MULTILINGUALISM AND MULTISENSORY TECHNOLOGIES

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ABSTRACT
This paper aims to examine how multilingualism and multisensory digital technologies mutually reinforce each other and how their interaction may contribute to the development of more inclusive language learning ecosystems. After outlining the theoretical framework of multilingualism in its cognitive, metalinguistic and socio-communicative dimensions, the study reviews key evidence on the impact of digital devices, with a focus on multisensory technologies. The literature highlights how tools such as augmented reality (AR), virtual reality (VR) and immersive environments can act as complex cognitive settings, enhancing lexical memory, supporting contextualised meaning-making and fostering implicit learning. At the same time, multilingualism emerges as a cognitive resource linked to greater tolerance of informational complexity, more efficient management of competing inputs and increased adaptability in multimodal contexts. Overall, multisensory technologies appear not only to support but also to reshape language learning processes through the integration of symbolic and perceptual systems, pointing to the need for further empirical research on their transformative potential.

KEYWORDS
Multilingualism; language learning; inclusive education; multisensory technologies; augmented reality; virtual reality; artificial intelligence.

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1. Introduction

The decision to address the topic of multilingualism and language learning stems from an observation of the profound changes characterising the contemporary world, which is increasingly dynamic, diverse and multicultural.

The aim of the research is to analyse the literature on the relationship between digital, immersive and multisensory technologies and language learning, with particular attention to their effects on the processes of acquisition, motivation and communicative participation. Building on the available evidence, which mainly relates to second-language learning, this study also aims to explore, on a hypothetical basis, the possible applications of such technologies in multilingual contexts – an area for which the literature is currently more limited.

This study takes the form of a narrative review of the literature. The literature search was conducted using the main academic databases and research platforms: PubMed, Scopus and Google Scholar. The selection of studies covered various thematic areas related to the relationship between multilingualism and digital technologies, including language learning, multilingualism, machine translation, Digital Language Learning Ecosystems, the use of digital and multisensory technologies in teaching, and the sociolinguistic dimension of artificial intelligence.

Migration flows that began in the 1970s and intensified further in the 1990s have helped to reshape the social and geopolitical fabric, particularly in Europe. Faced with these cultural and social transformations, the education system has not always been able to respond effectively to the new demands imposed by modernity. Today's classrooms are increasingly characterised by the presence of pupils from migrant backgrounds or the children of immigrants, who require appropriate educational pathways and effective inclusive strategies. All of this requires, in

parallel, specific and ongoing teacher training: a fundamental element which, however, does not always receive the necessary attention.

The term 'multilingualism' refers to the presence and use of multiple languages within the same social, cultural or institutional context (Treccani, 2025). This phenomenon can be analysed at both the individual and collective levels; however, when the focus is on an individual's linguistic competences, the most accurate term to use is plurilingualism, a concept distinct from multilingualism, although the two terms are often confused in everyday language.

Research into multilingualism in schools has shown numerous positive effects on pupils' cognitive, linguistic, social and cultural development, especially when the individual achieves an appropriate balance between proficiency in their first language (L1) and their second language (L2). This perspective is based on the 'threshold level' theory developed by Cummins in 1983, according to which the benefits of bilingualism only become fully apparent once sufficient proficiency in both languages has been attained (Cummins, 1983).

Today, multilingualism represents one of the most significant challenges for contemporary education systems, which are called upon to rethink pedagogical models and teaching practices from an inclusive and ecological perspective. Educational institutions are increasingly becoming complex and diverse linguistic environments, characterised by the coexistence of different linguistic repertoires; this makes it necessary to adopt educational approaches capable of recognising and valuing linguistic diversity as an educational and cultural resource.

2. The transformation of communication environments

The cognitive, linguistic and social benefits of multilingualism are now even more important in a society profoundly transformed by technological innovation and the proliferation of digital environments. Whilst multilingualism fosters the

development of transferable skills such as cognitive flexibility, intercultural openness and communication skills, the digital transformation of learning is redefining the ways in which these skills are developed, shared and enhanced.

The evolution of digital technologies has, in fact, significantly altered the contemporary educational experience, giving rise to new learning ecosystems characterised by interactivity, accessibility and continuous connectivity. In this context, learning no longer takes place exclusively within the traditional school setting, but extends to digital platforms, immersive environments and multisensory tools that enable students to interact with a variety of languages, cultures and modes of communication.

Digital technologies have not merely created new communication tools; they have radically transformed the environments in which languages are used, learnt and negotiated, thereby redefining the very nature of contemporary multilingualism.

In the past, multilingualism was generally defined as the presence and use of multiple languages in distinct and well-defined communicative domains. From this perspective, each language was regarded as an autonomous and independent system, whilst the multilingual individual was described as someone capable of switching between linguistic codes according to specific communicative needs.

In recent decades, thanks largely to the theoretical contributions of Ofelia García and Li Wei, this approach has undergone a significant revision. Multilingualism is now conceived as a dynamic phenomenon, characterised by the constant integration of available linguistic resources. From this perspective, speakers do not use languages as separate compartments, but mobilise their entire linguistic repertoire to interpret reality, build social relationships and express their identity.

It is within this context that the concept of translanguaging (Wei, 2018) is situated, referring to the flexible and interconnected use of the various linguistic

competences possessed by an individual. The development of digital technologies has further facilitated the spread of these practices, creating communicative environments in which the alternation and combination of different languages occur naturally, immediately and continuously.

One of the most significant aspects of the digitalisation of communication processes is the profoundly multilingual nature of online environments. Digital platforms, in fact, constitute spaces for interaction in which different languages and cultures coexist and are constantly intertwined.

Social networks, streaming services, virtual communities, forums and online video games facilitate daily encounters between users from different geographical and linguistic backgrounds. In such communicative ecosystems, the use of a single language is often the exception rather than the rule. Instead, practices such as code-switching, the use of loanwords, informal translation processes and the combination of resources from different linguistic repertoires are commonplace (Ho, 2024).

A significant example is provided by the communication habits of the younger generations: an Italian student might consume audiovisual content in English, communicate in Italian via instant messaging apps, use English expressions whilst playing online games, and collaborate with international counterparts on shared digital platforms. In such a context, contact between different languages becomes a routine part of everyday life, making multilingualism a structural feature of contemporary communication rather than a marginal or occasional phenomenon (Garcia & Wei, 2014).

The evolution of digital communication environments is not limited to the increasing coexistence of different languages, but also influences the ways in which meanings are produced and shared. In contemporary communication, in fact, the

transmission of information increasingly takes place through the integration of multiple semiotic resources, including written and spoken language, images, audiovisual content, emojis, GIFs, sound effects, animations and other forms of visual and gestural interaction (Jewitt, 2014).

From this perspective, in 2021, Kress and van Leeuwen emphasised that digital communication is inherently multimodal, as the process of constructing meaning does not depend on a single expressive code, but on the interaction between different modes of communication operating simultaneously (Kress & van Leeuwen, 2021).

This characteristic plays a particularly significant role in contexts characterised by linguistic and cultural diversity. The presence of visual, iconic and contextual elements can, in fact, aid understanding of content even when language skills are limited or still developing. Consequently, multimodality helps to reduce communication barriers, promoting more inclusive forms of participation and facilitating interaction between individuals from different linguistic backgrounds.

Digital technologies are helping to redefine not only linguistic practices but also the relationship between language and the construction of individual and collective identity. Whilst in the past language was often interpreted as one of the main indicators of national, ethnic or cultural belonging, the processes of globalisation and digitalisation have fostered the emergence of more dynamic, complex and transnational forms of identity.

Digital environments, in fact, enable individuals to participate simultaneously in multiple linguistic and cultural communities, transcending traditional geographical boundaries (Darvin & Norton, 2015). This possibility fosters the formation of plural and hybrid identities, which develop through interaction with diverse linguistic

repertoires and are not necessarily tied to a single language or a single cultural affiliation.

Another factor contributing to the redefinition of contemporary linguistic practices is the growing prevalence of artificial intelligence-based technologies. The introduction of machine translation systems, virtual assistants and multilingual chatbots is significantly transforming the way in which individuals interact with languages and access information.

Thanks to these tools, communication between people from different linguistic communities is becoming increasingly immediate and accessible. Artificial intelligence-based applications enable the real-time translation of messages, the production of content in different languages, the facilitation of understanding complex linguistic terms and structures, and the adaptation of communication materials to users' language proficiency levels. In this way, language barriers tend to diminish, fostering new forms of interaction and collaboration in international and multicultural contexts (Kasneci et al., 2023).

At the same time, the increasingly widespread use of these technologies raises important educational, linguistic and ethical issues (UNESCO, 2023). Whilst artificial intelligence broadens opportunities for access to intercultural communication and knowledge, it also raises questions regarding the role of language learning, the safeguarding of speakers' communicative autonomy, and the risk that the widespread use of automated tools may foster a certain homogenisation of expressive patterns and communicative practices.

The most recent research interprets these transformations by increasingly referring to the concept of the digital linguistic ecosystem (Pinto-Llorente & Izquierdo-Álvarez, 2024). This perspective views linguistic practices as the result of a complex network of relationships that develop within contemporary digital environments.

In this context, languages are no longer conceived as tools used in separate and rigidly defined contexts, but rather as resources that circulate and transform within highly interconnected communication systems. Within these systems, individuals, digital technologies, online communities, algorithms, multimedia content and socio-cultural practices interact simultaneously, contributing to the construction of new forms of communication and participation.

From this perspective, multilingualism cannot be reduced to a mere competence possessed by the individual. Rather, it appears as an emerging phenomenon that takes shape through the continuous interaction between people, technological tools and communicative environments. Consequently, linguistic plurality becomes a structural feature of contemporary digital ecosystems, in which communicative practices are increasingly fluid, collaborative and transnational.

Whilst digitalisation has progressively transformed communicative spaces into environments characterised by increasing linguistic plurality, multimodality and interconnectivity, immersive and multisensory technologies represent a further stage in this evolution. Tools such as virtual reality, augmented reality, AI-based conversational agents and interactive digital environments expand the ways in which language is experienced and used. In such contexts, language is no longer merely a system of signs to be read or heard, but becomes an integral part of an experience that simultaneously engages the perceptual, bodily and relational dimensions. This transformation opens up new opportunities for language learning, fostering more contextualised and participatory acquisition processes, whilst also offering interesting prospects for the design of more inclusive educational environments capable of promoting linguistic and cultural diversity.

3. Multisensory and immersive technologies

In recent years, several studies have shown that immersive and multisensory technologies are not merely tools to support language teaching, but help to profoundly transform the ways in which language skills are acquired, used and experienced (Yu, Z. & Duan, P., 2024; Mayer et al. 2015; Ilhan & Kaçanoğlu, 2024).

Whilst language learning has traditionally been based primarily on reading, writing, listening and the memorisation of vocabulary and grammatical structures, the latest digital innovations have introduced approaches that are more centred on experience, active participation and interaction with the environment. In this context, technologies such as virtual reality and augmented reality facilitate forms of situated learning, in which language is acquired within realistic and meaningful communicative contexts. The learner is no longer merely a recipient of linguistic content, but becomes the protagonist of experiences that simulate authentic communicative situations and require the use of language to achieve concrete objectives (Cai et al., 2022).

Consider, for example, a student learning German: rather than simply studying vocabulary relating to a railway station through exercises or word lists, they can immerse themselves virtually in a German railway station, buy a ticket, ask for information about train timetables or interact with digital interlocutors who communicate in the target language. In such situations, learning takes place through action, direct experience and social interaction, enabling learners to associate words, meanings and linguistic structures with concrete contexts of use.

Language is therefore not learnt solely as a set of abstract rules to be memorised, but as a situated communicative practice, constructed through the dynamic relationship between the individual, the environment and social interaction. From this perspective, language learning takes on an increasingly experiential and

multisensory dimension, in which the learner's active engagement becomes a central element in the development of communicative skills.

One of the theoretical perspectives that has gained increasing prominence in the study of language learning is that of embodied cognition. According to this approach, cognitive processes do not depend exclusively on brain activity, but emerge from the dynamic interaction between mind, body and environment. Thought, memory and language are therefore deeply influenced by the sensory, perceptual and motor experiences that the individual undergoes during everyday activities (Lan et al., 2015).

From this perspective, understanding a word or concept does not simply mean activating an abstract mental representation, but also involves the reactivation — at least in part — of the bodily experiences associated with that specific meaning. For example, hearing or reading an action verb such as 'run' may involve areas of the brain linked to the planning and execution of movement, suggesting that language is closely connected to individuals' bodily experiences.

When applied to language learning, the theory of embodied cognition argues that language acquisition is particularly effective when linked to concrete, contextualised experiences in which the learner can actively interact with the environment through movement, sensory perception and action. From this perspective, language is not acquired solely through memorisation, but through meaningful experiences that involve the body and interaction with the context (Wei, 2018). Numerous studies have shown that linking linguistic input with semantically congruent gestures and actions can enhance vocabulary learning and retention, with benefits observable even several months later (Macedonia & Knösche, 2011; Andrä et al., 2020; Mathias et al., 2021). More recent evidence also shows that multimodal cues, such as meaningful gestures and visual information

associated with speech, can facilitate semantic processing and comprehension in a second language (Zhang et al., 2023).

The implications of this approach are particularly interesting in the context of multilingualism. According to 'embodied cognition', the languages known to an individual do not constitute isolated and independent systems, but are closely linked to networks of perceptual, emotional, social and motor experiences. A language learnt within the family may be associated with specific emotional and relational experiences; a language acquired in a school setting may evoke formal situations and study activities; a language used whilst playing sport, on the other hand, may be linked to experiences of movement, collaboration and participation in group dynamics. Each language is therefore deeply intertwined with the contexts in which it is used and with the bodily and social experiences that accompany it (Reggin et al., 2023).

One of the most robust findings comes from Chen's meta-analysis, which examined numerous studies on virtual reality-assisted language learning. The research findings show an improvement in language skills with a moderate effect size (Hedges' g = 0.662); an improvement in affective and motivational aspects (Hedges' g = 0.570); and greater engagement and participation compared with traditional teaching (Chen et al, 2022).

Another meta-analysis, conducted by the same author, examined 17 studies involving 993 participants; in this case, an even higher overall effect size (effect size = 0.825) of extended reality (VR, AR and MR) on language learning was found. The study therefore demonstrates how VR technology enables multilingual learners to use multiple languages simultaneously, simulate authentic communicative contexts, reduce language anxiety and develop intercultural skills through immersion in virtual environments (Chen et al., 2022).

3.1 Virtual reality and foreign language anxiety

Within this theoretical framework, immersive and multisensory technologies can be regarded as particularly effective tools for promoting forms of learning consistent with the principles of embodied cognition. Virtual reality environments, augmented reality and interactive simulations enable learners to learn languages through the active exploration of digital spaces, interaction with virtual objects and interlocutors, and exposure to visual, auditory and, at times, tactile stimuli. Students do not merely observe or listen passively, but use the language to carry out concrete tasks, make decisions and achieve specific objectives within realistic contexts. In this way, language learning takes on a genuinely experiential dimension, in which language, body and environment jointly contribute to the construction of knowledge.

One of the challenges of traditional language learning is the lack of authenticity in interactions. Immersive technologies can enhance what is termed 'social presence' — that is, the perception of genuinely interacting with other people — through avatars, shared virtual environments and collaborative simulations. Several studies, for example, show that virtual reality (VR) can reduce so-called 'foreign language anxiety', encouraging greater participation (Yu & Duan, 2024; Kaplan-Rakowski & Gruber, 2023; Ye et al. 2026). Foreign language anxiety is defined as: 'a complex of perceptions, beliefs, feelings and behaviours related to language learning in the classroom, arising from the unique nature of the foreign language learning process' (Horwitz, Horwitz & Cope, 1986). Virtual reality (VR) can help reduce this form of anxiety by addressing the three elements that most contribute to it: the fear of speaking, the fear of being judged by others, and performance anxiety (Dhimolea et al., 2022). Through this tool, students would have the opportunity to practise their language skills within immersive environments perceived as safe and

controllable. By interacting with avatars and simulated scenarios, students can experience authentic communicative situations, whilst reducing their fear of social judgement and of making mistakes. Furthermore, the ability to repeat activities and progress gradually fosters the development of communicative self-efficacy. In this way, virtual reality helps to create emotional conditions more conducive to language learning, promoting more active participation and greater confidence in one's own communicative abilities (Yu & Duan, 2024).

A recent study reports that virtual reality does not directly reduce foreign language anxiety (FLA), but acts through intermediate psychological mechanisms. The author sought to understand how exposure to virtual reality influenced FLA in Chinese students learning English as a second language (ESL). The study involved over 1,000 university students and analysed four main variables: exposure to virtual reality environments; communicative confidence; perceived fluency; and foreign language anxiety. The findings show that exposure to immersive virtual environments increases students' communicative confidence and perceived fluency, factors which in turn help to reduce anxiety associated with using a foreign language. These results suggest that the educational potential of immersive technologies extends beyond the development of language skills to include improvements in students' emotional well-being and communicative self-efficacy (Gu, 2025) .

Digital technologies are not merely tools to support language teaching; rather, they shape new learning ecosystems in which interaction, multimodality and flexibility foster the development of language skills in increasingly multilingual and intercultural contexts.

A recent study conducted by Alhawsawi and Alzaid analysed the relationship between learning English vocabulary as a second language (L2) or foreign language (ESL/EFL) and the use of virtual reality (VR) tools. The systematic review was

conducted in accordance with the PRISMA protocol guidelines and examined studies published over a ten-year period, between 2013 and 2023. Following the selection process, 23 empirical studies were included, involving a total of approximately 1,500 participants. The majority of the sample consisted of university students, who accounted for 78.3 per cent of the participants in the studies analysed. As regards the technological tools employed, the most frequently used platforms were Google Expeditions, Unity, EduVenture and various virtual environments developed specifically for particular educational projects. These technologies were integrated into immersive teaching activities aimed at language and intercultural learning.

The main findings highlighted a significant improvement in vocabulary acquisition. Students who used virtual reality demonstrated better word retention, greater recall ability and a better understanding of the meaning of words in context. Virtual reality tools appear to facilitate learning as words are associated with concrete contexts and lived experiences, rather than being learnt in an abstract manner. Other findings include greater motivation and engagement, increased cognitive and emotional involvement, and greater confidence in communication, as students perceive the virtual reality environment as a safe space where they can make mistakes without being immediately judged by their peers or the teacher. The limitations identified in the review relate to the high cost of the equipment, the risk of cognitive overload, and the scarcity of longitudinal studies (Alhawsawi & Alzaid, 2025).

4. Digital Language Learning Ecosystem

Immersive technologies represent just one of the many possible applications of digital transformation in language learning. From an even broader perspective, there are the so-called Digital Language Learning Ecosystems (DLLE) — digital

ecosystems that expand opportunities for language exposure and communicative interaction, overcoming the spatial and temporal constraints typical of traditional teaching. In these contexts, technology does not merely serve a utilitarian function, but helps to create learning environments in which language skills are developed through participatory, collaborative and multimodal processes.

The use of online learning platforms, remote collaboration tools, multimedia resources and artificial intelligence-based applications enables the creation of authentic and meaningful language experiences. Learners can practise their communication skills in real-life situations, interacting with a variety of content, tools and interlocutors, even outside the school setting. This approach is in line with the extended learning perspective, as it promotes the integration of formal learning, informal experiences and digital environments, creating continuity between different contexts of life and language use (Pinto-Llorente & Izquierdo-Álvarez, 2024).

Another point of interest concerns the relationship between these digital ecosystems and multilingualism. DLLs, in fact, promote translanguaging practices (the dynamic and integrated use of multiple languages within a single communicative or learning process, aimed at constructing meaning and enhancing individuals' language skills), enabling students to make flexible use of their entire linguistic repertoire (García & Wai, 2014). The availability of machine translation tools, multimodal resources and opportunities for intercultural interaction facilitates the transition between different languages and helps to enhance students' existing language skills. In this way, digital technologies support more inclusive educational models, capable of recognising and promoting linguistic diversity as a resource for learning.

However, for this potential to translate into real educational opportunities, the integration of digital ecosystems for language learning must be accompanied by thoughtful instructional design. In this context, the teacher's role is gradually evolving from that of a mere conveyor of content to that of a facilitator of complex learning experiences, guiding students towards a critical, responsible and inclusive use of digital technologies (Nguyen & Tuamsuk, 2022).

4.1 Digital Storytelling

Another methodology of particular relevance to language teaching and the promotion of multilingualism is digital storytelling (DST). According to Linville and Vinogradova (2023), this approach enables students to develop language skills by creating digital narratives that integrate different languages, media and expressive resources. It is a form of multimodal digital composition, that is, a communicative practice that combines written text, images, audio, video, music, graphics and other digital elements to construct meaning. This multimodal nature makes DST particularly well-suited to multilingual contexts, as students can simultaneously use multiple languages and different modes of expression to recount their experiences, stories and cultural identities.

The systematic review, conducted in 2024 by Ma Q and Zhang Z, based on an analysis of 24 empirical studies published between 2013 and 2022, sought to understand how Digital Storytelling has facilitated the construction of meaning amongst bilingual students. The research was conducted mainly in North America in secondary schools (58.3 per cent), primary schools (29.2 per cent) and universities (20.8 per cent). One of the most significant findings to emerge from the review concerns the strengthening of linguistic and cultural identity. According to the authors, through digital storytelling, pupils can share their personal stories, migration experiences, family culture and mother tongue, thereby seeing aspects

of their identity – often overlooked in traditional school settings – recognised and valued. Furthermore, this is said to promote the preservation of their languages of origin, preventing their gradual loss amongst second-generation immigrants. A particularly significant aspect is that digital storytelling promotes practices of translanguaging, enabling students to freely use and combine the different languages in their linguistic repertoire. In this way, languages are not viewed as separate systems, but as integrated resources for constructing meaning and expressing one's identity.

Finally, the review by the two authors highlights how Digital Storytelling contributes to the development of language skills, particularly vocabulary, writing, storytelling, communication and metalinguistic reflection. This is thought to occur because students are involved in all stages of story construction — from planning to writing, through to recording and revising content — thereby simultaneously activating various linguistic processes. The combination of language, images, audio and video would therefore make DST a particularly effective methodology for promoting inclusive and multisensory learning processes (Ma & Zhang, 2024).

4.2 AI and Chatbots

Among the technologies contributing to the transformation of digital language learning ecosystems, generative artificial intelligence systems and conversational chatbots are playing an increasingly significant role. These tools further expand the possibilities offered by digital language learning ecosystems, enabling learners to access authentic, personalised and continuous practice experiences. For this very reason, in recent years, a number of studies have begun to investigate the effectiveness of chatbots in supporting language learning and the development of communication skills in multilingual contexts.

Among these, for example, is the 2024 meta-analysis by Wang et al., which aimed to assess the effectiveness of chatbots in language learning. The study examined 28 field studies, comprising a total of 70 effect sizes (such as grammar, vocabulary, speaking ability, etc.), involving learners of different ages, levels of language proficiency and educational contexts. The results highlighted a moderate positive effect on language learning ($g = 0.484$), suggesting that chatbots can serve as a valuable tool for developing language skills. In particular, according to the authors, they would facilitate communicative practice, increase exposure to the target language and enable personalised learning pathways. At the same time, the effectiveness of these interventions appears to be influenced by various factors, including the students' proficiency level, the quality of the interface and the chatbot's interactive capabilities. The results of the meta-analysis also point to benefits at an affective and motivational level, highlighting greater engagement and increased confidence in language use, as well as a reduction in communicative anxiety (Wang et al, 2024).

According to the authors, chatbots prove to be particularly promising tools because they enable students to practise independently, flexibly and continuously. The ability to interact with these systems at any time promotes greater exposure to the language and allows activities to be tailored to the individual learner's needs and proficiency level. This helps to make language learning more accessible, extending it beyond the confines of formal educational settings and integrating it into everyday practices.

Another particularly interesting study is the 2024 paper published by Zhang, Meng and Ma, which involved 131 Chinese university students studying English. Over a six-week period, 65 students used an AI-based conversational assistant, whilst the remaining 66 followed a traditional teaching programme without AI support.

At the end of the intervention, the students who had used the conversational assistant showed a significant increase in their willingness to communicate in English and in the enjoyment they derived from learning, accompanied by a reduction in language anxiety. In the control group, however, no significant changes were observed in these same areas.

The findings highlight that linguistic competence does not necessarily correspond to a willingness to communicate. In this regard, AI-based conversational tools can provide a practice environment perceived as less judgemental, fostering greater confidence prior to interacting with real interlocutors (Zhang et al. 2024).

A further contribution to this topic is provided by the 2025 meta-analysis by Li, Wang and Yang, which focuses on the use of generative AI chatbots in second language learning. The authors analysed 41 experimental or quasi-experimental studies, involving a total of 3,515 participants and 48 effect sizes. The study highlighted an overall positive and statistically significant effect of the use of generative chatbots on language learning (ES = 0.576; 95% CI: 0.385–0.768). The result therefore indicates a moderate effect, confirming the potential of generative AI as a tool to support second-language acquisition (Li et al. 2025).

In conclusion, these findings highlight how recent developments in generative artificial intelligence have significantly expanded the educational potential of chatbots.

5. Discussion and Conclusions

Current literature indicates that the relationship between language learning and digital technologies cannot be interpreted solely in instrumental terms, that is, as the mere use of technological devices to support language learning. On the contrary, the evidence described in this review suggests that digital and multisensory technologies can have a more profound impact on learning processes,

facilitating the acquisition and consolidation of language skills through the integration of visual, auditory, motor and contextual stimuli. From this perspective, immersive environments, virtual and augmented reality, and systems based on artificial intelligence can be seen not merely as support tools, but as genuine learning contexts capable of broadening the ways in which learners engage with language.

With regard to this paper, an initial point for reflection concerns immersive technologies and the way in which they are contributing to a profound transformation of the very nature of language learning. The meta-analyses examined all show moderate to high positive effects on the acquisition of language skills. Furthermore, some findings are particularly interesting when interpreted in the light of embodied cognition theory. According to this perspective, language is not acquired exclusively through abstract processes of symbolic processing, but through the interaction between mind, body and environment. Immersive technologies appear to offer particularly favourable conditions for this type of learning, as they enable learners to associate words, concepts and linguistic structures with concrete experiences, actions and realistic communicative contexts. The effectiveness of the learning process, as highlighted by the research, may therefore stem not only from the technological novelty of the tools used, but also from their ability to promote forms of situated, experiential and multisensory learning.

Digital technologies also appear to have effects that go beyond the mere development of language skills. Indeed, some studies highlight benefits in terms of motivation, emotions and identity. Furthermore, research on virtual reality shows a reduction in foreign language anxiety and an increase in communicative confidence, whilst evidence relating to digital storytelling emphasises the role of such practices in strengthening students' linguistic and cultural identity. This

evidence suggests that multisensory technologies can promote not only language learning but also psychological well-being, a sense of belonging and an appreciation of linguistic and cultural diversity. This aspect takes on particular importance in multicultural educational contexts, where recognition of students' mother tongues and multilingual identities is a fundamental element in building truly inclusive environments (Cai et al. 2022; Gu, 2025).

It is also particularly interesting to assess the effectiveness of different types of educational technology. Artificial intelligence-based chatbots generally show moderate positive effects on language learning, confirming their potential, particularly as tools for communicative practice and personalised learning (Wang et al., 2024). In studies on virtual reality and extended reality, the effect sizes observed on language learning are usually higher. Although great caution is required when interpreting this evidence, such differences in effect size might suggest that technologies capable of simultaneously engaging a greater number of perceptual and sensory channels are able to produce more substantial educational effects. If, in future, this hypothesis were to be confirmed in comparative research, it would further reinforce the idea that the multisensory dimension is one of the key elements in understanding the effectiveness of new technologies in language learning.

Despite the numerous potential benefits, the literature also highlights certain limitations and critical issues that cannot be overlooked. Indeed, challenges remain regarding the costs of immersive technologies, the risk of cognitive overload, inequalities in access to digital resources, and the need for adequate training of teaching staff. Added to this are ethical and linguistic issues relating to the growing use of artificial intelligence, including the potential risk of standardisation of communication models and the marginalisation of minority languages that are under-represented in digital systems. All these factors suggest that technological

innovation, in itself, is not sufficient to guarantee inclusion and educational quality (UNESCO, 2023; Alhawsawi & Alzaid, 2025).

To date, unfortunately, the scientific literature does not report any significant or sufficiently robust studies designed to support a possible association between the use of multisensory technologies and multilingualism. It therefore appears necessary to promote further empirical studies – particularly longitudinal and intercultural ones – in order to gain a deeper understanding of how multisensory technologies can contribute to the development of truly inclusive educational ecosystems, capable of valuing linguistic and cultural diversity as a fundamental resource for learning and social participation.

The future of language education may lie not simply in adding technology to multilingual classrooms, but in designing learning ecosystems in which multilingual cognition and multisensory interaction become mutually reinforcing dimensions of language learning.

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