Tracking the New Trends in Immersive Virtual Reality-Assisted Foreign Language Education: A Systematic Review of Empirical Studies

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Abstract

This article follows up on a previous review of 30 empirical studies that examined the use of immersive virtual reality (iVR) for teaching foreign language (FL) published before 2021. That review concluded that iVR was an emerging technology in FL education. However, since then, iVR technology has rapidly developed and garnered more attention in FL education. To track the new trends in iVR-assisted FL education, we conducted a follow-up systematic review using the PRISMA method. We found 38 empirical studies published between January 2021 and March 2023, which is more than those previously found. Our findings revealed new trends and more benefits, yet more challenges compared to the previous review. The new trends discovered include an increase in both the quantity and quality of publications, research expanding from adults to younger learners, and a variety of language skills investigated. Moreover, the research focus has broadened from the iVR technology per se to its influence on different learners (e.g., gender and FL level) and the combination with other technologies or instructional strategies, such as High-iVR (i.e., users can interact with the virtual environment naturally with a sense of physical presence and full-body movement) and learner-created VR environments. The reported benefits of iVR-assisted FL education include enhancing learners' engagement and FL skills, while the challenges include handling operational issues and unstable internet connection. Drawing from the insights gathered through this review, we derive educational, technological, and research implications that contribute to the field of iVR-assisted FL education.

Keywords: new trends, benefits, challenges, iVR, FL, iVR-assisted FL education

1. Introduction

1.1 Background

Globalization and information technology are bringing about a great shift in human civilization and the relationship between humans, nature, and different social groups. Language proficiency has evolved into a critical educational issue as well as a symbol of personal social status. Favorable government policies and an effective educational model can promote FL teaching. According to the standards of the American Foreign Language Learning, FL education addresses five goals known as the 5Cs: communication, culture, connection, comparison, and community (Xie, Liu, Zhang, & Zhou, 2021). FL education encourages students to use an FL for communication in the areas of listening, speaking, reading, and writing to express their ideas, feelings, and opinions as well as to experience various cultures and gain an appreciation for the target language's past and present. As a result, FL should not be used only for memorization and grammar practice, instead, FL can be used to supplement other subjects' learning and to compare the characteristics of the native and target languages, as well as the different cultures. Learning should be extended beyond the classroom to the global community to cultivate lifelong learners.

Real-life full immersion in a natural language environment is the most effective method for learning an FL (Kaplan-Rakowski & Wojdy'nski 2018; Terehoff, 2000). However, real-life immersion in countries is not always viable or accessible due to the lack of resources since the learner's native language is the desired one (Freed, 1998).

By creating a strong sense of presence, virtual reality (VR) has the potential to be applied in FL education to promote interactive and contextualized learning experiences (Hua & Wang, 2023). VR has evolved very quickly since the beginning in the 1960s. Compared to previous two-dimensional (2D) virtual environments, today's VR tools are much more advanced and interactive, with three-dimensional (3D) virtual environments and customizable avatars (Lin & Lan, 2015). The growing interest in using VR technologies for language learning and teaching underscores the significance of comprehending the most efficient methods to integrate VR into FL education.

1.2 Non-, Low- and High-Immerivse VR

Non-immersive, low-immersive, and high-immersive VR are different types of VR experiences that vary in their level of user immersion and interaction (Lee & Wong, 2014; Kaplan-Rakowski & Gruber, 2019). See Table 1.

Non-immersive VR (Non-iVR) refers to experiences that lack deep perception and provide very limited interaction, typically using 2D displays such as a desktop monitor. Examples of non-iVR include language learning apps and video tutorials that use basic animations to teach language concepts.

Low-immersive VR (Low-iVR) involves more advanced 3D displays and devices such as head-mounted displays (HMDs) that allow the user to interact with the virtual environment in a more immersive way (Verjans, Luijten, & Verbraeck, 2021). Examples of low-iVR include virtual field trips and simulations of real-life scenarios.

High-immersive VR (High-iVR) is the most advanced form of VR, which offers the most immersive and interactive experience using advanced HMDs and motion-tracking devices. Users can interact with the virtual environment in more naturally, with a sense of physical presence and full-body movement (Ma, Bechkoum, & Benford, 2019). Examples of high-iVR in language learning include immersive language environments where learners can practice real-life communication skills in a simulated environment.

Table 1. Learning Conditions of Different Types of VR

Characteristics	Learning Conditions		
Name	Non-iVR	Low-iVR	High-iVR
Viewing method	Desktop monitor	HMD	Advanced HMD and motion-tracking devices
Immersion level	None	Low	High
Video type	Standard 2D pictures	360 °videos	360 °videos
Interactivity	No interactivity	Mouse scrolling, panning, zooming	Full-body movement
Examples			

In summary, the primary difference between Non-iVR, Low-iVR, and High-iVR is the level of immersion and interaction they provide. Non-iVR is the least immersive, Low-iVR provides a moderate level of immersion, and High-iVR provides the most immersive experience with a high degree of interaction. We restrict our focus to iVR, including Low-iVR and High-iVR but exclude studies on other technologies (e.g., Non-iVR, Augmented Reality, or Mixed Reality).

2. Literature Review

There have been some reviews on VR-assisted FL education in recent years. Huang, Zou, Cheng, and Xie (2021) selected and analyzed 88 papers published from 2011 to 2020, which investigated the application of VR and AR technology in language learning. The main research findings were that VR and AR-assisted language learning was supported by creating an immersive virtual world for learners. Meanwhile, this review concerned the benefits of AR and VR for language learning, including the improvement of students' learning outcomes, motivation enhancement, and learners' positive perceptions. Although VR and AR are associated with each other and have some connections, they are technologically different. Bahari (2021)'s review paper focused on VR technology only and reported not only the affordances but also the challenges of VR to teach FL skills. He reviewed 75 peer-reviewed articles published from 2010 to 2020 and revealed that there was an imbalanced trend of research on VR-assisted FL education and affordances in favor of speaking and listening skills compared to reading and writing skills. Zheng et al. (2023) gave more detailed findings by analyzing 69 empirical studies which were published by 6 Chinese and 6 international scholarly journals from 2010 to 2020. This review's findings included that English was the main target language of VR-assisted FL learning, the Second Life was the most popular VR environment, adult learners were the main participants of the experiments, and mixed types of data were mostly adopted to demonstrate the research questions.

Since VR technology can be divided into different types according to the level of immersion and interaction, Dhimolea, Kaplan-Rakowski, and Lin (2022) limited their research on High-iVR technology on language learning. They analyzed 32 peer-reviewed studies which were published between 2015 and 2020, and their findings were in line with that for effective learning, multiple exposures to High-iVR were very necessary, learning contextual vocabulary in VR was advantageous, and people had positive opinions of language learning in VR. Besides these, Peixoto, Pinto, Melo, Cabral, and Bessa (2021) focused on the iVR and did a systematic review to identify the characteristics, teaching strategies, tools, and shortcomings of iVR technology in FL education. The result revealed that the relation between iVR and FL learning is very positive, and also the connection between iVR and the user's satisfaction and motivation was quite positive.

To continue the line of Peixoto et al. (2021) and demonstrate the development of iVR-assisted FL education in the after-pandemic era, this paper reviews iVR-assisted FL education literature between January 2021 and March 2023 to focus on the following three research

questions:

(1) What are the new trends in research on iVR-assisted FL education in terms of research contexts?

(2) What are the new trends in research on iVR-assisted FL education in terms of VR technology and research method?

(3) What are the benefits and challenges of iVR-assisted FL education?

3. Methodology

We used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which was proposed by Moher et al. (2015), to conduct this systematic review.

3.1 Database Search

To compare our findings with those of Peixoto et al. (2021), we searched related articles from these databases: Scopus, Web of Science, ACM Digital Library, Science Direct, ProQuest, Saga, IEEE Xplore, and Springer, which are recognized as significant reliable sources of high-quality publications from Computer Science and Engineering areas. After that, snowballing (Wohlin, 2014) was used to find the articles that were not extracted using the search strings.

3.2 Identification of Search Terms

Using Wang, Lan, Tseng, Lin, and Gupta (2020)'s keyword search method, we set three groups of keywords to search. The first group included keywords related to "VR technologies". The second group included keywords referring specifically to "immersion". The third group included words about language learning. Based on the literature and our expertise, we didn't include articles that mentioned the terms "Augmented Reality" or "Mixed Reality", since they are always associated with VR but they are different technologically although they have some connections.

Most of the online searches made use of boolean operators. To accommodate the databases' search options, some operators needed to be modified. The general method for locating relevant articles is as follows:: ("VR" OR "Virtual Reality" OR "Virtual Worlds" OR "Virtual Environments" OR "3D") AND ("Immersive" OR "Immersion" OR "Head-mounted display" OR "HMD" OR "CAVE" OR "360") AND ("Second Language" OR "Foreign Language" OR "English" OR "Language") NOT ("AR" OR "Augmented Reality" OR "Mixed Reality")

3.3 Searching Criteria

In the following screening process, our study was guided by specific eligibility criteria. The following inclusion and exclusion criteria had to be met for manuscripts to be considered for our review (Table 2):

Table 2. Inclusion Criteria and Exclusion Criteria

Inclusion Criteria (IC)	Exclusion Criteria (EC)
published between January 2021 and March 2023	published before January 2021 and after March 2023
use iVR technology	use Non-iVR, Argument Reality, or Mixed Reality
focus on FL teaching or learning	focus on the native language
from peer-reviewed journals	from conference proceedings, book chapters, magazines, news, posters
empirical study using quantitative, qualitative, or mixed methods,	reviews, not empirical research
write in English	write in Chinese, Japanese, Korean, or some other languages
full-text available	not accessible

3.4 The Screening Process

PRISMA procedures are identification, screening, eligibility, and inclusion. We followed the four steps to do the selection (Figure 1).

The screening process involved 5 procedures: firstly, remove the duplicated articles; secondly, read the titles and abstracts to remove the articles according to the inclusion and exclusion criteria; thirdly, read the full texts to remove the articles which do not conform with inclusion criteria; fourth, use the snowballing to further locate the articles in Google Scholar, and last, extract data from the final filtered articles. All articles were imported into Endnote software which permitted to deletion of the duplicated papers, filtrating, and export of it to a spreadsheet.
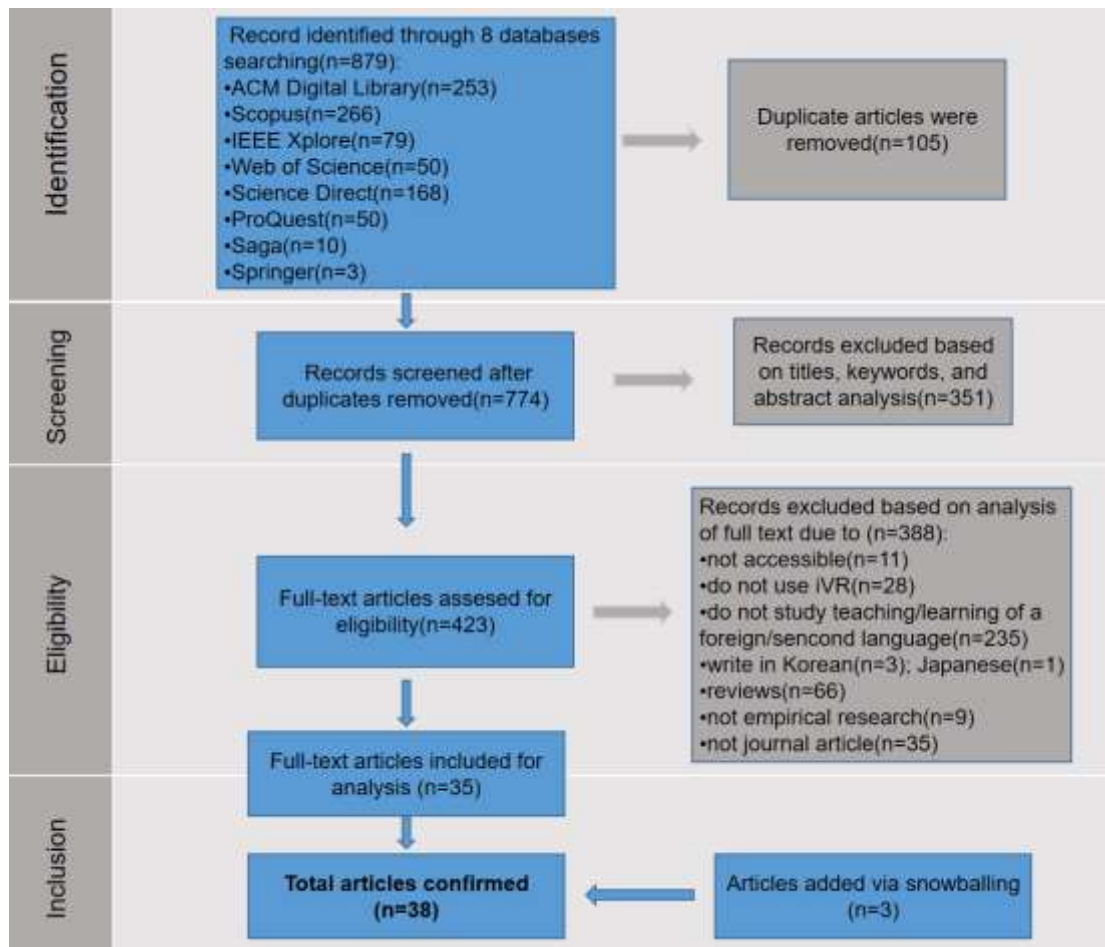
Figure 1. Data Collection Process

3.5 Data Analysis

We used a Microsoft Excel spreadsheet to record and organize the results of the 38-article analysis. Table 3 displays the chosen coding categories for this review as well as their relationship to our three research questions. Then, to identify the codes and categories, we read and examined the complete texts of the articles included in the systematic reviews.

Table 3. Coding Categories of Research Questions

Research Questions	Coding Categories
RQ1: What are the new trends in research on iVR-assisted FL education in terms of research contexts?	•Years of publication •Participants' number •Participants' age •Participants' gender •Participants' original FL level •Number of research groups •Target language and language skills
RQ2: What are the new trends in research on iVR-assisted FL education in terms of VR technology and research method?	•VR environment (High-iVR or Low-iVR) •VR learning platform (general or customized/ pre-created or learner-created) •Research methods
RQ3:What are the benefits and challenges of iVR-assisted FL education?	•Learning outcomes •Participants' comments

4. Results

4.1 New Trends in Research on iVR-Assisted FL Education in Terms of Research Contexts

4.1.1 Number of Publications

15 out of the 38 articles were published in 2021, and 19 in 2022. We only covered the first three months of the year 2023, so there were

only 4, maybe there would be more publications later this year. Figure 2 is the distribution of the studies by year of publication in the Peixoto et al (2021)'s review and this follow-up review.
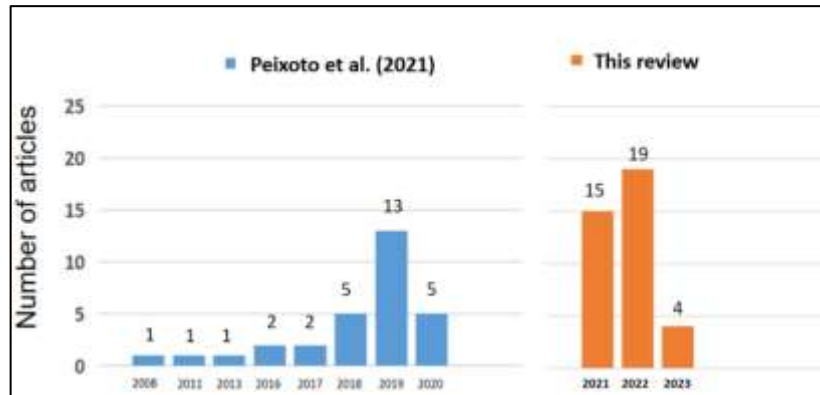

Figure 2. Distribution of Papers Included in Peixoto et al. (2021) and This Review

4.1.2 Participants

(1) The number of participants

The scale of the 38 studies varies greatly. The participants' number range from as few as 10 (Wu, Miller, Huang, & Wang, 2021; Chen & Sevilla-Pavón, 2023) to as many as 2176 (Kaplan-Rakowski, Dhimolea, & Khukalenko, 2022). Most of the studies (25) had 20–80 participants, some (3) had less than 20, and some others (8) had more than 80, 2 studies didn't give the specific number of participants (X. Wang, 2022; Han & Ansari, 2022).

(2) The type of participants

Regarding the participants' types, among the 38 studies, 29 investigated college students, 5 examined young students in primary (1) and secondary schools(4), 1 study (Kaplan-Rakowski et al., 2022) researched the FL teachers, and there were 3 articles didn't give the specific information of the participants (Figure 3). It is worth noting that, of the 29 articles that investigated college students, some zoomed in FL for special purposes. For example, Wu et al. (2021) investigated the FL for nursing students, Li, Ying, Chen, and Guan (2022) examined the FL for geography learning, and Lin, Barrett, Liu, Chen, and Jong (2021) investigated the FL for tourism.

(3) The gender of the participants

Regarding gender, 19 articles of the studies documented the gender of the sample. Of these articles, 14 articles had more females than males, especially in Wu et al. (2021), all 10 participants were female. But there were also exceptions. For example, the 27 participants in Peixoto, Bessa, Gonçalves, Bessa, and Melo (2023) were all males.

(4) The FL level of participants

Regarding the participants' FL level, 14 articles demonstrated this in detail. For example, Wu et al. (2021)'s participants were pre-intermediate English learners (around IELTS 4.0); participants' English proficiency levels of Chen and Sevilla-Pavón (2023) ranged from B2 (upper intermediate) to C1 (advanced) according to the Common European Framework for Languages (CEFL); in Chan (2023), the FL (English) of the participants were generally low (Level 3: 51.61%; Level 4: 38.71%). None of these articles showed a direct correlation between the experiment results and the student's original FL level except Cui, Whittinghill, Fukada, Mousas, and Adamo (2021), whose participants were divided into four groups (less than one year, one to two years, two to three years, and more than three years of Japanese language learning).
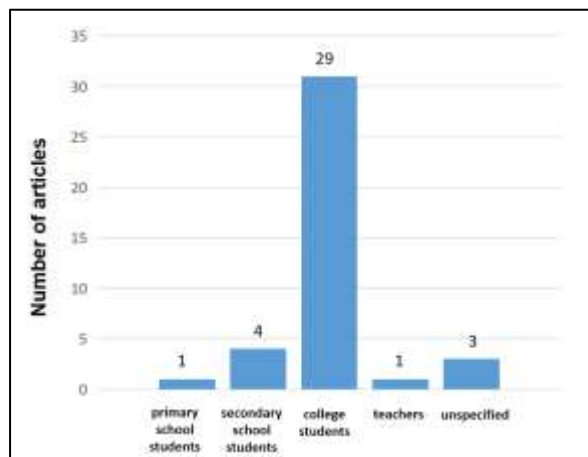
Figure 3. Distribution of the Studies by Participant Type

(5) The groups of participants

Most of the articles(16/38) involved 2 groups, setting one group as the experimental group and the other as the control group. Six articles only had one group in their experiments, while there were also four articles (Figueroa, Gil, & Taniguchi, 2022; Papin & Kaplan-Rakowski, 2022; Wang & Sun, 2021; Wang, Guo, Wang, Tu, & Liu, 2021) involved 3 groups, and two articles (Khodabandeh, 2022; Cui et al., 2021) even used 4 groups. See Figure 4.
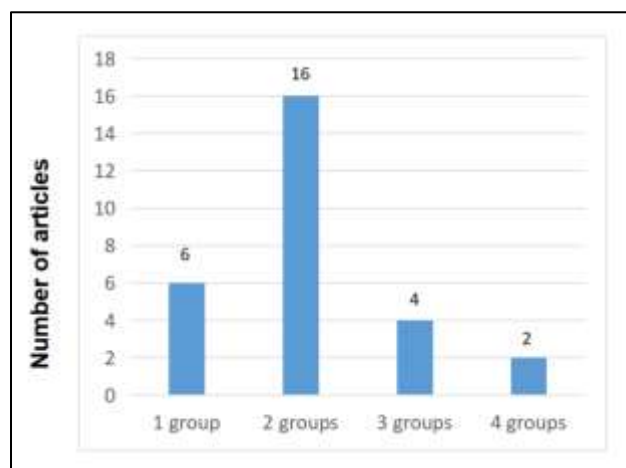

Figure 4. Distribution of the Studies by Participant Groups Number

4.1.3 Target Language and Language Skill

Since our review was a follow-up review of Peixoto et al. (2021), we only focused on iVR-assisted learning in FL. Among the 38 studies, 22 examined FL English, 5 Chinese, 7 unspecified, and the other respectively for Japanese (1), Italian (1), Philippine (2), Spanish (1), and French (1).

Of the language skills, the most studied were vocabulary (8), speaking (7), writing (5), and the overall language level (5). A few investigated cultural ability covering intercultural communicative competence (2), listening (2), interpretation(2), reading (1), and negotiation (1). Figure 5 shows the distribution of articles by language skill and Table 4 shows the list of studies by language and language skills.
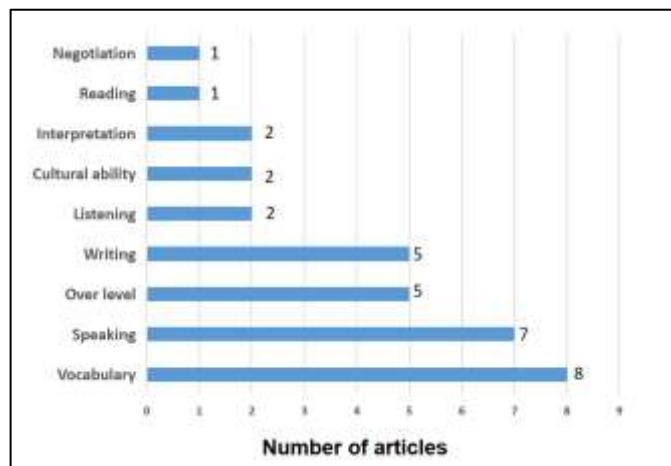
Figure 5. Distribution of Studies by Language Skill

Table 4. List of Studies by Language and Language Skill

Native language	FL	Language skills
		Listening
Chinese	English	Tai (2022)
Portuguese	English	Peixoto et al. (2023)
		Speaking
Chinese	English	Xie et al. (2022); Chen, Chang, Hwang, & Zou (2021)
Unspecified	English	Cai et al. (2021); Lin et al. (2021)
Mixed	Chinese	Zhang (2022)
Japanese	Philippine	Figueroa et al. (2022)
English	Spanish	Enkin (2022)
		Reading
Chinese	English	Z.Wang et al. (2021)
		Writing
Chinese	English	Wang et al. (2022)
Unspecified	English	Lin et al. (2021); Khodabandeh (2022)
English	Chinese	Wang, Grant, & Grist (2021)
Vietnamese	Chinese	Lan & Tam (2022)
		Vocabulary
Chinese	English	Li et al. (2022); Chen, Hung, & Yeh (2021)
Italian	English	Repetto et al. (2021)
Unspecified	English	Bacca-Acosta et al. (2021)
Mixed	Chinese	Chen & Yuan (2023)
Greek	Italian	Nicolaidou, Pissas, & Boglou (2021)
Japanese	Philippine	Figueroa et al. (2022)
Chinese and English	French	Papin & Kaplan-Rakowski (2022)
		Negotiation
Chinese	English	Chen & Sevilla-Pavón (2023)
		Interpretation
Chinese	English	Chan (2022), Chan (2023)
		Cultural ability
Chinese	English	Gao et al. (2021)
Malaysia	Chinese	DeWitt, Chan, & Loban (2022)
		Overall language level
Chinese	English	Wu et al. (2021); Ma & Tsai (2021); Li & Madina (2022); Wang (2022); Han & Ansari (2022)
English	Japanese	Cui et al. (2021)

4.2 New Trends in Research on iVR-assisted FL Education in Terms of VR Technology and Research Method

4.2.1 iVR Technology

Different kinds of iVR technology were examined in the 38 studies (Figure 6). 26 studies reported on High-iVR technology, and 12

Low-iVR technology, while 3 were unspecified. Both High-iVR and Low-iVR technologies were used at the same time to make a comparison in 3 articles (Figueroa et al., 2022; Bacca-Acosta et al., 2021; Papin & Kaplan-Rakowski, 2022). In addition, 17 of the 38 studies were researched on commercial/general platforms, like Mondly VR, Edu Venture, etc, 10 were on revised or developed general platforms, and there were also 11 platforms customized for the specific needs of the learners. Detailed information can be seen in Table 5.

Some platforms were developed from general ones to improve their practicability and effectiveness. For example, in Chen and Yuan (2023), a Chinese-learning VR app based on Mondly VR was revised and developed in iterative consultations with several Chinese as second language teaching experts, to adapt the app to the language levels of the participants.

A variety of customized platforms were developed by the researchers or teachers to meet the unique requirements of the courses or language abilities being examined. For example, Gao et al. (2021) designed four different scenes connected by Santa Claus's guide in VR conditions to investigate the effectiveness of Virtual Reality for cultural learning.
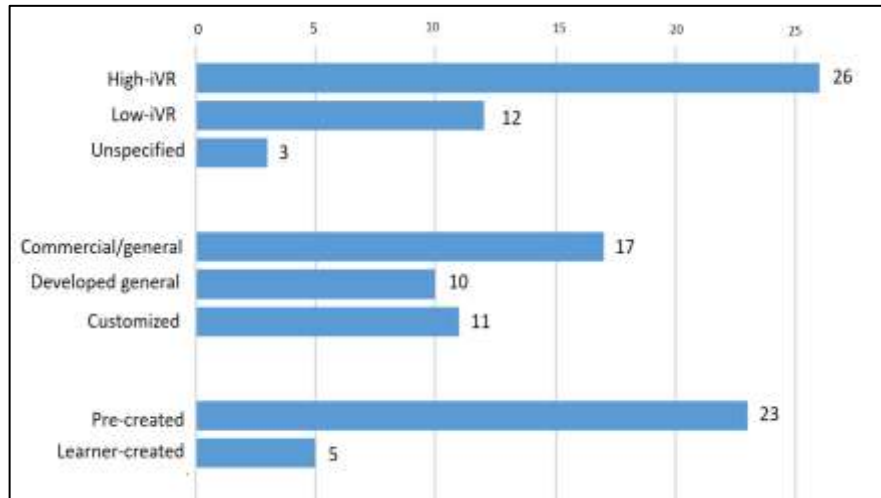

Figure 6. Distribution of Studies by Type of VR Environment

Table 5. List of Studies Investigating Different Types of VR Environment

VR Platform	
Commercial/general platform	
Spatial	Chen & Sevilla-Pavón (2023)
AltspaceVR	Enkin (2022)
VIP app	Chan (2023)
360°videos/pictures	Lan & Tam (2022); Papin & Kaplan-Rakowski (2022); Repetto et al. (2021)
Mondly VR	Nicolaidou et al. (2021); Tai (2022)
SVVR	Wang et al.(2022)
Edu Venture	C.H.Chen et al.(2021); C.Y. Chen et al.(2021)
Mobile-based VR application	Chan (2022)
VR language apps	Kaplan-Rakowski et al. (2022)
Unspecified	Figueroa Flores et al (2022); Li et al (2022); Ma & Tsai (2021); Xie et al. (2022)
Revised and developed the general platform	
Peixoto et al. (2023); Figueroa et al. (2022); Chen & Yuan (2023); DeWitt et al. (2022); Lin et al. (2021); Lin & Wang (2021); Bacca-Acosta et al. (2021); Wang & Sun (2021); Ahlers et al. (2022); Cai et al.(2021)	
Customized platform	
Wu et al. (2021); Ding, Qi, & Dai (2022); Y. Wang et al. (2021); Gao et al. (2021); Khodabandeh (2022); Li & Madina (2022); Cui et al. (2021); Z. Wang et al. (2021); Wang (2022); Han & Ansari (2022); Zhang (2022)	
VR Learning environment	
Learner-created	
DeWitt et al. (2022); Lin & Wang (2021); Wang & Sun (2021); C.H.Chen et al.(2021); Ahlers et al. (2022)	

4.2.2 Research Method

A majority (32) of the studies used a mixed research method, and the six others used a single research method. Test (21) and questionnaire (19) were the mostly used methods in this review. Of the 21 articles taking tests as the research method, 3 took the method of delayed post-test. Besides tests, questionnaires, interviews, and surveys, which were commonly used in the studies, some special research methods

appeared in our review, including recall (2), observation (4), reflection (3), eye-tracking (1), and communication analysis (1) (See Table 6). The research methods used in these 38 studies can be seen in Figure 7.
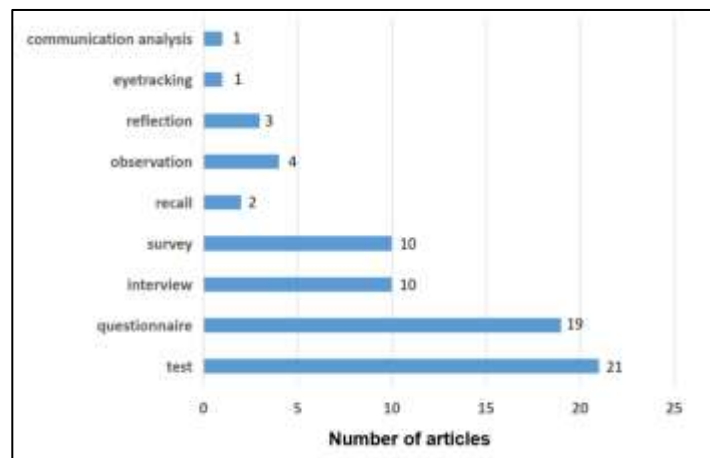

Figure 7. Distribution of Studies by Research Method

Table 6. List of Studies by Special Research Methods

Research method
Communication analysis
Ahlers et al. (2022)
Eye-tracking
Bacca-Acosta et al. (2021)
Reflection
Lin et al. (2021) ; C.H.Chen et al. (2021); Figueroa Flores et al. (2022)
Observation
Chen & Sevilla-Pavón (2023); Figueroa et al. (2022); Ding et al. (2022); C.Y. Chen et al.(2021)
Recall
Chen & Sevilla-Pavón (2023); Tai (2022)
Delayed post-test
Chen & Yuan(2023); Lin et al. (2021); Papin & Kaplan-Rakowski (2022)

4.3 Benefits and Challenges of iVR-assisted FL Education

4.3.1 Benefits of iVR-assisted FL Education

The benefits of iVR-assisted FL education reported in studies could be divided into two aspects: cognitive and affective (Table 7). The cognitive benefit lies in having a positive impact on language learning outcomes, while the affective benefit lies in having a positive impact on the learners' emotional and psychological aspects, which may further promote FL learning.

There were 29 studies investigating the effectiveness of iVR-assisted FL education that generally yielded positive results: iVR technology was helpful to the learning of all FL and all FL skills by not only young but also adult learners. Furthermore, iVR technology had the potential to improve learners' cognitive abilities when learning language by improving knowledge retention, independent and active learning, critical thinking and reflection, aroused concentration, and so on, excepting Peixoto et al. (2023), who stated that there was no significant difference between learning via traditional listening or iVR. Eighteen of the 29 articles also reported learners' positive attitude on iVR-assisted FL education.

Similarly, studies investigating FL learners' experiences in iVR-assisted FL education also mainly reported positive findings. These findings were generally about the affective benefits of iVR, including facilitating positive attitudes and emotions, like satisfaction, interest, concentration, enjoyment, and so on. These positive attitudes and feelings can then be translated into positive behaviors like task engagement, enhance positive psychological traits like motivation, confidence, self-efficacy, and communicative openness, and simultaneously lessen negative psychological traits like FL stress and anxiety.

4.3.2 Challenges of iVR-assisted FL Education

Although research findings were very positive, eight studies also identified challenges of iVR-assisted FL education (Table 8).

The challenges in Table 8 are much less than the benefits listed in Table 7. These challenges included technical issues which may make users discomfort, like disorientation, dizziness, fatigue, neck pain, etc (Wu et al., 2021; Chan, 2022; Peixoto et al., 2023), and unstable

internet connection(Zhang, 2022; Chen & Yuan, 2023; Figueroa Flores et al., 2022). Another challenge was related to the application of the VR, which was not easy for users, for example, Nicolaidou et al. (2021) stated that the VR application process was too complex for the users, and comparatively, the mobile application was more user-friendly. Besides these, distraction was also a challenge because of the small screen (Chan, 2022) or the need to wear two sets of glasses since they needed to wear their eyeglasses and the VR glasses at the same time (Wu et al., 2021). Moreover, a cognitive load may as a possible limitation to FL vocabulary learning in High-iVR (Papin & Kaplan-Rakowski, 2022). Lack of qualified learning content (Chen & Yuan, 2023) and the transfers of learning places (Zhang, 2022) were also the challenges mentioned.

Table 7. Benefits of iVR-assisted FL Education

Cognitive benefits
Improve language skills
Wu et al. (2021); Ma & Tsai (2021); Li & Madina (2022); Wang (2022); Han & Ansari (2022); Chen & Sevilla-Pavón (2023); Chan (2022); Chan (2023); Li et al. (2022); C.H.Chen et al. (2021); Tai (2022); Gao et al. (2021); Wang et al. (2022); Z.Wang et al. (2021); Xie et al. (2022); C.Y. Chen et al.(2021); Peixoto et al. (2023); Repetto et al. (2021); Lin et al. (2021); Cai et al. (2021); Bacca-Acosta et al. (2021); Khodabandeh (2022); Y. Wang et al. (2021); DeWitt (2022); Lan & Tam (2022); Chen & Yuan (2023); Zhang (2022); Nicolaidou et al. (2021); Figueroa et al. (2022); Enkin (2022); Papin & Kaplan-Rakowski (2022).
Stimulate interaction
Chen & Yuan (2023); Cui et al. (2021); C.Y. Chen, et al. (2021).
Help knowledge retention
Chen & Yuan (2023); Lin et al. (2021); Peixoto et al. (2023).
Improve independent and active learning
Chan (2022)
Improve Critical thinking and reflection
Chan (2022)
Arouse Concentration/attention
Ding et al. (2022); Cui et al. (2021)
Improve learning efficiency
Ding et al. (2022)
Affective benefits
Satisfaction/positive attitude
Figueroa et al.(2022); Peixoto(2023); Y. Wang et al. (2021); Chan (2023); DeWitt et al. (2022); Lan & Tam (2022); Lin et al. (2021); Gao et al. (2021); Ma & Tsai (2021); Tai (2022); Z.Wang et al. (2021); Repetto et al. (2021); Kaplan-Rakowski et al. (2022); Han & Ansari (2022); Ahlers et al. (2022); Zhang (2022); Peixoto et al. (2023); Wu et al.(2021)
Aroused learning interest/enjoyment
Chen & Sevilla-Pavón (2023); Ding et al. (2022); Enkin (2022); Peixoto et al. (2023); Li & Madina (2022); Han & Ansari (2022); Ahlers et al. (2022); Zhang (2022).
Promote engagement
Figueroa et al.(2022); Enkin (2022); Figueroa Flores et al. (2022); Chen & Yuan (2023); Chan (2022); Li et al. (2022); Nicolaidou et al. (2021); Tai (2022); Papin & Kaplan-Rakowski (2022); Wang & Sun (2021); Li & Madina (2022)
Enhanced motivation
Figueroa Flores et al.(2022); Wu et al.(2021); Peixoto et al. (2023); Chen & Yuan (2023); Chan (2022); Wang et al. (2022); C.H.Chen et al. (2021); Y. Wang et al. (2021)
Lower stress
Enkin (2022)
Reduced anxiety
Chen & Yuan (2023); Chan (2022); Tai (2022); Wang et al. (2022); Z. Wang et al. (2021)
Promote confidence
Chen & Yuan (2023); Chan (2022)
Promote Self-efficacy
Lin & Wang (2021); Wang et al. (2022); C.Y. Chen et al. (2021).

Table 8. Challenges of iVR-assisted FL Education

Challenges
The VR application is not user friendly/challenging to handle technical and operational issues
Nicolaidou et al. (2021); Chen & Yuan (2023); Figueroa Flores et al.(2022); Zhang (2022)
Experienced a few health effects(disorientation, dizziness, fatigue, neck pain etc)
Wu et al.(2021); Chan (2022); Peixoto et al. (2023)
Inconvenient (had to wear two sets of glasses)
Wu et al.(2021)
Associated costs
Figueroa Flores et al.(2022); Chen & Yuan (2023)
Screen is "too small" and "not very clear"
Chan (2022)
Cognitive load as a possible limitation to FL vocabulary learning in HiVR
Papin & Kaplan-Rakowski (2022)
Lack of qualified learning content
Chen & Yuan (2023)
Unstable internet connection
Zhang (2022); Chen & Yuan (2023); Figueroa Flores et al.(2022)
Transfer of learning place affected students' motivation
Zhang (2022)

5. Discussion

After reviewing the empirical studies on iVR-assisted FL education published after 2021, some comparisons can be made with Peixoto et al. (2021) to describe the latest developments and discoveries in this field of study.

5.1 New Trends of Research on iVR-assisted FL Education

The reviewed studies have shown several clear trends, including the expansion of the research's field of inquiry in terms of the quantity and quality of publications, the participants, the research focus, the target language skills, the research methods, and the type of applied technology.

5.1.1 Increase in the Quantity and Quality of Publications on iVR-assisted FL Education

Since the recent study used the same search string as Peixoto et al. (2021) did, the quantity and quality of the publication in these two papers can have a comparison first.

Peixoto et al. (2021) established no year limits in their selection, after study selection and further data extraction, 30 full-text articles were left in their research. Among those 30 articles, the earliest one was published in 2008, and the latest one in 2020. We covered the last two years' articles (from January 2021 to March 2023), after the similar even more strict data extraction, 38 articles were left in this review. From this figure, we can find that the number of studies published on this topic has a sharp increase in the recent two years.

Peixoto et al. (2021) conducted a quality assessment of their included articles. The quality rating was given according to the type of publication and the sample size. For example, a journal paper was given 3 points; a paper which was published at a conference and as a full paper, was awarded 2 points, while a paper which was published at a conference and as a short paper, then it was given 1 point. However, the papers in this review were all papers from journals, the conference articles or conference proceedings were all excluded from selection. This indicated that the quality of the articles on this topic also improved in the latest two years.

Although the pandemic has passed, the online teaching experience was accumulated during the pandemic period. This will help to stimulate the increase in the quantity and quality of research and provide examples for the creation and application of iVR technologies in FL education.

5.1.2 Expansion of iVR-assisted FL Education from Adult Learners to Younger Learners

Peixoto et al. (2021) divided the educational stages in their research into the first stage of tertiary education, the post-secondary non-tertiary education, and the second stage of tertiary education, which were all education for adult learners. In our review, college students were still the most studied group of participants (31/38), but more and more studies have moved to the learners of secondary school (4/38) and primary school (1/38). This is a significant increase given the more obstacles in getting young learners than adult learners due to some ethical or practical problems. This suggests that the influence of iVR in school settings has shifted in recent years from adult learners to much younger learners.

5.1.3 Expansion of Research Focus

While the majority of articles examined the learning effectiveness of iVR-assisted FL education, and some explored language learners'

perceptions, there were also some articles focused on the learners' differences. Also, there were some articles focused on the combination of iVR with other technology or instructional strategy, but did not only focus on the VR technology itself anymore.

They wanted to investigate whether learners with different characteristics may have different learning effects with iVR-assisted FL education. For example, Khodabandeh (2022) investigated whether introverted learners and extroverted learners had different learning effects. The result showed no significant differences between the performance of introverts and extroverts, meaning that both had the same performance. Cai et al. (2021) investigated whether field-dependent learners and field-independent learners had different learning effects in the virtual environment. He concluded that the difference between the virtual and real outcomes was due to the learners' cognitive styles, and there was a significant interaction effect between cognitive style and testing environment on spoken English learning outcomes.

Cui et al. (2021) investigated whether gender and the number of years studying FL (Japanese) significantly impact the learning results with iVR-assisted FL education. Different from Peixoto et al. (2021)'s review, in which none of the studies found meaningful discrepancies separating the genders. Cui et al.(2021) in our review proved from their experiment that gender significantly impacts their measurements. They also concluded that females felt significantly more immersed in the game than males, paid significantly more attention to the in-game virtual characters than males, and perceived the virtual characters to be significantly more realistic than males.

In terms of the original FL level, Cui et al.(2021) revealed that participants who had studied the FL (Japanese) for less than one year were significantly more immersed in the game than those who had studied it for more than three years; participants with less than a year of Japanese study perceived the virtual characters to be significantly more realistic than those with one to two years of Japanese study; participants with more than three years of Japanese study felt they had significantly less interaction with the virtual characters than those with less than two years of Japanese study.

Also, in some studies, the VR technology was not used alone. It was used with other technology or instructional method to improve the teaching effect. For example, to improve students' English writing performance, Wang et al. (2022) combined VR technology with AWE, a technology-based feedback tool, to form the SVVR-AWE approach. C.Y. Chen et al. (2021) proposed a progressive question prompt-based peer-tutoring approach in VR contexts (PQP-PTVR) to assist students' English-speaking development.

5.1.4 Variety Language Skills Investigated

As reported by Peixoto et al. (2021), English is by far the most investigated FL (23/38), and improved in these two years (40.6% in Peixoto et al., 2021; 52.6% in this review) and the second is the Chinese (5/38). Apart from English and Chinese, some other FL were studied in a few articles.

Yet, Peixoto et al. (2021) didn't mention the detailed language skills in their review. Our review concluded the detailed language skills that were investigated in the 38 articles. From our review, we can see that most (8/38) focused on vocabulary, then speaking(7/38), while only one on reading and negotiation, but we can also find there was no study on grammar learning, which is also a very important skill for FL learners. This distribution of study by language skills and the outcome of each article can give inspiration to the following researchers.

5.1.5 Diversity of Research Methods

In the studies of our review, the adopted research methods ranged from the most basic experiment to cutting-edge eye-tracking. The majority of the studies (32/38) used mixed methods, and lots of the experimental studies also investigated learners' perceptions.

Similar to Peixoto et al. (2021), tests (21/38) were the most widely used research instrument, and the second most widely used questionnaire increased from 26.7% to 50%. What is worth mentioning is that 3 articles used delayed post-tests to investigate learners' knowledge retention, which was not in Peixoto et al. (2021).

What's more, our review concluded the number of participant groups in the experiment. It's not difficult to find that more researchers wanted to divide their participants into more than 2 groups, four articles had 3 groups and two had 4 groups. This indicated that more and more researchers wanted to make more detailed comparisons in their experiments, but did not afraid of the complex implementation process.

5.1.6 Increase in Application of High-iVR, Learner-Created VR Environment, and Customized VR Platform

Although Peixoto et al. (2021) did not categorize the empirical studies as High-iVR or Low-iVR, the description in their review indicated that the majority of the studies were about Low-iVR technologies. In comparison, we discovered that more than half of the reviewed studies (26/38) investigated High-iVR technologies. Another finding is that some studies (5/38) appeared to investigate the VR technologies that can be used by learners to create their learning environment and share their work while FL is learning. In addition, from Peixoto et al. (2021)'s demonstration of the displays, the game engines, the platform, and the content type, we can get most of the VR platforms were general commercial ones. We reported eleven out of 38 articles examining customized platforms, and 10 articles developed and revised the general platform for their special learning purpose. In conclusion, VR technologies in FL education reported in the studies are becoming more and more immersive, more learner-created, and with more peculiarity.

5.2 Benefits and Challenges of iVR-assisted FL Education

Thanks to advances in iVR technology and the increased use of such technologies in FL education, empirical research has produced more findings in the past two years than ever before.

Based on the two main findings of Peixoto et al. (2021), one of which is the relationship between iVR and foreign language learning is quite positive, particularly compared with conventional pedagogy practices, and the other is that the relation between iVR and the users' motivation and satisfaction is also quite positive, our review supported them with more detailed information.

On the cognitive level, iVR assisted in the development of a variety of language skills like listening, speaking, vocabulary, cultural knowledge, communicative competence, critical thinking, memory retention, and so on. On the affective level, iVR increased learners' motivation and task engagement while decreasing FL anxiety and stress, etc. The majority of the students showed a positive attitude toward the iVR-assisted FL education. This is probably because more multimodal resources have been developed recently and because iVR learning platforms can be tailored by teachers to better meet the needs of their students. The students in the reviewed studies may have developed more positive attitudes toward using VR technology in their learning as a result of becoming more accustomed to it.

Although Peixoto et al. (2021) didn't mention the drawbacks or challenges of the iVR-assisted FL education, they really existed as our review revealed. While there is no criticism of the general platforms of iVR, more and more researchers devoted to revising and develop the platform or customize the platform, indicating that they were not so satisfied with the original iVR learning environment and attention has been moved from the quantity to the quality of the iVR resources. Furthermore, the handling of technical and operational issues, the physical discomfort, and the unstable internet were the mostly complained things. These would constrain the learners' experience while learning with iVR. Furthermore, while many articles reported that iVR could promote students' motivation, Zhang (2022) claim that the transfer of learning place in the iVR environment affected students' motivation. While the other articles demonstrated the enhanced learning outcomes of iVR-assisted FL education, Peixoto et al. (2023) verified that there was no significant difference between learning via traditional listening or iVR and Papin & Kaplan-Rakowski (2022) stated that cognitive load can be a possible limitation to FL vocabulary learning in High-iVR.

In summary, research findings in this review suggested more positive effects than negative ones of iVR on FL education. The iVR-assisted FL education merits more specific investigations.

5.3 Practical Implications

Some practical implications for practitioners and researchers can be drawn from the above review.

5.3.1. Educational Implications

This review summarized the multiple advantages of iVR-assisted FL education, indicating that iVR is a promising technology for facilitating FL education. To best incorporate iVR technology into their teaching, language teachers should improve their competency in using it. While this is happening, we cannot undervalue the importance of the instructor and overvalue the role of technology (Selwyn, 2016). To achieve a high standard of iVR-assisted FL education, instructors, as significant subjects in the educational system, must take the initiative to promote the instructional designs and strategies when implementing iVR technologies. In addition, since the research findings revealed the influence of personal differences like gender, FL proficiency (e.g., Cui et al., 2021), or cognitive style (e.g., Cai et al., 2021), and personality difference (e.g., Khodabandeh, 2022) on the effectiveness of iVR-assisted FL education, the specific characteristics of the learners must also be taken into account by the developers of iVR platforms and learning materials in order to maximize the benefits of iVR technology in FL education while avoiding its drawbacks.

5.3.2 Technological Implications

Similar to how Barrett et al. (2021) claimed that immersion is a key factor in predicting language learners' acceptance of VR technology, our review has demonstrated the effectiveness of High-iVR platforms for FL education. Therefore, more High-iVR platforms ought to be created to enhance learning activities' functions to engage students. The development of more specialized VR language learning platforms has been made possible as the technology has advanced, so this would not be a difficult task to complete.

However, the high immersion condition was not necessarily suitable for every teaching objective. One article in our review (Papin & Kaplan-Rakowski, 2022) found in its research that although low immersion VR seemed to offer an ideal balance of immersion and effectiveness for vocabulary learning, higher immersion did not necessarily lead to better vocabulary learning, and the Low-iVR group found the technology easier to use. This example gave us some inspiration that the technology developers should dig deeply into the characteristics of different target foreign languages and specific language skills, and then develop different targeted virtual reality platforms for different languages and language skills training.

Besides these, no matter what kind of technology, easy to operate and comfortable to wear are welcomed by users. Since there are also some studies reflecting the discomfort and trouble of wearing VR devices in high immersion learning environments, the comfort of VR hardware such as head-mounted devices will continue to be improved, while the price of it could be lowered accordingly to facilitate the availability of more learners to use it at home to do self-study when necessary.

5.3.3 Researching Implications

At the very beginning, more research on iVR-assisted FL education is required for a broader range of FL learning settings and FL learners. According to our review, the majority of research on iVR-assisted FL education was conducted in school settings, particularly universities, and very limited in secondary and primary school although we have found a little expansion from the previous study. However, it's not very enough to give the demonstrated and potential benefits of iVR-assisted FL education. Further studies could be done to investigate the

use of iVR in a variety of language learning settings, for example, language learning for special purposes, international enterprises staff training, self-directed language learning settings, and so on. Besides, inspired by Zhang, Sher, Hong, and Dai (2022), which explored the usability of applying virtual reality to the vocational skills of autistic students in technical high schools, more research could be conducted to explore the iVR-assisted FL education on special populations. These above-mentioned researches could aid in identifying the universal mechanism underlying the efficacy of iVR-assisted FL education and, eventually, improving its implementation.

In terms of language skills, many articles did research on vocabulary, speaking, reading, writing, interpretation, and some other skills like cultural ability which can influence the superficial language ability from a deep level. But we can not find an article revealing the effectiveness of students' grammar learning with the use of iVR tools. We suggested that further research could explore this area because grammar is also a very important part when learning a foreign language.

To fully comprehend the effects of individual differences on iVR-assisted FL education, more research is also required. From our review, we can find that some researchers have investigated the differences in learners' gender (Cui et al., 2021), learners' personalities (Khodabandeh, 2022), and learner's cognitive styles (Cai et al, 2021), but these are not enough. We need to learn more about how the implementation of iVR-assisted FL education is impacted specifically by individual differences such as age, motivation, geography, computer experience, and others. Such information might, over time, help iVR-assisted FL education become more effective.

6. Conclusion

By reviewing the most recent studies on iVR-assisted FL education from January 2021 to March 2023, we aimed to identify new trends as well as the advantages and disadvantages of iVR-assisted FL education. We discovered that the number and the quality of studies have been increasing, at the same time, the scope of research on the type of participants, research focus, target language skills, research methods, and the type of iVR technology has been expanding. Moreover, despite its drawbacks, iVR has been demonstrated to be advantageous for language learning in both cognitive and affective domains.

We proposed some implications for education, technology, and related research based on these findings. These results may be applied to education to enhance iVR-assisted FL education platforms and materials to accommodate various FL learners' differing needs. In terms of technology, more sophisticated and advanced equipment that is also low-cost and comfortable has yet to be developed. To understand the fundamental principles and the more particular patterns of iVR-assisted FL education, more research will be required in the future.

It should be noted that the empirical studies discussed here are not all-inclusive. Although we searched the most well-known scholarly databases for keywords related to iVR-assisted FL education, some biases in the searching and screening process may exist. Other journals and databases may contain related studies. The findings of these studies, however, are sufficient to update our knowledge of iVR-assisted FL education.

Declarations

Conflict of interest: None.

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