virtual characters. Berns et al. (2018) explored users' engagement with iVR content through voice commands and a chatbot.

(3) Advanced Tracking and Interaction Modalities:

- **Locomotion and Object Manipulation:** In a virtual supermarket scenario (Phyo et al., 2021b), users learned basic vocabulary by teleporting, grabbing objects, and hearing audio utterances.
- **Eye-Tracking:** Bacca-Acosta et al. (2022) utilized eye-tracking to reveal insights into students' information processing and attention in dynamic iVR environments.
- **Hand Tracking:** Maragkou and Rangoussi (2018) used Leap Motion controllers to provide users with a tangible connection between real and virtual hands, enhancing interaction feedback.

(4) Gamification Elements: Paccotacya and Lovon (2018) and Horita et al. (2014) demonstrated that gamification elements introduced in vocabulary learning prototypes yielded favorable results compared to traditional methods.

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