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Review

A Systematic Review of AR and VR Enhanced Language Learning

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Abstract: This paper provided a systematic review of previous Augmented Reality (AR) and Virtual Reality (VR) studies on language learning. A total of 88 articles were selected and analyzed from five perspectives: their ways of integrating AR or VR tools in language learning; main users of AR and VR technologies; major research findings; why AR and VR tools are effective in promoting language learning; and the implications. It was found that (1) immersing learners into virtual worlds is the main approach to language learning in AR and VR studies; (2) university students were the main users of AR/VR technologies; (3) the major research findings concerning the benefits of AR and VR included improvement of students' learning outcomes, enhancement of motivation, and positive perceptions towards using AR and VR; (4) AR and VR tools promoted language learning through providing immersive learning experience, enhancing motivation, creating interaction, and reducing learning anxiety; and (5) implications identified from previous research include the need of providing training for teachers, enlarging sample sizes, and exploring learner factors such as learner engagement and satisfaction.

Keywords: augmented reality; virtual reality; language learning; computer-assisted language learning

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1. Introduction

As emerging technologies, Augmented Reality (AR) and Virtual Reality (VR) have been widely applied in the education of various disciplines. AR refers to a three-dimensional (3D) technology that presents digital information in the real world [1]. It could enhance users' visualization of the real-world with virtual objects through graphic computing and object recognition technologies [2]. The positive effects of AR on learning include improved performance, increased motivation and engagement, and fostered collaboration among learners [3]. AR is of great potential in the field of language education as it has features such as contextual visualization (i.e., presenting virtual information in rich contexts) and learning interactivity (i.e., embodying interactions with virtual content) [4].

VR is a 3D virtual world through which users are provided with visual simulations and feel they are immersed in an environment without limitations of time and space [5]. It is advantageous in that it provides students with a 3D space in which they can experience their own learning ([5] p. 224). VR is conducive to many educational filed such as engineer education, medical education, space technology and mathematics, general education and special needs education [6]. Shadiev and Yang [7] identified some benefits of VR in language learning which included visual support, enhanced learning interests and authentic learning opportunities.

Considering the similar natures of AR and VR technologies, some researchers discussed these two technologies together recently. For example, Bensetti-Benbader and

Brown investigated the use of AR and VR in language acquisition and found that AR applications led to effective learning as they promoted motivation and interactions, and that VR technologies assisted learning by providing learners with immersive environments for language learning [8]. The number of researches on AR or VR-enhanced language learning (hereafter, AR/VR-ELL) has been increasing in recent years, the review studies in this field were however limited. This difference between the big number of empirical studies and the small number of review studies further indicated a need for a comprehensive review that systematically analyzed the ways of AR and VR integration, main users of AR and VR technologies, findings, effectiveness of AR and VR technologies and implications of the previous studies. With such a systematic review, researchers and educators could easily understand the current stages of development in the field, identify potential research directions, and conduct studies on relevant research issues. The present review was conducted in response to this call, the research questions of which are listed as follows:

1. How were AR and VR used in language learning?
2. Who were the main users of the AR/VR-ELL system?
3. What were the major research findings?
4. Why were AR and VR effective in promoting language learning?
5. What were the implications for future research on AR/VR-ELL?

2. Literature Review

2.1. Reviews Studies on AR-Enhanced Learning and Language Learning

There have been several attempts at reviews on AR applications in educational setting. Bacca et al. analyzed 32 studies published between 2003 and 2013 in six indexed journals and found that learning achievements and motivation were the two major advantages of AR applications in education, and that the difficulty in maintaining superimposed information was one of the limitations of AR technologies [9]. Additionally, Akçayır and Akçayır [10] reviewed 68 articles that were published in the Social Science Citation Index journals from 2007 to 2015, the results of which indicated (1) an increase in the number of AR studies; (2) advantage of AR in facilitating communication and interaction, promoting self-learning, and enhancing learning achievement, motivation, engagement, and satisfaction; and (3) challenges in AR use such as increased cognitive load, distracted students' attention, and increased technology expenses and technical problems. Additionally, Garzón et al. [11] conducted systematic review and meta-analysis on 61 scientific journals and conferences proceedings from 2012 to 2018. They found learning gains and motivation were the main advantages of AR systems in education, and technological complexity, technical difficulties and resistance from teachers were the disadvantages of using AR in education. These three review studies were common in their research foci on the advantages and limitations of AR technologies in educational settings. However, they were limited in that they did not review how the AR technologies were integrated into the teaching and learning, or why AR technologies were effective in promoting language learning, and their implications.

After reviewing 73 studies on AR in educational settings, which were published between 2000 and 2017, Hedberg et al. [12] found that 10.96% of the research were on language education, and that language was the subject that was the second most frequently investigated and supported with AR applications. Zhang [13] also pointed out an increasing trend of implementing AR technologies in language learning, as AR technologies were effective in engaging learners in learning. Yet the biggest problem of using AR in language education was teachers' and students' unfamiliarity of AR-based learning materials. Specifically, Khoshnevisan and Le [14] categorized the benefits of AR in language education into dimensions of learning outcomes and affective outcomes. Parmaxi, and Demetriou [15] analyzed research published between 2014 and 2019 systematically and identified the main benefits of AR in language learning, which included: (1) increase of motivation; (2) improvement of learning outcomes; (3) enhancement of interactions and (4) creation of opportunities for authentic language tasks. These reviews mainly focused on

the benefits of AR technologies in language learning, other aspects such us the approaches of using AR in language learning have not been explored yet.

2.2. Review Studies on VR-Enhanced Learning and Language Learning

VR applications in educational settings have also become increasingly more popular. Kavanagh et al. [16] categorized the motivation of using VR into intrinsic and pedagogical factors after analyzing 99 papers. Intrinsic factors included the increase of enjoyment and motivation, and the pedagogical methods that highly linked to VR included game-based learning, collaboration, and constructivism. Merchant et al. [17] reviewed 67 articles on VR-based instruction and found that positive results concerning the effectiveness of VR in promoting learning were generally reported in the studies. They also pointed out that VR-supported learning in game-based environments were more effective than simulation. In Tilhou et al.'s [18] thematic systematic review, they revealed that VR technologies provided better learning experiences for students and led to the increase of learning achievement and motivation.

Concerning VR-enhanced language learning, Solak and Erdem [19] also conducted a content analysis on 40 research articles that used VR in foreign language education and found that the effectiveness of VR and game-based learning were the main research issues in this field. In Lin and Lan's [20] comprehensive review of 29 articles on VR applications in language learning from 2004 to 2013, they identified the research focuses of VR-enhanced language learning were interactive communication, affections and beliefs and task-based instruction. Wang et al. [21] concentrated on the effects of VR on language learners and found that most learners achieved linguistic gains and affective gains by using VR technologies. Parmaxi [22] systematically reviewed research papers published from 2015 to 2018 of seventeen high-impact journals and conferences. The researcher revealed that VR technologies helped to enhance students' learning and provided different learning and teaching experience. In sum, these reviews on VR-enhanced language learning targeted mainly at the research focuses and advantages of VR, while how VR technologies helped to promote language learning had not been comprehensively discussed in depth.

2.3. Limitations of Previous Review Studies

After analyzing the aforementioned review studies on AR- and VR-enhanced learning and language learning, we identified two limitations of the previous reviews. Firstly, most of the review studies investigated only the research that were published before 2018, for example, Solak and Erderm reviewed the publications from 1995 to 2015 [19], Lin and Lan from 2004 to 2013 [20], Khoshnevisan and Le from 2007 to 2017 [14] and Zhang from 2013 to 2017 [13]. Thus, the studies in the field, which were published in the most recent three years, had not been reviewed yet.

Moreover, most review studies investigated the benefits of AR or VR applications language education, so many specific aspects concerning AR and VR enhanced language learning had not been thoroughly discussed yet, for example, how AR and VR were integrated into language learning and how AR and VR technologies could promote language learning.

Therefore, the present research is of research importance, as it systematically reviewed how AR and VR were used in language learning, who the main users were, what the major findings were, why AR and VR were effective in promoting language learning, and what the implications were for future research on AR and VR enhanced language learning. Compared to previous studies, our research has more foci on language learners and the use of technology in their learning processes.

3. Materials and Methods

3.1. The Manuscript Selection Process

The main methods for article selection in review studies included (1) selecting a defined set of studies from important journals in the field, (2) selecting all publications in

the leading journals, and (3) using databases such as Education Resources Information Center (ERIC) and Social Sciences Citation Index (SSCI) [10]. In this review, we applied the first method and selected articles published in journals that were indexed in SSCI and Arts & Humanities Citation Index (A&HCI). We used the Web of Science site (WOS), following Akçayır and Akçayır [10], as WOS provided easy access to the field tags of SSCI and A&HCI indexed articles. We used the advanced search function and input the search terms (TS = (AR OR "augmented reality" OR "augmenting reality" OR VR OR "virtual reality") AND TS = (language OR English) AND TS = (learn OR teach OR communicat* OR educat*). Then, the language "English," the document type "article," the indexes "SSCI and A&HCI", and the time span "2011–2020" were selected as the parameters. A total of 200 articles were found.

Additionally, we also searched articles from ERIC database to provide a more comprehensive result. We used ("Augmented Reality" OR "Virtual Reality") AND (Language OR English) as the search terms, 140 articles were found until 10 March 2021. 51 articles were excluded manually since they were not published between 2011 and 2020 and therefore, 89 articles were left.

Figure 1 displayed the articles selection process. A total of 20 duplicated articles were deleted, and two domain experts checked the remaining 269 articles independently based on the inclusion and exclusion criteria manually (Table 1) to determine whether the articles should be included. First of all, 39 articles were excluded since they did not used AR/VR technologies in the research. Secondly, 114 articles were excluded as AR/VR technologies were used for learning other subjects such as programming language, science, or medical subjects. Additionally, 28 articles were excluded since they were non-empirical research such as review paper or positional paper. To this end, 88 articles were finalized (Appendix A, Table A1).

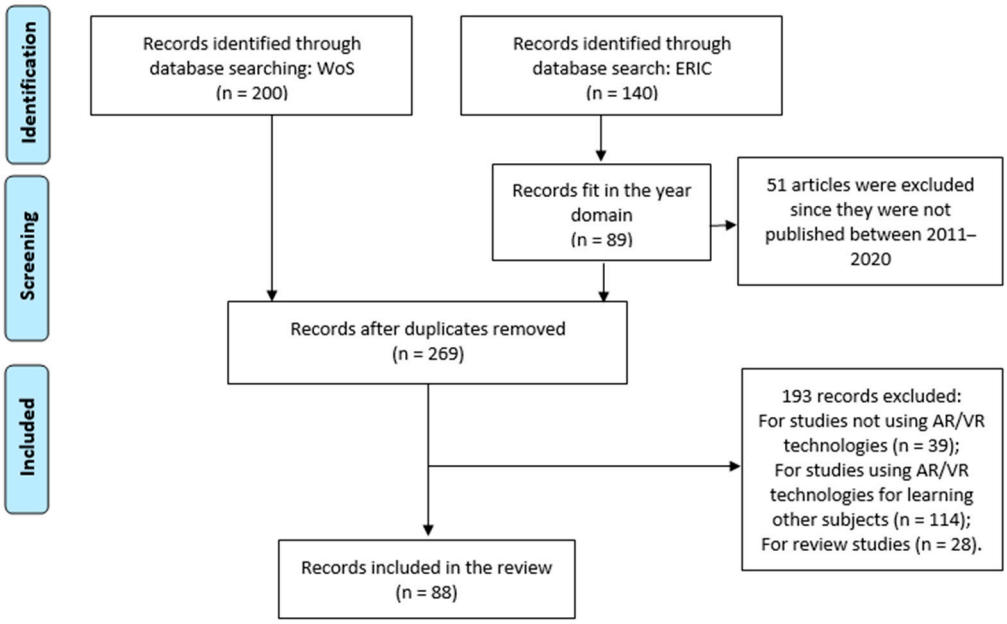

Figure 1. The manuscript selection process.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Must use AR/VR technologies.	AR/VR technologies were not used.
Must be about the use of AR/VR technologies for natural language education.	AR/VR technologies were used for learning other subjects.
Must be empirical research.	Non-empirical research was excluded.

3.2. The Data Coding and Analysis Processes

The same two researchers took part in the coding process. Regarding to research question 1, it was guided by the targeted language skills and knowledge, learning approaches and learning locations. For research question 2, we followed the coding scheme of Wang et al. [21]. To identify the research findings, effectiveness of AR/VR in language learning and research implications, the researchers read the articles one by one carefully and wrote down relevant information based on the research questions. After that, the researchers grouped the same coded data into categories. Two researchers coded five papers together and discussed the coding results until no disagreement, and the researchers followed the same criteria for coding the remaining papers.

4. Results

4.1. How Were AR and VR Used in Language Learning?

4.1.1. Targeted Knowledge and Skills of AR/VR-ELL

As shown in Figure 2, AR and VR tools were often used for vocabulary learning. A total of 28 out of 88 articles adopted AR/VR tools to enhance vocabulary acquisition, e.g., [23–25]. 18 articles investigated AR and VR supported speaking, e.g., [26–28]. 10 studies examined AR and VR for writing, e.g., [29–31], and another 10 discussed AR and VR enhanced cultural learning, e.g., [32–34]. In addition, AR and VR tools were used to promote development of language skills and knowledge such as reading, e.g., [35,36], listening, e.g., [37,38], integral language learning, e.g., [39,40], Chinese character, e.g., [41,42]; grammar learning e.g., [43,44] and English alphabet [45,46].

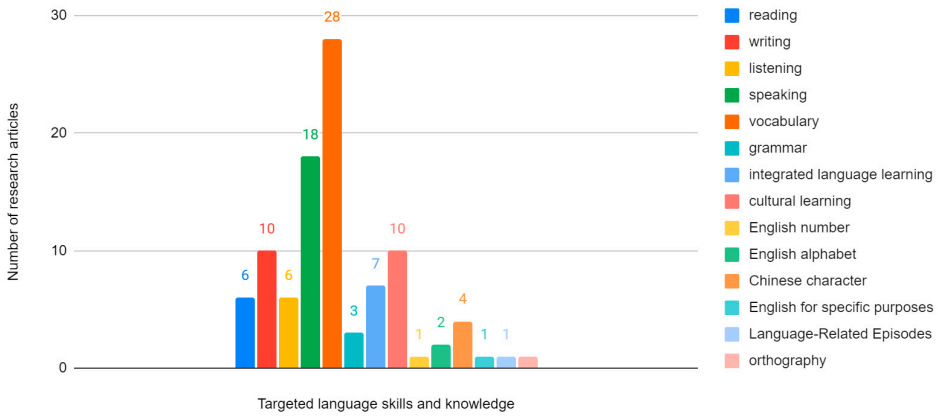

Figure 2. Targeted knowledge and skills of AR/VR-ELL.

4.1.2. Technical Tools for AR/VR-ELL

Table 2 showed the top 3 common tools of AR and VR technologies. The most common tools used in AR enhanced learning was HP Reveal (Aurusma), e.g., [47–51]. It was AR platform that allowed users to obtain the virtual content by their mobile devices [2]. Teachers used this application to convert the images into 3D, which enabled students to visualize the learning content. Some researchers developed their own learning content with the help of Unity [24,42,46,52–55] and Vuforia [24,52,53,56], it led to these two technical tools were frequently used in language research. Unity was a game engine and Vuforia was a software for users to create AR applications. These two engines could be integrated to create AR content such as recognition and tracking [53].

For VR tools, several studies used VR tools developed by Google such as Google Expedition [27,57,58], Google Earth [29] and Tour Creator [30,59]. It comprised 360-degree images that enabled users to have closer look at the view. For Edu Venture, it is a cloud-based system that offered a spherical video-based virtual reality learning experience [31,60,61]. A 360-degree camera was used in the system which allowed users from different parts of the world to design and watch the edited content via their mobile devices. Since Unity is a

game engine that able to generate virtual content, it is not surprised that researchers also adopted this software to create the VR learning environment, e.g., [62–65].

Table 2. Common AR and VR tools.

Technical Tools	Reference
HP Reveal (Aurasma)	[2,42,43,47–51]
Researcher developed AR Games/Systems supported with Unity	[24,42,46,52–55]
Researcher developed AR Learning systems built by Vuforia	[24,52,53,56]
VR tools developed by Google	[27,29,30,57–59]
EduVenture	[31,59–61]
Researcher developed VR learning systems built by Unity	[62–65]

In addition to AR and VR, researchers such as Chen [66] and Braun and Slater [67] adopted Second Life (SL) in their research. It was one of the most popular 3D multi-users virtual environments (MUVEs). It enabled users to create their own avatars using the computers in the simulated environment and communicate with each other through voice or text chat. Participants in Chen's [66] research were assigned to complete tasks in simulated real-world scenarios constructed by SL. Examples of tasks include ordering food in the restaurant and introducing attractions of learners' home country to visitors. It provided opportunities for them to interact and communicate with other students from different cultures. Similarly, Braun and Slater [67] used SL as a platform to simulate virtual interpreting scenarios such as visitor center, tourist office and meeting room. In this way, students could conduct bilingual dialogues in different interpreter-mediated business and public services settings.

4.1.3. Approaches to AR/VR-ELL

AR and VR assisted language learning mainly through immersing learners in a virtual world with 3D images, videos and games as indicated by our review results. For example, the AR application Aurasma, which offered 3D images with sound and movement, was applied in two studies [2,51]. The results indicated that Aurasma promoted effective vocabulary learning by enabling students to visualize 3D images of the target words and thus enhancing their understanding of the meanings [2]. While in the research done by Yang and Mei [51], Aurasma was used to teach orthography with the feature of stroke-by-stroke animation, and it assisted learning by demonstrating how to write characters steps by step and fostering orthographic awareness. VR technologies such as Google Cardboard and Google Expeditions also provide learners with 3D images for cultural and language learning, e.g., [27,30]. The 3D 360-degree mode that comprised detailed descriptions allowed learners to observe and interpret the cultural spots, so they felt as if they were at the spots of interest [30]. Yang and Liao [68] also pointed out that with these technologies, students could have a close glance towards the cultural products, which was conducive to cultural and language learning but difficult to achieve with other media or tools.

In some studies, AR and VR videos were used to enhance language learning. For example, Chen [52] used AR videos to support students' English learning. When students scanned the insect specimen through the AR video-enhanced English learning system (RVEL), video clips that provided explanation of the insects would be showed on screen. It helped students to understand the learning content in a more direct and explicit way, which significantly improved students learning achievement. In Dolgunsöz's [69] research, Samsung VR Googles was adopted to provide VR videos to develop students' writing skills. It was found that the writing performance of students who watched VR videos were improved in the delayed test. Since the VR videos allowed students to turn and

move to see more details of the environment, it supported long term retention thereby enhancing students' writing performance. Huang et al. [30] also applied a spherical video-based virtual reality (SVVR) approach in a descriptive writing course. The SVVR system integrated "Tour Creator" to create 360-degree videos of the learning context. The results indicated that the SVVR system enhanced students' writing performances by situating them in a simulated environment, it provided students deep learning experience regarding the learning context.

AR and VR games were also integrated in the classroom to promote language learning. The games that were investigated in our reviewed papers include Pokémon Go [70], ChronoOps [36,71] and House of Language [72] and Haunted [26]. Both Pokémon Go and ChronoOps are location-based mobile AR games. The characteristics of a place-based AR mobile game is that it integrates augmented reality mechanics with the Global Positioning System (GPS) that guided players to specific locations on the digital gap [70]. In Pokémon Go, the animated Pokémon monster would show up on the mobile devices when the players travel around, and the players were able to catch the virtual monster wherever they go [70]. ChronoOps also adopted this kind of technology, the players were required to find the green technology sites at their surroundings using the AR game mechanics. House of Language was a VR game for language acquisition. Players in this game were placed in a house with a cartoon character who taught them the names of the objects in foreign language. Learners acquired language by observing the names of the 3D objects and hearing the pronunciations of the items in the game settings [72]. Haunted was a cooperative VR game. In the game, the players collaborated with each other in a shared realistic environment and communicate via voice chat to complete the tasks [26]. They need to collect the target objects from different rooms and oral skills were enhanced by communicating with their partners. The results of these studies indicated that AR and VR games facilitated learning by creating opportunities for learners to apply knowledge and interact with the virtual world [9].

4.1.4. Locations of AR/VR-ELL

Our review results showed that AR and VR studies on language learning were mostly conducted in classrooms, e.g., [32,41] and computer labs, e.g., [26,40], where it was easier for researchers to manipulate the technology and monitor the research process. Other locations include campuses, e.g., [39,71] and cultural spots, e.g., [33,38]. Since most of the VR technologies required participants to wear headsets to immerse them in a simulated environment, VR research were more common in indoor locations. While some AR applications were mobile based, researchers tended to apply Mobile Augmented Reality applications (MAR) and place-based applications for outdoor learning as these applications allow users to move around to explore learning content freely, which provided contextual learning [39].

4.2. Who Were the Main Users of the AR/VR-ELL System?

It was found that the major group of users of the AR/VR-ELL systems were university and graduate students (Figure 3). Among the 88 papers that we reviewed here, a total of 41 were conducted among university and graduate students, e.g., [69–71]. This is perhaps because educational technologies were better and more frequently applied in higher education [73,74], and most researchers worked in higher education institutions and thus had easier access to get university students as their research participants.

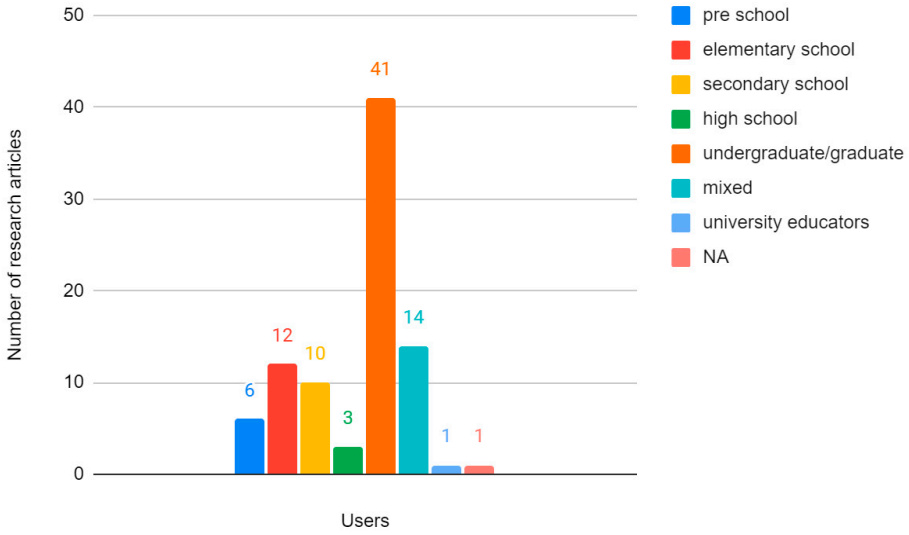

Figure 3. Main users of AR/VR-ELL system.

Some of the reviewed studies on AR/VR involved participants of different age groups, e.g., [26,75] and some investigated both students and non-students, e.g., [38,76]. So, mixed users were also frequently investigated in the reviewed studies.

Several studies were conducted among elementary students, the results of which indicated that AR and VR can well motivate elementary students and help them concentrate on target knowledge, e.g., [37,52].

Following these types of participants, users of the AR/VR-ELL systems included (1) secondary school students, e.g., [38,40]; (2) preschool students, e.g., [2,23,45]; (3) high school students [20,28,61]; (4) university educators [77].

4.3. What Were the Major Research Findings?

4.3.1. Learning Achievement

According to the research results, researchers found that AR or VR technologies was effective in promoting students' development of vocabulary knowledge, e.g., [76,78,79]; speaking skills, e.g., [27,66]; writing skills, e.g., [30,80]; and cultural language knowledge, e.g., [33,68].

Ibrahim et al. [76], Solak and Cakir [79] and Yeh and Lan [78] compared the vocabulary learning performance of the students who learned with AR or VR tools to those who learned in conventional approaches and found that the students in the AR and VR groups outperformed the other groups. They argued that this was because AR and VR presented the word knowledge in near authentic contexts, which was conducive to students' comprehension of word meanings and consolidation of form-meaning connections, and consequently it was easy for them to recall the target word knowledge later. Students in study carried out by Ibrahim et al. [76] used Microsoft HoloLens, which was an AR head-mounted display to learn vocabulary. All the objects of the target words were placed with the labels in a room setting. The learners adopted the AR device to move around the room and see the labels of the words with annotations. The results of this study proved that students learning vocabularies with virtual labels are more effective. This was because AR technology was able to show the objects in real time and space which makes students remember the words more deeply. Solak and Cakir [79] also indicated that students performed better in vocabulary learning with the help of AR technology. In their study, the targeted vocabulary was presented with pictures, text and voice. The multimodal resources were embedded into markers through AR technology. Teachers presented the animation of the vocabulary to the students in the class in the first place, followed by introducing the pronunciation and the use of the words. In such a way, students were able to acquire the contextual meaning of the words with AR technology. Yeh and Lan [78] also found

students are easier to remember the words when using VR technology. This study made use of the authoring tool Build & Snow for 3D construction. Students in this study were required to apply the vocabularies they learnt in class to create their own story in a 3D virtual context. It provided opportunities for students to review the words and produce language output, which contributed to the recall of the vocabulary.

Most of the research that intend to practice speaking skills adopted VR technologies. Taskiran's research [43] is one of the limited studies that used AR application Aurasma for practicing speaking skills and listening skills. In this research, students were required to collect the correct item in a messy room. They listened to the description of the given object and reported the information to their groupmate in order to find the object. The oral ability would be enhanced by describing the object in the targeted language. Furthermore, Reitz et al. [26] created a virtual gaming environment for students to practice communication skills. As mentioned, students in the game *Haunt* completed the mission of the game through communicating with their partners. It was found this game evoked large amount of speech and students' communication skills were enhanced. In addition, Xie et al. [27] investigated VR supported learning of oral language and found that the vocabulary and content used by the students who learned with VR were significantly better than those who learned without the technology. Participants were asked to act as a tour guide and introduce Chinese famous spots to the audience on their presentation using Google Cardboard and Google Expedition. It was found that students have better performance on fluency, pronunciation and grammar with VR tools. The researcher suggested that the use of VR technology provide both verbal and visual information during the presentation. That information served as mental cues to remind students which helped to maintain fluency. Students also pointed out that VR tools help to reduce anxiety since they felt the audience were concentrated on the scenery via Google viewers. The attention of the audience was shifted and the presenters were more relaxed. Accordingly, students could be more fluent in their presentations. As VR technologies helped to create speaking opportunities and reduce anxiety in speaking, most of the research employed VR for facilitating students' speaking skills.

Both AR and VR technologies were used for supporting writing. These two technologies offered visual content for learners which allowed them to get more understanding of the writing content. Liu and Tsai [80] claimed that AR learning materials provide linguistic and content knowledge in English composition. The learning activity in this study was designed to introduce the campus of the students using AR-based learning material. The AR learning materials adopted the GPS system, the peripheral image and description of the buildings in the campus would be shown on students' mobile devices if they point in a specific direction. It provided visual description and allowed students to access information more easily, which enhanced information expression. Students were asked to conduct a field trip around the campus and describe the scenery they observed in their essay. The researcher found that students were able to apply the vocabulary and expressions that provided in AR learning material in their writing. It implied AR learning materials provided linguistic support for students to expand their vocabulary repertoire. In Huang et al. [30], students participated in the descriptive writing activity using spherical video-based virtual reality (SVVR). The SVVR system integrated Google's Tour Creator, Google Street View, textual and pictorial information that allowed students to view in 360-degree mode. In the writing activity, students explored the context and obtained hints and messages with SVVR, followed by producing a descriptive article. The results showed that students had significant improvement on writing performance in terms of content and appearance. Content and appearance were two dimensions that evaluate descriptive writing. Students who were able to describe the context detailly and use the words and sentences correctly have higher scores in the content and appearance dimension respectively. With the use of SVVR, students were able to internalize the learning materials in a more profound way and obtain more concrete knowledge, which allowed them to express the context deep in the writing content [30].

AR provided cultural learning by allowing learners to interact with the cultural content and VR placed learners in the cultural context for enhancing their cultural understanding. Chang et al. [33] applied a mobile augmented reality (MAR) system in cultural learning. The MAR system detected the cultural spot automatically when students arrived at the spot. The learning route would be shown on the screen and students were encouraged to search and explore the attraction. Visual images and text information of the attraction were provided by the system during the exploration. It offered more fun for students to discover the culture in detail which resulted in higher learning performance. Yang and Liao [68] intended to evaluate learning effectiveness on cultural contents with the use of AR and computer vision (CV) incorporated technology, called VECAR. This system enabled learners to use natural hand gestures to interact with the cultural content. Students were able to rotate, scale and modify the virtual objects which helped them to visualize and play around the culture content. Hence, students performed better in cultural learning than students who merely understood culture depend on verbal explanations. Berti et al. [32] utilized VR to foster cultural understanding. Students viewed the 360-degree videos with Google Cardboard which allowed students to immerse themselves in the cultural context. The contextualized learning content enabled learners to explore various aspects of the targeted culture closely, which fostered cultural understandings.

4.3.2. Learning Motivation

AR and VR were effective in increasing learner motivation, as indicated by the results of several studies, e.g., [2,26,37]. These two technologies offered interactive learning content for students which thereby enhancing their learning motivation. In Redondo et al.'s [2] research, it was found that students had significant improvement of motivation when learning with AR compared with students who learnt with traditional method. In their study, students were assigned to learn vocabulary with the AR application *Aurasma*. This App presented the targeted vocabulary with 3D image, sound and movement which allowed students to visualize the learning content. The researcher also proved that students had a higher level of enjoyment with the use of AR. It might help to explain why students were motivated to learn since they are enjoy using the AR. In Hao and Lee's [37] research, an ARCS model (attention, relevance, confidence, and satisfaction) was used to evaluate students' motivation. According to this model, the first step of enhancing motivation was to arouse students' curiosity (attention). The learning activities should be designed in line with students' goal (relevance) to achieve success (confidence), and the learning process and outcome would determine the students' satisfaction. The results of this study indicated the increase of learner motivation, especially in the dimension of confidence. This is perhaps because thoughtful planning was made to ensure students in different language levels were able to understand the learning content. It provided a sense of learning control which leads to the high-level of confidence.

Reitz et al. [26] also found students were motivated by playing VR games. In their research, a VR game named *Haunted* was used to improve students' oral proficiency. The aim of this game was to haunt away non-player-characters (NPCs) and got the objects that they are protected. The players communicated via voice chats in order to collaborate with others to complete the tasks. When students were playing this game, they would use the target language to interact with other players which provided opportunities to practice their oral language. The result of this study indicated that language learners found it is motivating and interesting for them to play the game. Since the games had posed challenges to the learners and motivation was generated by challenges, the language learners have a sense of satisfaction if they successfully complete the task, which motivated them in language learning.

4.3.3. Learners' Perceptions of AR and VR

Positive perceptions of students about AR and VR are generally reported in the reviewed studies. Many students considered the use of AR and VR technologies beneficial

for academic learning, e.g., [35,51,57]. In Cheng and Tsai [35], an AR picture book was developed to enhance students' reading. Using the camera in the tablet to aim at the picture in the printed book, computer-generated information would show on the screen automatically. Both parents and children were invited to participate in this study and parents perceived the AR book is beneficial for their children learning. Parents felt that the AR book can help their children to understand the content more in depth and enhance children's motivation for learning. Yang and Mei [51] adopted an AR application to assist Japanese orthographic learning through a model-based AR platform. Students were able to download the application on their mobile device. The application provided immediate stroke-by-stroke animation overlay on the real text. Students perceived this function enabled them to learn how to write hiragana characters effectively. In Xie et al.'s research [57], students perceived the use of VR technologies were beneficial for their Chinese language learning. Students used Google Expeditions and Google Cardboard to observe the Chinese tourist attraction and prepared their own presentation. They reported that the use of VR provided contextual learning materials for them and eased their nervousness during the presentation.

Since AR and VR tools enabled students to interact with the virtual objects, the novelty experience led students to perceive learning with these tools are fun and enjoyable, e.g., [26,81]. Teachers observed that students have a high level of enjoyment when using the AR technology in Chen and Chan's [26] research. Students learned animal-related vocabulary using AR flashcards on iPads. The AR flashcards allowed students to manipulate and interact with the objects that popped up on their devices, which made the learning experience more enjoyable. Pack et al. [81] developed a prototype Virtual Reality learning Environment (VRLE) called Virtual Reality Language Learning Lab to teach students writing structure. Students were asked to highlight the sentences (e.g., topic sentence, supporting sentence and conclusion) with different colors according to their functions. The VRLE allowed students to select a color from buckets virtually and paint on the paragraph on a digital canvas. The results showed the majority of students agreed they enjoyed using the VR program. They reported the feelings of presence and immersive experience provided by VR, which made them feel fun and interesting.

Some negative perceptions were identified in the research as well. Teachers in the study conducted by Chen and Chan [23] worried about the effectiveness of AR tools. As mentioned, AR flashcards were applied in this study to enhance students' understandings of the vocabulary. Teachers found that some students focused more on the animation and sounds provided by the technology rather than the learning content. The parents were concerned that AR learning might lead to the excessive use of digital technologies which would affect children's learning [35]. Students in Dolgunsöz et al.'s [69] research also found some technical limitations of VR technology. They claimed the VR videos in the research had low quality and the videos caused physical discomfort for them.

4.4. Why Were AR and VR Effective in Promoting Language Learning?

Immersive learning and the increase of motivation were the main factors that promote language learning, e.g., [37,68]. As discussed before, AR tools simulated virtual information and applied the information into the real world. It provided learners with immersive feeling by interacting with the virtual objects [23]. Additionally, VR tools offered immersive environments by activating visual and motor channels to provide learners with immersive sense [27]. Students were able to understand the learning content within the context, which provided them more in depth and comprehensive understandings. In addition, students felt enjoyable and fun when they were interacting with AR and VR tools, e.g., [23,81]. It aroused their interest in learning and induces further exploration of the learning content. In such cases, students were motivated to learn and highly engaged in the learning activities which resulted in positive effects on their learning.

Furthermore, AR and VR technologies helped to develop students' language skills through creating interaction. According to sociocultural theory, people interacted with

the society and culture in which they lived to shape their intelligence [82]. It implied that humans are able to learn through interaction. Interaction was a crucial element in language learning since learners practice the language they learnt through interaction with others. Safar et al. [45] reported students have higher degree of interaction in the English class with the use of AR tools. The AR apps "AR-Flashcards Animals-Alphabet" and "AR Alphabet Flashcards" were selected in this study. The initial alphabets of the animals were presented in a three-dimensional way with animal sounds and animated movement. Students could visualize the learning content with iPads and manipulate the devices by themselves, which made the interaction between children and the technologies inevitable. The researcher also indicated that students who had a higher degree of interaction performed better in the achievement test. AR technology attracted students' attention and led students to actively participate in the learning process. It made the learning content deeply rooted in students' minds and resulted in higher achievement. While VR tools provided a platform for language learners to interact, communicate and collaborate with different learners. A VR social networking site vTime was chosen in Liaw's [83] research. After downloading the application in the cell phone, it could be placed into the VR Box to experience virtual environments. Learners were required to carry out conversation with others in the virtual environment using the language skills they learnt from class. With the use of VR tools, learners were able to interact with people from all around the world in the simulated environment without time and space constraints [66,83]. It created opportunities for students to practice their language skills.

The use of AR and VR technology also helped to reduce learning anxiety [40,57,83,84]. As mentioned, AR and VR technologies were often integrated with games. Compared with traditional learning, games provided a comfortable and less stressful learning environment for students. AR and VR games created a both authentic and comfortable language learning environment, which helped to reduce learning anxiety [26]. They had lower mental effort since the AR and VR devices provided hints for them to complete the tasks [85]. For VR technologies, learners had their avatars in the simulated environment which allowed them to hide their identity. It provided a sense of security for the learners since other users would not recognize them if they made any mistakes during the learning process. The use of VR tools helped to reduce learning anxiety and ease nervousness of students [57]. Students were more willing to speak out and practice in the learning activities which is essential for improving their language skills. In sum, the features of AR and VR tools enabled students to have more learning opportunities and reduce their anxiety in learning language skills.

4.5. What Were the Implications for Future Research on AR/VR-ELL?

Since both of the technologies were relatively new, how teachers corporate AR and VR tools in teaching should be further explored. Redondo et.al [2] suggested that future research can establish guidelines for teachers to incorporate AR tools in the classroom. Similarly, Yeh and Lan [78] agreed that there was a need to have research on the combination of teacher professional development and VR technology development.

Regarding the research design, researchers intended to enlarge their sample size and include different participants in future studies for both AR and VR studies. Participants from different grade levels [30,37,45], different backgrounds [23,76] and different characteristics [30] should be included. Additionally, increasing the numbers of participants for future research were mentioned by the researchers since research results from larger sample size would be more representative [35,45,84].

Furthermore, individual factors should be included for future study. It has been proved that AR and VR technologies effectively improved students' language learning. While whether the technologies had different impacts on students with different characteristics remained concerned. Future research could explore the effectiveness of the AR tools on students with different learning styles [69] and different learning strategies [38]. As previous studies had researched on affective factors like motivation and attitudes, other

human factors like self-efficacy [71,79] and cognitive aspects [40,84] could be added in future research.

Current studies did not evaluate the instructional methods when adopting the AR and VR tools. Therefore, research topics on developing new approaches to teach with AR could be investigated [68]. For example, Sydorenko et al. [71] interested in whether specific instruction is given would change the learning outcome. In addition to the instructional method, the teaching material should be examined in future studies. Redondo et al. [2] pointed out the importance of content in using AR. If future studies could explore the appropriate learning content, teachers would benefit from it a lot. Content related topics like the amount of content and the complexity level of content could be further investigated.

5. Discussion

5.1. Comparison of the Present Study and the Previous Research

This review systematically analyzed research papers related to AR and VR tools for language learning. The results showed that these tools were integrated with games to enhance students' learning motivation. It supported the research of Bacca et al. [9] and Khoshnevisan and Le [14]. These researchers also found games are one of the popular formats of AR technologies. The possible reasons for explaining this result was that both games and AR and VR tools focused on interaction and interaction is a crucial element in language learning. Students were capable of applying language skills when they were interacting with the virtual world. Our research also identified Aurasma was the most frequently used tool in AR research. While AR pop-up books were the most popular AR technologies in Khoshnevisan and Le's [14] review which was different from our research result. It might be due to the reason that the research analyzed in this review was published between 2007–2017. Limited games were designed based on AR technologies. With the popularity and technological advancement in AR, increasing numbers of AR applications were developed and became the major approach that integrated with AR tools.

Our research found VR tools developed by Google were most popular in VR research, which is different from other research results, e.g., [20,22]. Many researchers consider SL as a sub-category of VR, including Merchant et al. [17], Solak and Erdem [19], Lin and Lan [20], Wang et al. [21] and Parmaxi [22]. Solak and Erdem [19] defined VR as computer generated artificial worlds or immersive environments in which learners explore and interact with (p. 21). They categorized SL into the three-dimensional immersive virtual reality environment since it provided visual representations of the users to symbolize their presence in the virtual world. According to Lin and Lan [20], VR was the system comprised a full integration of artificial intelligence and a wide variety of social communication tools (p. 486). Therefore, they categorized Second Life as open social virtualities that immersed users in real life contexts to interact with others. Both Merchant et al. [17] and Wang et al. [21] regarded Second Life as the virtual worlds. Merchant et al., [17] argued virtual worlds had the ability to construct and interact with the virtual objects. Since Second Life allowed users to generate authentic settings, learners could be engaged in participating interactive activities. Wang et al. [21] placed Second Life as the socially oriented virtual worlds. Students created interaction between the avatars and the contexts without regulating users' decision. Previous studies revealed the significant role of VR in language education. For example, Lin and Lan [20] found Second Life was the most utilized platform in VR-ELL from 2009 to 2013, Wang et al. [21] was most commonly used before 2014 and Parmaxi [22] also found SL was frequently employed between 2015 to 2018. Therefore, we included Second Life in our review. However, as Second Life is not exactly VR, so we place papers on Second Life in a third section, in addition to AR and VR. Our research further proved SL remained as the frequently used platform in language teaching up to 2020. Since VR technologies were comparatively expensive than other technologies, SL served as a multi-users VR platform that allowed users to assess freely, which attracted many researchers to use this platform in their researches.

In terms of major users of AR and VR technology, this review pointed out university students were the main target audience. It is in line with the research results done by Bacca [9], Hedberg et al. [12], Kavanagh et al. [16], Solak and Erdem [19], Parmaxi and Demetriou [15] and Parmaxi [22]. However, our result was different from the review done by Akçayır and Akçayır [10]. They found that K-12 students ranked as the most preferable learner type because students from this group spend much of their time playing digital games. Therefore, researchers tended to choose K-12 students as their participants. Traditionally, K-12 students comprised students from elementary schools, secondary school and high school. In our review, we tended to separate these groups of students in order to have a more comprehensive understanding of the users of AR/VR tools. The difference of grouping methods in the current review led to the difference of the results. But we could still draw the conclusion that researchers are more likely to select participants at the concrete operational stage according to previous and current review, since students at this stage were capable of manipulating novel technologies. Our research also observed the trend that researchers invited users from different background in their research to provide a convincible result in recent years. Previous review did not identify this result as most of the research papers that focused on mix users were published in recent years, e.g., [26,76].

Our research suggested that enhancing learning achievement and motivation are the most obvious findings from AR and VR research. This result was also identified in previous review, e.g., Bacca et al. [9], Akçayır and Akçayır [10], Khoshnevisan and Le [14]. Our research further investigated how AR and VR technologies promote language learning specifically which is different from previous reviews that only analyzed the effectiveness of AR and VR in education generally. We concluded that these technologies enhance language learning by providing immersive learning and creating interaction. It confirmed the findings of Zhang [13] and Parmaxi and Demetriou [15] who also suggested AR provides immersive learning and increases learners' active interaction. While our research also claimed that reducing learning anxiety is one of the important factors to promote language learning, which is not pointed out by previous review. This is because the review conducted by Zhang (2018) and Parmaxi and Demetriou [15] only focused on AR in language learning, but our review focused both on AR and VR technologies. Our review found that VR technologies are effective in reducing learning anxiety by unrevealing students' identity and providing a comfortable environment which leads to such research results.

5.2. Limitations of AR and VR Technologies

Our study identified the effectiveness of AR and VR technologies in promoting language learning. However, there were some disadvantages of these two technologies. First of all, students' attention would be easily distracted by the virtual content provided by AR and VR technologies. According to our research, AR and VR technologies immersed students in a virtual world to enhance language learning. 3D images and videos were provided during to learning process which allowed students to learn in a more interesting way. While some students might only focus on the virtual content rather than the learning content [46,86], and therefore, the learning objectives could not be achieved.

Furthermore, using AR and VR technologies in language classes created challenges for classroom management. Since AR and VR technologies caused learning distraction, teachers need to make additional effort guide students' attention back to the learning tasks [23,29]. Additionally, both AR and VR technologies emphasized on student-centered learning [53,87]. Each of the students learned with their own devices and teachers had limited intervention on their learning. In such case, it is difficult for teachers to monitor each student's learning process and leads to difficulties to classroom management.

In addition, implementing AR and VR technologies was time consuming. Students in Chen et al.'s [29] reported that interacting with the VR technology costed them too much time. It might lead to the problem that the learning tasks could not be finished on time. For teachers, they need to prepare additional learning materials [65], which might cause extra burden for them.

5.3. Pedagogical Implications

According to our research result, the application of AR and VR technologies lead to better learning outcomes, which further supported previous review, e.g., [12,15,21]. This review demonstrated the effectiveness of AR and VR tools and therefore, these tools should be widely applied in language education. AR tools that are identified in current review (e.g., Pokémon Go, Aurasma, AR-Flashcards Animals-Alphabet and AR Alphabet Flashcards) were free to download which allowed teachers to use these applications to satisfy their teaching needs. Additionally, VR platforms such as Google Expedition and vTime were open access. Teachers were free to choose any one of them to support teaching. Our research revealed the potential of using AR and VR tools in language learning and provided the options for teachers to choose the tools that they need.

Our research pointed out the effectiveness of AR and VR tools in language education, there would be an inevitable trend of implementing these tools in classroom teaching. In order to cope with this trend, teachers need to design and develop relevant teaching materials to corporate with AR or VR tools. Teachers might consider to use different approaches (i.e., self-directed approach, task-based learning approach) when designing learning activities. Hsu [85] found students had higher flow experience in an AR activity in self-direct approach. As self-directed approach allowed students to control their learning pace, it was more flexible for students and they enjoyed more in the activities. Therefore, self-directed approach could be used in AR learning activities to enhance students' learning motivation. Task-based learning approach would be integrated with VR since VR technology was able to simulate real-life scenarios. It created more opportunities for students to use the target language in daily life, which fostered meaning-oriented use of the language.

As identified in our research, mobile-based AR applications were frequently used in current studies to conduct outdoor learning activities. The results from these studies also proved it was feasible for using those applications to support students' learning. Therefore, the instructors might consider to apply them for both formal and informal learning to provide dynamic learning experiences for students. For institutions, more training both for teachers and students would be needed to make sure AR and VR tools could be applied in the classroom effectively. Compared with AR tools, VR technologies were relatively new and costly which created more challenges to apply them in classroom settings. It also required the institutions to provide more devices to support the operation of the technology.

5.4. Research Implications

Our result indicates both AR and VR tools are often used for vocabulary learning. It implies most of the current AR and VR studies mainly focus on vocabulary acquisition. While studies on grammar and listening skills are limited. Current review and previous review [10,12,15] proved that the use of AR and VR technology is effective for learning. Our review further identifies AR and VR tools were able to promote language learning through enhancing students' motivation and creating interaction. Since grammar learning tended to be a more difficult and boring task for students, it might lead to unwillingness for them. While AR and VR were considered as fun and enjoyable tools, it helped to enhance students' motivation and solve these problems. Furthermore, AR and VR tools enabled students to interact with virtual objects or characters, we believed that students could learn grammar or listening skills through conversation. Above all, we suggested that further research could explore the learning effectiveness of students' grammar learning and listening skills with the use of AR or VR tools.

One of the major findings of the research is both students, teachers and parents held positive perceptions towards using AR and VR, e.g., [39,49]. Future research could be further investigated what factors contribute to users' positive perception. Specific factors (e.g., satisfaction and enjoyment) could be taken as considerations for further exploration. Several researchers also mentioned that students are highly engaged in learning when they are using these tools in the classrooms, e.g., [23,29]. While the researchers did not

really measure the levels of engagement in their studies. Future research could examine the effects of AR or VR tools on learning engagement with quantitative data in order to provide more comprehensive results.

6. Conclusions

This paper provided a systematic review of the present studies about AR and VR tools on language learning. The analysis was conducted according to the approaches of integrating AR and VR in language learning, the main users of AR and VR technologies, research findings, ways of AR and VR in improving language proficiency and research implications of previous research. It was found that immersing learners into virtual worlds was the main approach for language learning in AR and VR studies, since both of the technologies enabled users to interact with virtual objects to achieve immersive learning. College students were the main users of these two technologies, they were more capable of manipulating these relatively new tools. In terms of research findings, most of the studies found AR and VR tools were effective in promoting learning, enhancing motivation and students held positive attitudes towards using those tools. AR and VR enhanced language learning through providing immersive learning, improving motivation, creating interaction and reducing learning anxiety. Due to the effectiveness of AR and VR tools, there was an inevitable trend of integrating these tools in education. In such a case, researchers expected future studies to pay more attention on how AR or VR tools could be integrated into education in a better way, improving the design of the technologies and research and including more individual factors. Current reviews mostly focused on either AR or VR tools on language learning, limited papers focused on both tools. This paper filled in this gap by providing a comprehensive review of AR and VR tools in language learning. This review had a relatively small sample size, as AR and VR are relatively new topics in language learning. Future research could expand the data sources to generate more representative data.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Appendix A

Table A1. The coded papers.

Authors	Tittle	Journal	Reference
Ahmet & Bulent (2020)	The Effect of Virtual Reality Enhanced Learning Environment on the 7th-Grade Students'reading and Writing Skills in English	Malaysian Online Journal of Educational Sciences	[88]
Alemi & Khatoony (2020)	Virtual Reality Assisted Pronunciation Training (Vrapt) For Young Efl Learners	Teaching English with Technology	[89]
Alfadil (2020)	Effectiveness of virtual reality game in foreign language vocabulary acquisition	Computers & Education	[72]
Barrett et al. (2020)	Technology acceptance model and multi-user virtual reality learning environments for Chinese language education	Interactive Learning Environments	[90]
Berti et al. (2020)	Fostering Cultural Understanding with Virtual Reality: A Look at Students' Stereotypes and Beliefs	International Journal of Computer-Assisted Language Learning and Teaching	[32]
Bojórquez et al. (2016)	Study on mobile augmented reality adoption for Mayo language learning.	Mobile Information Systems	[53]
Braun & Slater (2014)	Populating a 3D virtual learning environment for interpreting students with bilingual dialogues to support situated learning in an institutional context.	The Interpreter and Translator Trainer	[67]
Castañeda et al. (2018)	Analysis on the gamification and implementation of Leap Motion Controller in the IED Técnico industrial de Tocancipá	Interactive Technology and Smart Educatio	[91]
Chang et al. (2020)	Enhancing English-Learning Performance through a Simulation Classroom for EFL Students Using Augmented Reality—A Junior High School Case Study	Applied Sciences	[47]
Chang et al. (2019)	The differences in pleasing value and learning performance among different groups using mobile augmented reality system for cultural environment learning	Multimedia Tools and Applications	[33]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Chen (2020)	AR videos as scaffolding to foster students' learning achievements and motivation in EFL learning	British Journal of Educational Technology	[52]
Chen (2016)	The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life	Computers & Education	[66]
Chen et al. (2011)	Level of abstraction and feelings of presence in virtual space: Business English negotiation in Open Wonderland	Computers & Education	[92]
Chen et al. (2020a)	Effects of captions and English proficiency on learning effectiveness, motivation and attitude in augmented-reality-enhanced theme-based contextualized EFL learning	Computer Assisted Language Learning	[4]
Chen & Hwang (2020)	Effects of experiencing authentic contexts on English speaking performances, anxiety and motivation of EFL students with different cognitive styles	Interactive Learning Environments	[59]
Chen & Chan (2019)	Using Augmented Reality Flashcards to Learn Vocabulary in Early Childhood Education	Journal of Educational Computing Research	[23]
Chen (2016)	The effects of virtual reality learning environment on student cognitive and linguistic development	The Asia-Pacific Education Researcher	[93]
Chen & Hsu (2020)	Self-regulated mobile game-based English learning in a virtual reality environment	Computers & Education	[66]
Chen et al. (2020b)	Google Earth Virtual Reality and expository writing for young English Learners from a Funds of Knowledge perspective	Computer Assisted Language Learning	[29]
Cheng & Tsai (2014)	Children and parents' reading of an augmented reality picture book: Analyses of behavioral patterns and cognitive attainment	Computers & Education	[94]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Chen & Tsai (2016)	The interaction of child–parent shared reading with an augmented reality (AR) picture book and parents' conceptions of AR learning	British Journal of Educational Technology	[35]
Chien (2019)	English for Ecotourism and Its Sustainability with Augmented Reality Technology	International Education Studies	[48]
Chien et al. (2020)	Effects of peer assessment within the context of spherical video-based virtual reality on EFL students' English-Speaking performance and learning perceptions	Computers & Education	[61]
Dalim et al.	Using augmented reality with speech input for non-native children's language learning	International Journal of Human-Computer Studies	[54]
Damio & Ibrahim (2019)	Virtual reality speaking application utilisation in combatting presentation apprehension	Asian Journal of University Education	[95]
Dolgunsöz et al. (2018)	The effect of virtual reality on EFL writing performance.	Journal of Language and Linguistic Studies	[69]
Eang & Na-Songkhl (2020)	The Framework of an AR-Quest Instructional Design Model Based on Situated Learning to Enhance Thai Undergraduate Students' Khmer Vocabulary Ability	LEARN Journal: Language Education and Acquisition Research Network	[24]
Ebadi & Ebadijalal, (2020)	The effect of *Google Expeditions* virtual reality on EFL learners' willingness to communicate and oral proficiency.	Computer Assisted Language Learning	[58]
Fuhrman et al. (2020)	The moving learner: Object manipulation in virtual reality improves vocabulary learning	Journal of Computer Assisted Learning	[64]
Gordon et al. (2019)	Affordance compatibility effect for word learning in virtual reality	Cognitive science	[96]
Hagström, & Winman (2018)	Virtually overcoming grammar learning with 3D application of Loci mnemonics?	Applied Cognitive Psychology	[65]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Hao & Lee (2019)	The development and evaluation of an educational game integrating augmented reality, ARCS model, and types of games for English experiment learning: an analysis of learning	Interactive Learning Environments	[37]
Harvey et al. (2020)	"To Be, or Not to Be": Modernizing Shakespeare With Multimodal Learning Stations	Journal of Adolescent & Adult Literacy	[97]
Hassani et al. (2016)	Design and implementation of an intelligent virtual environment for improving speaking and listening skills	Interactive Learning Environments	[98]
Hellermann et al. (2017)	Mobile reading as social and embodied practice	Classroom Discourse	[36]
Ho et al. (2011)	Design and implementation of a student-generated virtual museum in a language curriculum to enhance collaborative multimodal meaning-making	Computers & Education	[99]
Ho et al. (2017)	To activate English learning: Listen and speak in real life context with an AR featured u-learning system	Journal of Educational Technology & Society	[38]
Holden & Skyes (2011)	Leveraging mobile games for place-based language learning	International Journal of Game-Based Learning	[100]
Hsu (2017)	Learning English with augmented reality: Do learning styles matter?	Computers & Education	[84]
Hsu (2019)	Effects of gender and different augmented reality learning systems on English vocabulary learning of elementary school students	Universal Access in the Information Society	[85]
Huang et al. (2020)	Learning to be a writer: A spherical video-based virtual reality approach to supporting descriptive article writing in high school Chinese courses	British Journal of Educational Technology	[30]
Ibanez et al. (2011)	Learning a foreign language in a mixed-reality environment	IEEE internet computing	[101]
Ibrahim et al. (2018)	Arbis pictus: A study of vocabulary learning with augmented reality	IEEE transactions on visualization and computer graphics	[76]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Johnson et al. (2020)	Assessing the Impact of Game Modalities in Second Language Acquisition: ELLE the EndLess LEarner.	Journal of Universal Computer Science	[102]
Kaplan-Rakowski (2018)	The effect of stereoscopic three-dimensional images on vocabulary learning	Contemporary Educational Technology	[25]
Küçük et al. (2014)	Augmented reality for learning English: Achievement, attitude and cognitive load levels of students	Education & Science/Egitim ve Bilim	[40]
Lee (2020)	Problem-based gaming via an augmented reality mobile game and a printed game in foreign language education.	Education and Information Technologies	[103]
Lee & Park (2020)	Reconceptualization of the context in language learning with a location-based AR app	Computer Assisted Language Learning	[39]
Li et al. (2020)	An empirical study on using virtual reality for enhancing the youth's intercultural sensitivity in Hong Kong	Journal of Computer Assisted Learning	[104]
Li et al. (2016)	The design of immersive English learning environment using augmented reality	Educational Technology Research and Development	[77]
Liaw (2019)	learners' intercultural communication in an open social virtual environment	Journal of Educational Technology & Society	[83]
Lin et al. (2020)	The effects of an augmented-reality ubiquitous writing application: a comparative pilot project for enhancing EFL writing instruction	Computer Assisted Language Learning	[55]
Liu & Tsai (2013)	Using augmented-reality-based mobile learning material in EFL English composition: An exploratory case study.	British Journal of Educational Technology	[80]
Mills et al. (2020)	Culture and vision in virtual reality narratives	Foreign Language Annals	[34]
Pack et al. (2020)	University EAP students' perceptions of using a prototype virtual reality learning environment to learn writing structure	International Journal of Computer-Assisted Language Learning and Teaching	[81]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Peeters (2020)	Bilingual switching between languages and listeners: Insights from immersive virtual reality	Cognition	[105]
Peeters & Dijkstra (2018)	Sustained inhibition of the native language in bilingual language production: A virtual reality approach	Bilingualism: Language and Cognition	[106]
Redondo et al. (2020)	Integration of augmented reality in the teaching of English as a foreign language in early childhood education	Early Childhood Education Journal	[2]
Reitz et al. (2019)	VR-based gamification of communication training and oral examination in a second language	International Journal of Game-Based Learning	[26]
Repetto et al. (2015)	Is motor simulation involved during foreign language learning? A virtual reality experiment	SAGE Open	[75]
Richardson (2016)	Exploring the potential of a location based augmented reality game for language learning	International Journal of Game-Based Learning	[49]
Rodríguez-Castro (2018)	An integrated curricular design for computer-assisted translation tools: Developing technical expertise	The Interpreter and Translator Trainer	[8]
Safar et al. (2016)	The effectiveness of using augmented reality apps in teaching the English alphabet to kindergarten children: A case study in the State of Kuwait	EURASIA Journal of Mathematics, Science and Technology Education	[45]
Sahin & Ozcan (2019)	Effects of Augmented Reality in Teaching Old Turkish Language Mementoes on Student Achievement and Motivation	Contemporary Educational Technology	[50]
Solak & Cakir (2015)	Exploring the Effect of Materials Designed with Augmented Reality on Language Learners' Vocabulary Learning	Journal of Educators Online	[107]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Solak & Cakir (2016)	Investigating the role of augmented reality technology in the language classroom	Online Submission	[79]
Sorrentino, & Spano (2019)	Post-it notes: supporting teachers in authoring vocabulary game contents	Multimedia Tools and Applications	[56]
Sydorenko et al. (2019)	Mobile augmented reality and language-related episodes.	TESOL Quarterly	[71]
Tai et al. (2020)	The impact of a virtual reality app on adolescent EFL learners' vocabulary learning	Computer Assisted Language Learning	[86]
Taskiran (2019)	The effect of augmented reality games on English as foreign language motivation	E-Learning and Digital Media	[43]
Tsai (2020)	The Effects of Augmented Reality to Motivation and Performance in EFL Vocabulary Learning	International Journal of Instruction	[108]
Tuli (2020)	Evaluating Usability of Mobile-Based Augmented Reality Learning Environments for Early Childhood	International Journal of Human–Computer Interaction	[46]
Van Ginkel et al. (2020)	The impact of computer-mediated immediate feedback on developing oral presentation skills: An exploratory study in virtual reality	Journal of Computer Assisted Learning	[28]
Wang & Khambar (2020)	The application of game-based AR learning model in English sentence learning	Online Journal of Educational Technology	[44]
Wang et al. (2019)	Impact of digital content on young children's reading interest and concentration for books	Bilingualism: Language and Cognition	[109]
Wen (2018)	Chinese character composition game with the augment paper	Journal of Educational Technology & Society	[41]
Wen (2019)	An Augmented Paper Game With Socio-Cognitive Support	IEEE Transactions on Learning Technologies	[110]
Wem (2020)	Augmented reality enhanced cognitive engagement: designing classroom-based collaborative learning activities for young language learners	Educational Technology Research and Development	[42]

Table A1. *Cont.*

Authors	Tittle	Journal	Reference
Xie et al. (2019a)	Effects of using mobile-based virtual reality on Chinese L2 students' oral proficiency	Computer Assisted Language Learning	[27]
Xie et al. (2019b)	Using interactive virtual reality tools in an advanced Chinese language class: a case study	TechTrends	[57]
Yang et al. (2020a)	Facilitating Communicative Ability of EFL Learners via High-Immersion Virtual Reality	Journal of Educational Technology & Society	[62]
Yang et al. (2020b)	From experiencing to expressing: A virtual reality approach to facilitating pupils' descriptive paper writing performance and learning behavior engagement	British Journal of Educational Technology	[31]
Yang & Liao (2014)	Computer-assisted culture learning in an online augmented reality environment based on free-hand gesture interaction	IEEE Transactions on Learning Technologies	[68]
Yang & Mei (2018)	Understanding learners' use of augmented reality in language learning: insights from a case study	Journal of Education for Teaching	[51]
Yeh et al. (2020)	Enhancing EFL students' intracultural learning through virtual reality	Interactive Learning Environments	[60]
Yeh &Tseng (2020)	Enhancing multimodal literacy using augmented reality	Language Learning & Technology	[111]
Yeh & Lan	Fostering student autonomy in English learning through creations in a 3D virtual world	Educational Technology Research and Development	[78]
Zhao & Ma (2020)	ShadowPlay2. 5D: A 360-Degree Video Authoring Tool for Immersive Appreciation of Classical Chinese Poetry	Journal on Computing and Cultural Heritage	[112]

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