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Virtual-Agent-Based Language Learning: A Scoping Review of Journal Publications from 2012 to 2022

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Abstract: Researchers have pointed out the importance of virtual agents in technology-supported language learning; however, how to effectively combine the two remains a challenge for educators and educational technologists. To this end, this study reviewed publications in the field of virtual-agent-based language learning research from 2012 to 2022 in the Web of Science SSCI Core Collection database and explored the dimensions of publication trends, country and regional distribution, participants, research methodology, research platforms, role of virtual agents, language proficiency, research hot topics, theoretical foundations, and hot issues and trends in the field of virtual-agent-based language learning research. Cluster and co-occurrence analysis using VOSviewer software was used to analyze the links among country and region distribution, keywords, and terms. It was found that (1) the top four regions in terms of the number of citations for authors were, in descending order, Iran, Japan, South Korea, and Brazil; (2) the learner characteristics that scholars were most concerned about were learning effectiveness, memory performance, social presence, learning experience, and motivation; and (3) the results of co-occurrence analyses classified virtual-agent-based language learning research into eight clusters, namely, anthropomorphic virtual agents, the effects produced by virtual agents, the social interaction of virtual agents, animated virtual agents and language achievement, the gestures of virtual agents, the effects of virtual agents on learner characteristics, computer-assisted learning, and the design of virtual agents. The lack of the systematic application of virtual agents in language learning prevented previous studies from revealing the language learning process in virtual-agent-based learning environments. Therefore, this study made appropriate recommendations for future investigations on how virtual agents can improve language learning for researchers, teachers, and decision makers.

Keywords: virtual agents; cluster analysis; virtual-agent-based language learning; anthropomorphism; research issues

Citation: Gu, X.; Yu, T.; Huang, J.; Wang, F.; Zheng, X.; Sun, M.; Ye, Z.; Li, Q. Virtual-Agent-Based Language Learning: A Scoping Review of Journal Publications from 2012 to 2022. *Sustainability* **2023**, *15*, 13479. https://doi.org/10.3390/su151813479

Academic Editor: Hao-Chiang Koong Lin

Received: 1 August 2023
Revised: 1 September 2023
Accepted: 4 September 2023
Published: 8 September 2023

1. Introduction

The rapid development of educational technology has led to the widespread use of virtual reality technology in language learning. However, learners are often prone to the emotional experience of strangeness and isolation in virtual reality learning environments. The ability of virtual agents to interact with learners in a natural, humanlike manner makes learning easier, more engaging, and more motivating, and this deeper engagement leads to better learning outcomes [1]. Anthropomorphic agents provide a unique opportunity to increase the social and emotional qualities of the tutoring environment [2]. Previous research demonstrated the positive effects of virtual agents in terms of learner effectiveness, motivation, and social and emotional support for learners [3,4]. Lan et al. [5] showed that students who performed actions while watching their 3D avatars, rather than producing

actions by moving their bodies or remaining silent, had a more positive impact on the learning effect of second language vocabulary. Virtual agents are animated on-screen characters that help learners in multimedia environments, and these characters can flexibly play many roles in different scenarios, such as lecturers, coaches, tutors, and learning partners [6]. Lifelike virtual agents existing alongside students in the learning environment and creating rich face-to-face learning interactions open up exciting new possibilities [7]. As the use of virtual agents in subject education increases with the development of artificial intelligence technologies, research on virtual-agent-based language learning continues to grow, and scholars have attempted to synthesize the existing literature and provide an account of the theoretical core and structure of the field [1]. Previous research reviews focused on the role of virtual agents, application areas, technology products, and development progress; however, how to effectively utilize virtual agents in language learning is yet to be explored [1]. In this aspect, there is the need to investigate the current trends and explore the possibilities of the application of virtual agents in language education settings to further contribute to the expansion of implementing virtual agents in education. More specifically, although the use of virtual agents in language education is still novel in its technological applications and the related research on its effectiveness, its utilization and application are expected to substantially grow. Therefore, it is timely to provide a comprehensive overview of the current status and research trends by systematically mapping the key concepts of and directions in the research area. Therefore, this study reviewed publications in the field of virtual-agent-based language learning research in the Web of Science SSCI Core Collection database for the period of 2012–2022, aiming to bridge the research gap by providing an overview of the current status and trends in virtual-agent-based language learning research. The aim of this paper was to analyze the major journal and publication trends, national and regional distribution, participants, research methods, research platforms, roles of virtual agents, language proficiency, learner characteristics, theoretical foundations of learning, research themes, and trends in virtual-agent-based language learning research. This paper was written not only to understand the current status of the application of virtual agents in language learning research but also to provide the advantages and future trends of virtual-agent-based research in language learning. Meanwhile, the survey of this study may contribute to the trend of related articles in the field of virtual-agent-based language learning in recent years.

2. Literature Review

2.1. Virtual Agents

The definitions and understandings of virtual agents vary across different studies in the field. Virtual agents are defined as people who have the will to pursue their goals and plans [8–10]. Fink [11] loosely defined virtual agents as three-dimensional depictions of computer users in computer games, static or dynamic two-dimensional images representing user avatars on Internet forums and in other communities, or objects that reflect the personality of a computer user. The role of virtual agents was first derived from media equation theory, which applies human social rules to multimedia and treats media agents as real people. Reategui et al. [12] defined a virtual agent as a humanlike character available in instructional software that facilitates learning. This includes experts, peers, evaluators, and so on. As the facial expressions, body movements, and gestures of virtual agents realistically mimic various characters in real life, Woo [13] defined virtual agents as those that influence the perceptual capabilities of the system and anthropomorphize the virtual agent. In addition, Kuk et al. [14] defined virtual agents as computer-generated virtual tutors that are presented in the form of humans, animals, plants, and so on and that usually enable communication by text, speech, and movement.

Researchers of multimedia learning environments typically focus on whether the role of the virtual agent facilitates the learning process and the cognitive and affective experience of the learner. Virtual reality agents can socially interact with learners and, thus, facilitate learning. They can take on the role of a teacher, student, or peer and provide

emotional support during the learning process [15]. Research showed that virtual agents have a positive and beneficial impact on language learning outcomes, promoting learner motivation, learning experience, and learning satisfaction [6]. Moreno [16] stated that virtual agents help students to personalize their learning, thus helping to build an emotional bond between the student and the agent. In addition, virtual agents are motivating and facilitative for learners and can socially and emotionally support them [2]. Building on the definitions of virtual agents proposed by many researchers, this study argues that virtual agents are virtual characters that can participate in the learning process as virtual characters in a multimedia environment, supporting learners' learning through voice, text, facial expressions, and body movements, aiming to facilitate learners' learning, cognitive, and affective experiences.

2.2. Educational Agents and Language Learning

With the emergence and rapid development of technology-enhanced language learning (TELL) approaches to L2 pedagogy, researchers can harness the potential of cutting-edge technologies to explore innovative and novel approaches to problems closely related to second language teaching and learning [17]. Innovative technologies such as virtual reality enable learners to engage in immersive virtual activities through physical or virtual movements, and they have the potential to enable learners to achieve deeper levels of cognition when interacting with virtual objects, which meets the evolving expectations of learners [18,19]. Over the past decade, virtual reality technology has been used in a variety of educational applications [20]. Chen [21] stated that the use of virtual reality can increase learner engagement, motivation, active learning, and creativity in English courses due to the increased opportunities to interact with meaningful contexts that are provided. Immersion in an authentic context is particularly important when learning a second language [22]. Using the target language in an authentic context facilitates L2 learners' oral performance and formal accuracy [22,23]. Social agency theory suggests that by using social cues such as human language and visuals, virtual tutors can be seen as social agents with whom learners can develop partnerships and, thus, engage in the information processing and meaning making required for a deeper understanding of subject-related instructional material [24].

Over time, the most widely studied areas of virtual agents in language teaching and learning include reading, vocabulary, speaking, and listening. Virtual agents are more actively used and researched in second language learning than in first language learning [25]. During second language acquisition, learners achieve social interaction through virtual agents [5], thus facilitating language acquisition [25]. Furthermore, with the development of artificial intelligence, immersive learning is easier than creating real situations in the classroom [22]. Learners interact with objects in the environment through virtual agents (their own avatars or intelligent tutors), allowing for face-to-face interaction and, thus, avoiding temporal or spatial barriers [23]. The research findings suggest that virtual agents play a significant role in increasing motivation, concentration, learning satisfaction, and learner confidence during second language learning [6]. However, even if virtual agents are designed to help students learn in specific contexts, the impact of their role on the learning process and on learners' cognitive and affective experiences during language learning still needs to be further explored.

Several review studies were conducted to explore the trends in the use of virtual agent technology in education [1,2]. Johnson et al. [1], in their study, asserted that advances in natural language conversations, affective computing, machine learning, virtual environments, and robotics made more immersive and effective pedagogical agents possible, with potentially far-reaching impacts on the way people learn. Kim et al. [2] examined the impact of instructional agent roles on learners, discussed current advances in instructional agent roles and competencies, speculated on the future of agent role design, and found the effectiveness of these agent roles for learning and motivation. However, these studies examined the emerging trends in virtual agency in the form of predictions or summaries [1,2]. In addition, few studies specifically reported on the use of virtual agents in the field of

language education, specifically investigating the research hotspots and future trends of virtual agents in the field of language education. Therefore, as a scoping survey, this study collects studies on virtual agents in the field of language learning and synthesizes them.

This review aims to analyze the major journal and publication trends, national and regional distribution, participants, research methods, research platforms, roles of virtual agents, language proficiency, learner characteristics, theoretical foundations of learning, research themes, and trends in virtual-agent-based language learning research and to understand the current status of, advantages of, and future trends in the application of virtual agents in language learning research. At the same time, the research content of this paper may provide some inspiration for future research on language learning based on virtual agents. Based on the above objectives, this study addressed the following research questions.

RQ1: From 2012 to 2022, what were the major journals and papers on virtual-agent-based language learning research, and in which countries/regions were the studies conducted?

RQ2: Who were the participants in the last decade of virtual-agent-based language learning research? Which language learning abilities and learner characteristics of learners were explored?

RQ3: What research methods were used to conduct virtual-agent-based language learning research in the last 10 years?

RQ4: What were the main platforms and roles of the virtual agents used in virtual-agent-based language learning research over the last decade?

RQ5: What were the learning theory foundationsof virtual-agent-based language learning research in the last decade?

RQ6: What were the research themes and trends in virtual-agent-based language learning research conducted in the last decade?

3. Research Methods

3.1. Resource

This study searched for and reviewed the relevant literature in the Web of Science (WoS) SSCI Core Collection database on the applications of virtual agents in language learning from 2012 to 2022. WoS is the most common collection of scholarly publications in bibliometrics and scientometrics research, covering journals in a wide range of fields [26–29]. The data were collected from the titles, abstracts, and keywords of the literature from major journal databases. Based on the criteria, the researchers selected the important journals in the field of virtual agents ("pedagogical agents", "virtual agents", or "animation teaching agent") and language learning ("language learning" or "foreign language learning"). The total of the initial search result was 115 articles. After two researchers in the second phase downloaded and read the full texts of the 115 pieces of literature, the empirical research literature that matched the research topic and content was screened (see Figure 1), and 15 empirical studies were finally identified as eligible (see Appendix A).

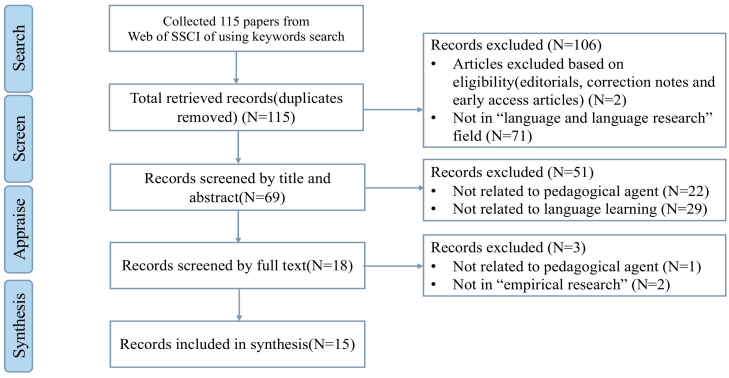

Figure 1. WOS database search steps.

3.2. Data Distribution

Figure 2 shows the publication of empirical research literature in the field of virtual-agent-based language learning between 2012 and 2022. As can be seen in Figure 2, 15 empirical studies were published in the field of virtual-agent-based language learning research between 2012–2022, and, increasingly, virtual agents are becoming a trend in the field of language learning. Learners can learn with the help of virtual agents in language learning.

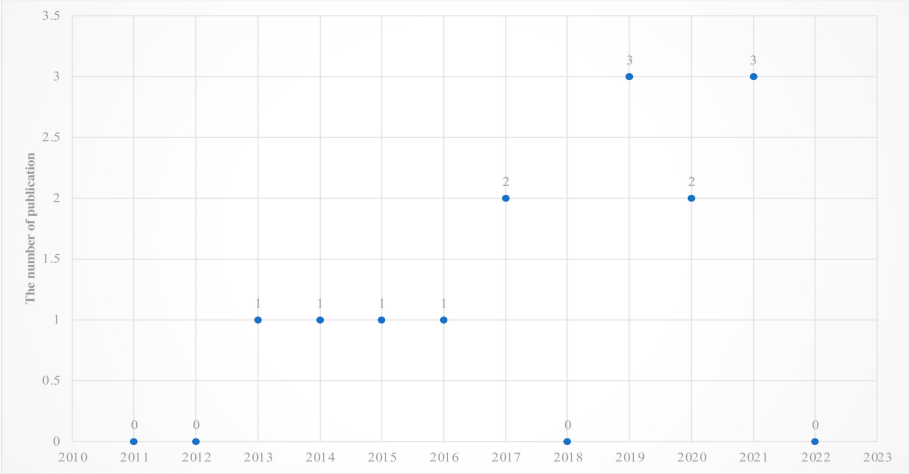

Figure 2. Research distribution between 2012 and 2022.

3.3. Literature Coding and Labeling

The coding system was adapted from the coding system of Xu et al., Zhong et al., and Taguchi [30–32]. Among the selected articles, journals, countries/regions, participants, research methods, language learning domains, learning theories, learning strategies, and teaching methods were targeted in the literature review. In this study, two experienced experts in virtual-agent-based learning and language learning were invited to assess and adapt the coded content of the research. Two other researchers read and categorized articles on virtual-agent-based language learning research according to the coding scheme. To calibrate the coding, the two researchers initially coded 115 studies each. The kappa value of the coding results from the two researchers was 0.85, which is a high level of agreement [33]. Disagreements were resolved through discussion until we reached 100% agreement. The coding criteria are described below.

(1) Participants: Participants' education levels were classified as preschool, primary education, secondary education (including middle and high school), higher education (including undergraduate and graduate students), adult education (i.e., adults receiving language training), and not specified [31].
(2) Duration of experiment: Less than or equal to 1 day, between 1 day and 4 weeks, between 4 and 8 weeks, between 8 and 16 weeks, etc. [32].
(3) Learning devices: The main devices used to conduct the study were classified as computers, tablets, mobile devices (including mobile phones), and virtual reality devices.
(4) Language skills: English language skills included listening, speaking, reading, writing, vocabulary, grammar, pragmatic skills, and overall learning. If the study included two or more skills, it was coded as a mixed skill study [33].
(5) Research methods: Qualitative (case study and rooted theory), quantitative (experimental study and corpus analysis), and mixed (action research and other mixed) [34]. Methods of data collection included quantitative data collection (including questionnaires, scales, and tests), qualitative data collection (including interviews, observations, and field notes), and mixed collection. The processing of quantitative data, such as ANOVA, and independent *t* tests, was also documented.

(6) Virtual agent role classification: According to Johnson and Lester's [1] coding scheme, the roles played by virtual agents in the learning process were classified as intelligent tutors and virtual peers. Also, we recorded the image of the virtual agent in each study.

If studies specified characteristics of English learners (e.g., gender and particular learners), we also coded these characteristics.

3.4. Analysis Tools

This study used VOSviewer version 1.6.17 as the tool for cluster analysis, co-occurrence analysis, and co-citation analysis. VOSviewer can construct networks of scientific publications, scientific journals, authors, institutions, countries, keywords, or terms. Items in these networks can be connected by co-authorship, co-occurrence, citations, bibliographic coupling, or co-citation links [35]. Each node connection graph created by VOSviewer typically represents a bibliometric network containing only one type of object [36]. Meanwhile, VOSviewer provides three types of visualization maps: network visualization, overlay visualization, and density visualization.

4. Results and Discussion

4.1. Publication

4.1.1. Publication Trends

The number of publications and citations is a good indicator of the development of a field or discipline. By analyzing the research on virtual-agent-based language learning published from the Web of Science SSCI Core Collection database, 15 publications came from 13 journals, as shown in Figure 3, with 2 articles on virtual-agent-based language learning research published in *Computer Assisted Language Teaching* and *Interactive Learning Environments*, respectively, topping the list. In addition, the citations from these two journals were also at the top of the list, indicating the forward-looking nature of the literature for virtual-agent-based language learning research.

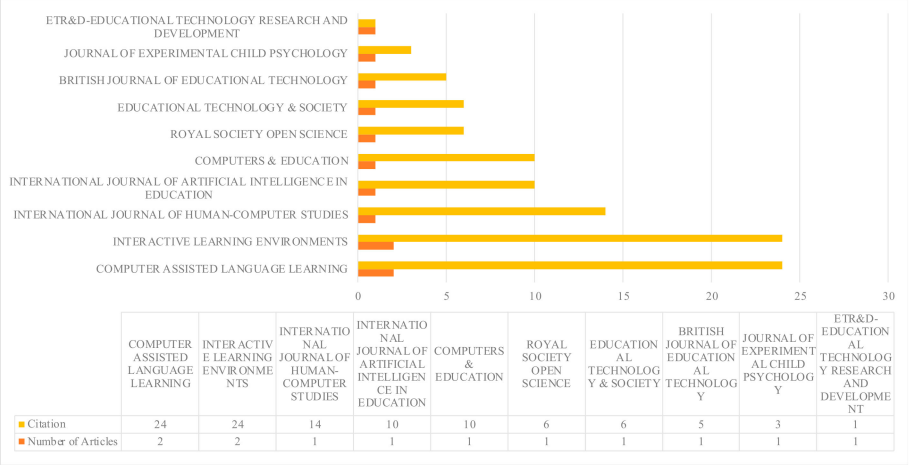

Figure 3. Journals publishing virtual teaching agent-based language learning (2012–2022).

Meanwhile, the literature citation analysis identified the five most-cited articles of the five current studies from *Interactive Learning Environments*, *Computer Assisted Language Learning*, the *International Journal of Human-Computer Studies*, *Computers and Education*, and the *International Journal of Artificial Intelligence in Education* (Table 1). Hong [37] and Hassani [38] stated that virtual-agent-based virtual reality instructional contexts can improve English learners' grammar usage, increase learners' proficiency, and, thus, improve learners' oral communication and academic performance. Davis [39] showed that virtual-agent-based speech can promote learners' social perceptual skills, influence learners' cognitive load, and improve learners' academic performance.

Table 1. Top five most-cited articles during 2012–2022.

Rank	Title	Journal	Year	Total Numbers of Citation
1	Design and implementation of an intelligent virtual environment for improving speaking and listening skills	*INTERACTIVE LEARNING ENVIRONMENTS*	2016	24
2	A courseware to script animated pedagogical agents in instructional material for elementary students in English education	*COMPUTER ASSISTED LANGUAGE LEARNING*	2014	14
3	The effects of animated pedagogical agents in an English-as-a-foreign-language learning environment	*INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES*	2016	14
4	Reconsidering the voice principle with non-native language speakers	*COMPUTERS & EDUCATION*	2019	10
5	Adding communicative and affective strategies to an embodied conversational agent to enhance second language learners' willingness to communicate	*INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE IN EDUCATION*	2019	10

4.1.2. Country and Regional Distribution

Based on the results of the search, an analysis of the publication trends and country/region distribution, virtual-agent-based language learning research from 2012 to 2022 comes from eight countries/regions around the world. The four labels of South Korea, Japan, the USA, and Iran are prominently shown in the visual map, as shown in Figure 4. The color range in the figure is blue–green–yellow from outside to inside, with the greater the number of items in a point's neighbourhood indicating the higher the weight of the neighbouring items is and the closer the color of the point is to yellow. Conversely, the lower the number of items in the neighbourhood of a point and the lower the weight of the neighbouring items are, the closer the color of that point is to blue. As shown in Figure 4, centering on each country/region, the color of each area depends on the number of publications in that country/region; the higher the number is, the more pronounced the yellow area is.

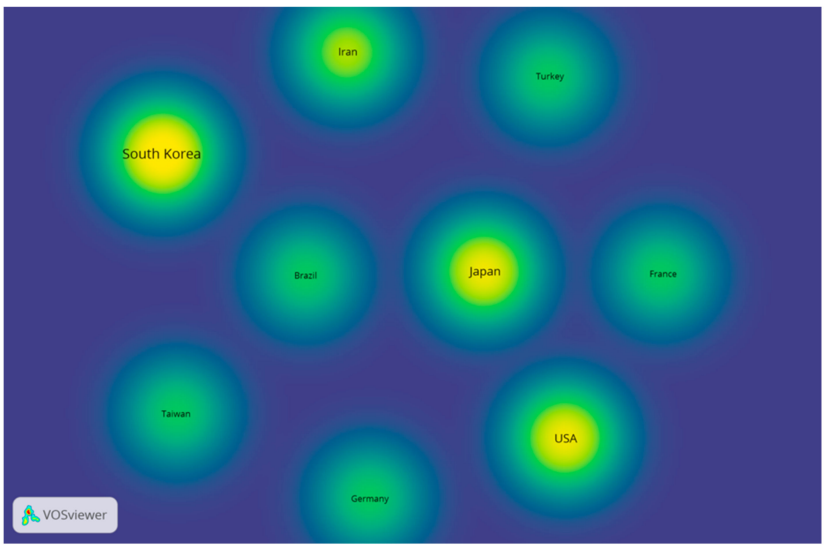

Figure 4. Visualization of the number density of the main distribution of country/region conducting virtual teaching agent-based language learning studies.

According to Table 2, the most-cited authors are from Iran (citations 34; publications 2), followed by Japan (citations 19; publications 3), South Korea (citations 16; publications 4), Brazil (citations 14; publications 1), Taiwan (citations 14; publications 1) and the United States (citations 6; publications 2). It can be seen that between 2012 and

2022, the country publishing the most research on virtual-agent-based language learning was Iran (citations 34; publications 2), followed by Japan (citations 19; publications 3) and South Korea (citations 16; publications 4). Based on Table 2 and Figure 4, it can be seen that Iran dynamically contributed the most to virtual-agent-based language learning research. Secondly, based on the number of publications, it can be seen that Japan and South Korea rank high in terms of their input of this research. At the same time, Brazil, Taiwan, Iran, Germany, and Turkey are also likely to be the countries/regions leading the development in this field.

Table 2. Virtual-agent-based language learning research by country/region between 2012 and 2022.

Rank	Country/Region	Total Number of Citations	Total Number of Publications
1	Iran	34	2
2	Japan	19	3
3	South Korea	16	4
4	Brazil	14	1
5	Taiwan	14	1
6	United States	6	2

4.2. Methods

4.2.1. Participants

Participants' education levels were categorized as preschool, primary, secondary (including middle and high school), tertiary (including undergraduate and postgraduate), and adult education (i.e., adults in language training), and unspecified participants were categorized as other. As can be seen in Figure 5, research on virtual-agent-based language learning is concentrated in the areas of higher education (number of participants = 1045; publications = 9) and primary education (number of participants = 172; publications = 2). This is followed by the areas of pre-school education (number of participants = 36; publications = 1) and adult education (number of participants = 26; publications = 1). In addition, few studies were conducted in the area of secondary education (both lower and upper secondary), as indicated by the statistics.

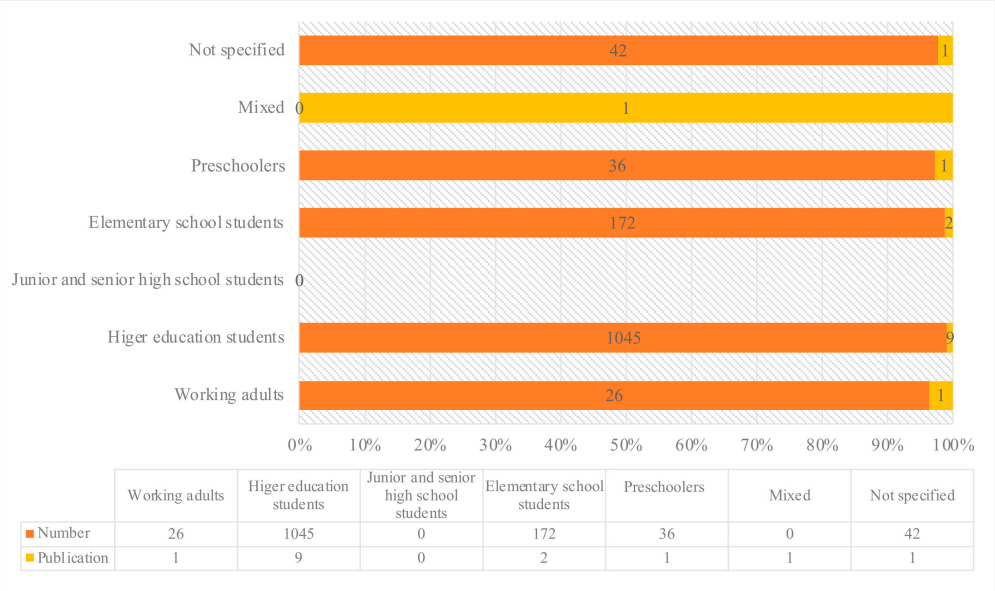

Figure 5. Statistics of key players in virtual teaching agent-based language learning research.

4.2.2. Research Methods

As shown in Table 3, the main research methods used in virtual-agent-based language learning research between 2012 and 2022 consisted of quantitative, qualitative, and mixed research. Of these, the largest proportion was quantitative research (47%) and mixed research (47%), with qualitative research accounting for only 7%. For the period from 2012 to 2022, there were seven articles using quantitative research, seven using mixed research, and only one using qualitative research.

Table 3. Main research methods of virtual teaching agent-based research between 2012 and 2022.

	Research Methods	Total Numbers of Publications
1	Quantitative research	7
2	Mixed research	7
3	Qualitative research	1

Table 4 illustrates the data analysis methods used in virtual-agent-based language learning studies from 2012 to 2022. Among these studies, descriptive statistical analysis (reporting frequency, mean, percentage, etc.) was used most frequently (14 articles), followed by ANOVA (10 articles). In addition, there was a trend toward the diversification of data analysis methods for virtual-agent-based language learning studies, which included linear mixed-effects models (two articles), independent *t* tests (one article), regression models (two articles), Levene's test (one article), and growth curve analysis (one article), in addition to descriptive statistical analysis and ANOVA. All studies were tested for the reliability of the scales and questionnaires used in the data collection and processing.

Table 4. Main data analysis methods of virtual teaching agent-based research between 2012 and 2022.

Research Methods	Descriptive Statistical Analysis	Analysis of Variance	Linear Mixed Effects Model	Independent *t* Test	Regression Model	Levene's Test	Growth Curve Analysis
Total	14	10	2	1	2	1	1

4.3. Virtual Agents

4.3.1. Device Analysis

Figure 6 shows device use in virtual-agent-based language learning research from 2012 to 2022, including computers (12 articles), projectors (3 articles), virtual reality devices (1 article), eye trackers (1 article), mobile devices (1 article), and interactive screen media (1 article). Most of the studies on virtual-agent-based language learning used a combination of computers and new technologies (e.g., computers and virtual reality devices, computers and projectors, etc.) to provide learners with a diverse multimedia learning environment. Hassani [38] used a combination of computers and virtual reality devices to enable students to learn English grammar and phonetics in a virtual world and improve their proficiency in spoken language. Tsuji and Sho [40] used interactive screen media to explore the effects of cues on Japanese vocabulary learning by infants and toddlers.

4.3.2. Role of Virtual Agents

As can be seen in Figure 7, virtual agents played the role of intelligent tutor, virtual peer, or a combination of intelligent tutor and virtual peer roles in virtual-agent-based language learning research between 2012 and 2022. Of the three common roles, intelligent tutor was the most common. Of the 15 papers screened for this paper, there were 10 studies in which the virtual agent played the role of an intelligent tutor. Also, in four other studies, the virtual agent played the role of both an intelligent tutor and a peer, participating in the learning process. In addition, in one study, the virtual agent functioned as a peer of the learner, and Rosenthal-Von Der Pütten et al. [15], in their investigation of the effects of different learning strategies on second language learners' learning outcomes, found that

changes in the gestures of the virtual agent as an intelligent tutor had a positive effect on learning effectiveness and memory performance. In a virtual-reality-context-based English listening instruction study, the normal gesture frequency of the virtual human enhanced learners' learning satisfaction, and the inclusion of the agent improved their learning outcomes [41]. Hassani [38] showed that in a virtual reality teaching context, the virtual agent as a virtual peer could improve English learners' grammar learning and increase their speaking proficiency. In English reading courses, virtual agents appearing as teachers or students can improve students' learning outcomes and moods [42].

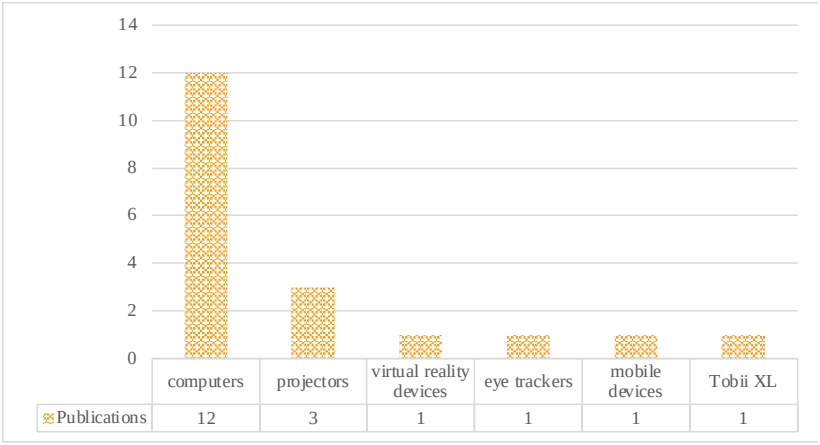

Figure 6. Distribution of devices used in virtual teaching agent-based studies between 2012 and 2022.

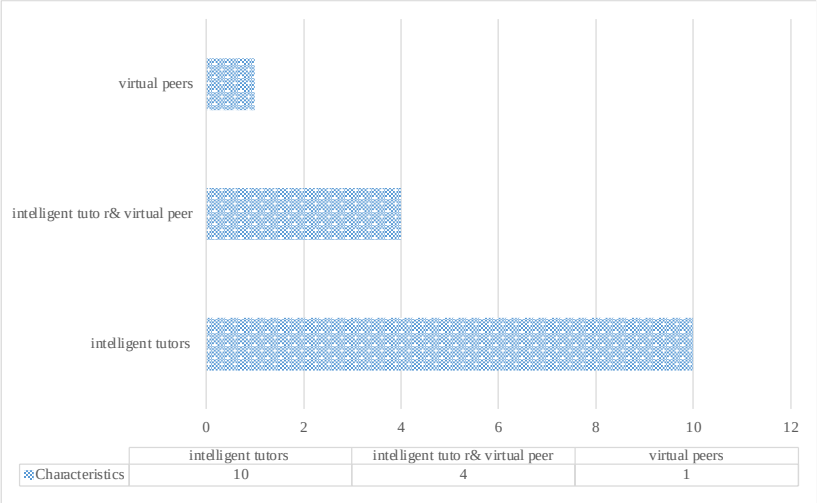

Figure 7. Distribution of virtual agents' roles in virtual teaching agent-based language learning studies between 2012 and 2022.

4.4. Research Hotspots and Frontiers

4.4.1. Research Hotspots

In order to understand the hot topics in virtual-agent-based language learning from 2012 to 2022, this study used VOSviewer for keyword co-occurrence analysis. On the superimposed visual network map (Figure 8), items are represented by circles. Each circle represents a keyword, and the size of a node circle is determined by the number of keyword occurrences. The thicker the line linking two keywords is, the more frequently the two keywords appear together. As shown in Figure 8, there are a total of 51 topic keywords in the virtual-agent-based language learning study, and, after merging synonyms, a total of 32 topic keywords are presented in the superimposed visual network map.

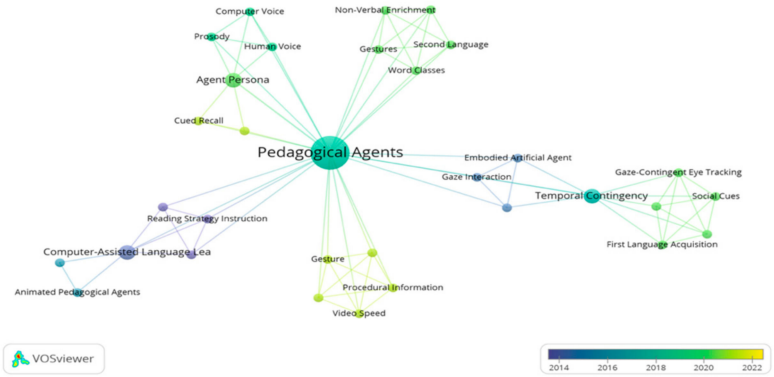

Figure 8. Topic keyword co-occurrence analysis for virtual teaching agent-based language learning research between 2012 and 2022.

In this study, VOSviewer was used to analyze the interrelationships and trends in virtual-agent-based language learning research. A co-occurrence analysis of all the keywords from 15 papers was conducted using VOSviewer. As can be seen in Figure 9, the themes of virtual-agent-based language learning research were divided into eight clusters: virtual agents, the impact of virtual agents, social interaction, language learning, the gestures of virtual agents, second language acquisition, computer-assisted learning, and the anthropomorphism of virtual agents. There is a significant correlation between each keyword cluster.

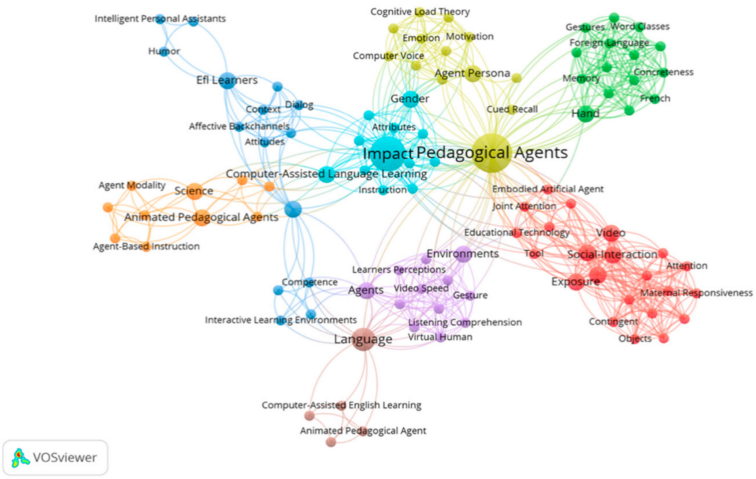

Figure 9. Cluster view of the virtual-agent-based language learning research.

The essence of the yellow cluster is the anthropomorphic virtual agent in language learning research. Within the yellow clusters are keywords such as phonological, emotional, motivational, and cognitive load theories. Davis and Robert [43] showed that improvements in virtual agent phonology, with the development of technology, can promote learners' social perceptual skills, influence their cognitive load, and improve their academic performance.

The cyan cluster is the influence produced by virtual agents in language learning research and encompasses gender, contribution, and instruction. Kim's [44] study noted mixed results in terms of the influence of learner gender and virtual peer attributes on text comprehension. Learners' perceptions of their agents did not differ according to learner gender or virtual peer attributes.

The red cluster is the social interactions of the virtual agents and includes 22 keywords such as contingency, tools, and educational technology. The findings suggest that enriching non-human teachers (virtual agents) with communication cues not only elicits gaze following but also supports infants' learning [40].

The brown cluster includes a total of five keywords: language, animated virtual agent, computer-assisted learning, language achievement, and system. In an intelligent virtual reality learning environment, learners' grammatical errors were reduced by 3%, learners' pronunciation duration was reduced by 16%, and learners' proficiency increased by 11% with the aid of virtual agent support [38]. The results of Gonulal [45] showed that human–computer interaction with a voice-activated agent can improve learners' overall English proficiency and discrete language skills and can provide additional assistance to English learners.

The green cluster is the gestures of the virtual agent and includes 15 keywords such as memory, imagery, and concreteness. Demonstrations based on animated virtual agents have a positive effect on foreign language vocabulary memorization [12].

The blue cluster is related to participants in the studies of language learning based on virtual agents and includes 15 keywords such as learning attitudes, emotions, communication strategies, learner competence, the level of body language communication, and the willingness to learn. The role of animated virtual agents in an English reading course varies by role type. The experimental results showed that the application of virtual agents can help students learn and control their emotions [42].

The orange cluster is computer-assisted learning and includes 10 keywords such as animated virtual agents, agent-based guided learning, the morphology of agents, and social perception. Kim [44] showed that virtual agent peers can improve learners' social perception of their peers and comprehension of texts. These findings suggested that the gesture type and frequency play a crucial role in agent perception and foreign language user learning [7].

The purple cluster contains 12 keywords such as agent, learning environment, gesture, and gesture frequency, representing the anthropomorphic design of the virtual agent. Davis's [7] findings suggested that the use of virtual agent gestures significantly enhances the role of the agent and improves learners' cue recall and recognition. During second language acquisition, gestural imitation by animated virtual agents was particularly helpful in learning nouns, while pictures were most helpful in remembering verbs. The findings suggested that animated virtual agents are realistic virtual characters that enhance learning [46]. When the learning group consists of foreign language students, virtual agents should use representations and beat gestures to help students understand more of the language, and the frequency of gestures needs to be increased to address the lack of language listening skills in this group [7]. The results of the study showed that participants learned better with instruction based on anthropomorphic virtual agents, which was effective at teaching English idioms, compared to that based on non-anthropomorphic virtual agents [17].

4.4.2. Research Topics

The research on virtual-agent-based language learning from 2012 to 2022 reveals a variety of research directions, covering all aspects of language learning, including not only English language knowledge but also English language skills such as listening, reading, and writing. As can be seen from Figure 10, the most-researched direction of language learning is reading (47%), followed by vocabulary (40%) and, thirdly, speaking (33%). Among English language skills, listening and writing accounted for 13% and 7%, respectively. For English language knowledge, grammar accounted for 13% and phonics for only 7%. In addition, the literature contains 7% of studies on overall English language proficiency. From these results, it is clear that the research on virtual-agent-based language learning focused on reading, vocabulary, and speaking instruction. The languages were mainly English (publications = 13), followed by Japanese (publications = 1) and Korean (publications = 1). The experimental results suggest that the use of virtual agents can facilitate students' reading in English and improve their academic performance in learning [42,44]. Davis [43] stated that the effect of virtual agent gesture frequency on learners can be used to improve the listening level of English learners. The findings suggest that enriching non-human teachers (virtual agents) with communication cues can support infants' Japanese vocabulary learning [40]. Animated virtual-agent-based presentations have a positive effect on Korean vocabulary recall [15].

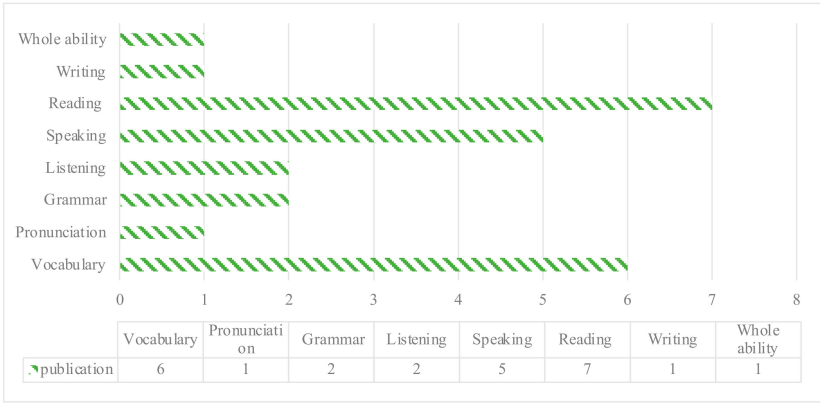

Figure 10. English language skills involved in virtual-agent-based language learning studies.

4.4.3. Virtual Agents and Learner Characteristics

As can be seen in Figure 11, studies on virtual-agent-based language learning from 2012 to 2022 addressed a wide range of learner characteristics, including learning effectiveness, memory performance, social presence, learning experience, and motivation. Of these, six studies explored the effects of virtual agents on language learning performance, four studies explored the memory performance of virtual-agent-based language learners, and four explored learners' social perceptions in virtual agent environments. In addition, scholars explored the effects of virtual agents on learning experience (publications = three), motivation (publications = two), learning satisfaction (publications = two), attention (publications = one), relevance (publications = one), self-confidence (publications = one), critical thinking (publications = one), cognitive and affective states (publications = one), cognitive load (publications = one), and anxiety about learning English (publications = one). As can be seen in Figure 11, between 2012 and 2022, there was a trend toward a diversity of topics being discussed in virtual-agent-based language learning research, mainly assessing learners' learning effectiveness, memory performance, social presence, and learning experience as well as motivation and learning satisfaction. Rosenthal-Von Der Pütten et al. [15] explored the effects of animated virtual-agent-based presentation instruction on the learning and memorization of foreign language vocabulary. The results showed that gestural imitation was particularly helpful for learning nouns, while pictures were most helpful for remembering verbs. In second language acquisition, gestural imitation by animated virtual agents was particularly helpful for learning nouns, while pictures were most helpful for remembering verbs. These findings suggested that animated virtual agents are realistic virtual characters that enhance learning [46].

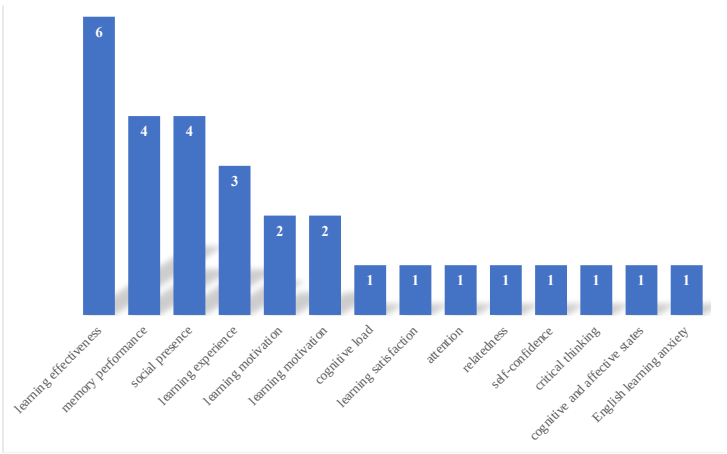

Figure 11. Learner characteristics involved in virtual teaching agent-based language learning.

4.4.4. Analysis of the Theoretical Basis of Learning

Virtual agent communication theory is interdisciplinary and primarily comes from the disciplines of education and psychology. Figure 12 illustrates the theoretical underpinnings involved in virtual-agent-based language learning research from 2012 to 2022. The most-used theories were social agent theory (f = 7) and multimedia cognitive theory (f = 5). These were followed by cognitive load theory (f = 3), dual coding theory (f = 2), and language acquisition theory (f = 2). In addition, of the 15 papers screened in this study, some drew on social cognitive theory (f = 1), natural education theory (f = 1), dominant learning theory (f = 1), central teaching theory (f = 1), and rhythmic impulse theory (f = 1) as their theoretical foundation (see Figure 12). The majority of the studies built the theoretical framework of the research on the basis of social agency theory and multimedia cognitive theory.

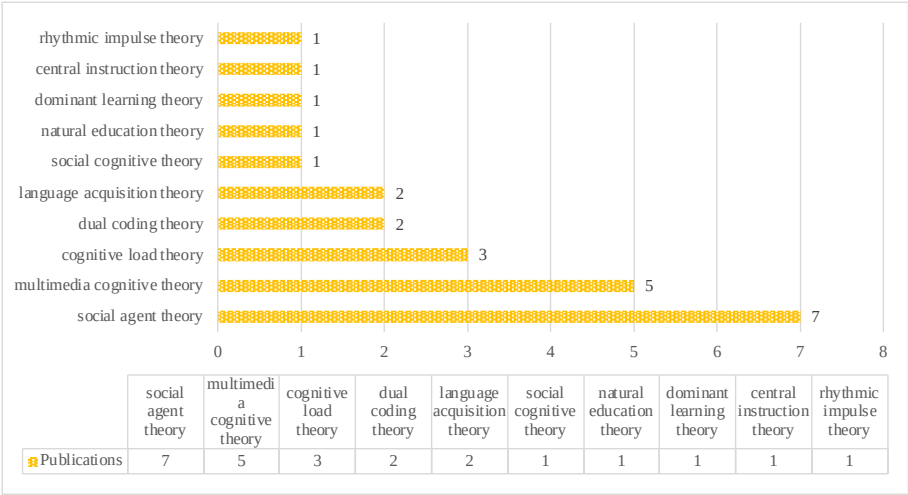

Figure 12. Learning theories included in virtual teaching agent-based language learning research.

Social agency theory suggests that social cues can initiate students' social schemas and increase their willingness to engage in social interactions, thus further facilitating students' understanding of personal assistant communication. The social cues of the virtual agent trigger a sense of peer relationship, which leads to deeper cognitive processing in the learning process. The design of the agent may change or have a motivational effect due to the impact of the virtual agent on learner motivation [47].

Cognitive load theory is a theory of individual information processing and working memory use. The cognitive theory of multimedia learning posits that the human information processing system consists of two channels for processing information: the auditory channel and the visual channel. As these channels have a limited information capacity, in order to maximize the learning process, information should be distributed over both channels to avoid additional cognitive load [48].

Overall, it is clear from the analysis that theories from the fields of education and psychology continue to dominate the theoretical underpinnings of the empirical research on the effects of virtual agents on language learning.

5. Conclusions and Suggestions

In recent years, with the promotion of virtual reality technology in the field of education, the technology has been widely used, especially in the field of language learning [15,43,49]. A number of research scholars endeavored to explore the impact of virtual agents on learners' language learning. For example, virtual agents can adopt a teacher's role in the teaching and learning process, guiding learners to complete communicative tasks through dialogue in a virtual learning environment and improving their language learning performance in the process of interaction [45].

This paper presented a visual bibliometric analysis of the research related to virtual-agent-based language learning from 2012 to 2022. We constructed a series of scientific maps showing the publication trends, country and regional distribution, participants, research methods, research platform analysis, role of virtual agents, language proficiency, learner characteristics, and theoretical foundations of learning. In addition, we used the visualization tool VOSviewer to conduct a literature co-citation analysis and keyword co-occurrence analysis of the 15 screened articles to explore the research hotspots and frontiers between 2012 and 2022. Based on the results of the data analysis, we put forward several findings in response to the research problem, which are described as follows.

(1) Between 2012 and 2022, articles published in *Computer Assisted Language Teaching* and *Interactive Learning Environments* on virtual agents in the field of language learning ranked the highest, as did the number of citations. Moreover, there were increasing opportunities for research on virtual-agent-based language learning to be published in various journals. During the period of 2012–2022, the authors of research on virtual-agent-based language learning were distributed across a wide range of countries/regions, with a major concentration in Japan, South Korea, and the United States. The top four countries/regions in terms of article citations were Iran, Japan, Brazil, and Taiwan. Other countries such as Germany and Turkey also made important contributions to virtual agents in the field of language learning research.

(2) The research on language learning based on virtual agents is mainly concentrated in the fields of higher education and primary education. This is followed by the pre-school and adult education levels. In addition, few studies focused on the use of virtual agents in secondary language education (including middle and high school), as indicated by the statistical results. The disciplinary directions of virtual-agent-based language learning research between 2012 and 2022 showed a comprehensive trend: the most-researched language learning directions were reading, vocabulary, and speaking, followed by listening, writing, grammar, and phonological knowledge. It can be seen that virtual-agent-based language learning research pays much attention to learners' basic language competence. The language learning environment provided through virtual agents can provide learners with near-realistic learning scenarios that meet the environmental requirements of language learning and can help with language learning [15,38]. The main learner characteristics studied in virtual-agent-based language learning research include learning effectiveness, memory performance, social presence, learning experience, and motivation. Scholars also focused on the effects of virtual agents on learners' learning experience, learning motivation, learning satisfaction, attention, relevance, self-confidence, critical thinking, cognitive and affective states, cognitive load, and English learning anxiety. Many scholars pointed out that when virtual agents are combined with language learning strategies, learners' own characteristics are developed. For example, integrating communication strategies based on virtual animated agents into second language learning and taking advantage of the tutor and peer functions of virtual agents can provide anthropomorphic interpersonal communication relationships and authentic oral communication scenarios, which can help to improve L2 learners' engagement and oral proficiency [25].

(3) Between 2012 and 2022, the main research methods used in virtual-agent-based language learning research consisted of quantitative, qualitative, and mixed research. Of these, the most used were quantitative and mixed research, with few scholars using qualitative research methods. The research analysis methods focused on the use of descriptive statistics and analysis of variance, while the learning behavioral characteristics of participants were recorded.

(4) In the field of virtual-agent-based language learning research, most studies used computers or computers and new technologies (e.g., computers and virtual reality devices, computers and projectors, etc.) to provide a multimedia learning environment for learners. In the form of computers or computers combined with new technologies, virtual agents were able to provide authentic language learning environments that fulfill the learning experience and emotional experience of learners [41,42]. In virtual-agent-based language

learning research, intelligent tutors were the most common role of virtual agents. In addition, some studies also explored the role of virtual agents as peers, juggling the role types of tutors and peers in language learning education. This categorization was consistent with that in Johnson's study [18]. The existing prior research explored the role of virtual agents, which can act as humanlike tutors or learning partners during the learning process, engaging in interactive learning scenarios in the role of participants [1,50].

(5) Of all the theoretical foundations of virtual-agent-based language learning research, most studies were based on social cognitive theory and multimedia cognitive theory, followed by cognitive load theory, dual coding theory, and language acquisition theory. In addition, a small number of studies also focused on the guiding role of social cognitive theory, nature education theory, dominant learning theory, central teaching theory, and rhyming pulse theory in the application of virtual agents.

(6) The main research objectives of the research on virtual-agent-based language learning between 2012 and 2022 were to investigate the impact of the characteristics of the virtual agent itself on learners and the impact of the virtual agent on learner characteristics during participation in the language learning process and to assess the role of the virtual agent in the language learning process [51,52]. After a cluster analysis of all the keywords in the study of virtual-agent-based language learning between 2012 and 2022, it was found that the study was divided into eight clusters, namely, anthropomorphic virtual agents, the impact produced by virtual agents, the social interaction of virtual agents, animated virtual agents and language achievement, the gestures of virtual agents, the impact of virtual agents on learner characteristics, computer-assisted learning, and the design of virtual agents.

This paper reviewed publications on virtual-agent-based language learning research in the Web of Science SSCI Core Collection database from 2012 to 2022 (the type of literature was limited to "articles"). The findings of this paper may be influenced by classification and coding. Based on the findings of this study, the following recommendations are made for future research on virtual agents in the field of language learning.

(1) The majority of participants in virtual-agent-based language learning research were higher education students and primary school students. However, research on virtual agents in the field of education is rich and diverse. Therefore, it would be a worthwhile effort to investigate how virtual agents affect the language learning of junior and senior secondary school students in virtual-agent-based language learning research.

(2) Currently, a growing number of scholars are focusing on the application of virtual agents in the field of education and are trying to evaluate the impact of virtual agents on the educational process by means of empirical studies. For future research, richer research methods, such as qualitative research (discourse analysis, qualitative summaries, etc.) can be added to explore the issues related to virtual agents in the field of education in a more in-depth and comprehensive manner.

(3) Communication strategies based on animated agents have a positive effect on the oral communication skills of second language learners, and more effective learning strategies could be considered for virtual-agent-based language learning [53]. For example, different learning strategies, such as task-based or game-based strategies, could be used to help young children learn foreign language vocabulary. Ayedoun proposed a model based on a set of communication strategies (CS) and Affective Reverse Channels (AC) that develops the ability of these virtual agents to engage in natural and friendly conversations with learners [25].

(4) The research on virtual-agent-based language learning was pressured by various factors such as academic pressure, length of instruction, and technological maturity. In future research, the effectiveness of virtual-agent-based language learning should be enhanced by incorporating the needs of curriculum reform and the development of artificial intelligence technology.

(5) Further research is needed to understand whether there is a novelty effect on virtual agents and learning outcomes. Currently, most students are being exposed to virtual agents for the first time in language teaching and learning, so it is unclear whether the novelty

factor of the research agent has an impact on the findings. Researchers pointed out that when learners are familiar with a brand-new technology-supported means of learning, it may have a possible negative impact on learners' motivation to learn [54]. Considering that familiarity with technology may have an impact on learners' motivation and learning effectiveness, it would be valuable to analyze the impact of technology use in language teaching classrooms on students' language proficiency. Therefore, further research may examine these issues.

(6) In the field of developmental psychology, the use of AI as a tool for assessing virtual agent–human interactions has significant advantages [55]. The current research is limited by technology, and AI has enormous potential to open up new possibilities for the accurate and cost-effective assessment of subtle human behavior.

This study has theoretical and practical significance. Theoretically, this study provides researchers with the research hotspots, trends, and advantages of the application of virtual agents in language education, which makes up for the lack of summarizing the research hotspots of virtual agents in language education in past studies and emphasizes the future development trend of virtual-agent-based language research. In practice, the results of this study are of guiding significance for further research and the practice of virtual agents in language learning, which is helpful for researchers to grasp future development trends and improve the application effect of virtual agents in language teaching.

Although this scoping review sheds light on the impact of virtual agents on language learning, it has some limitations. First, this study retrieved articles from only one database (Wos SSCI). Second, since the scope of the review in this study included only peer-reviewed journal articles, future researchers may also include peer-reviewed conference proceedings. Third, the language of the articles retrieved in this study was English, which may have excluded some other languages from this study. Given the limitations of the current study, future studies may use other research databases where articles containing more types of languages are retrieved.

Author Contributions: Conceptualization, X.G. and X.Z.; methodology, X.G., T.Y., J.H. and F.W.; software, X.G.; validation, X.Z. and F.W.; formal analysis, X.Z.; investigation, X.G., T.Y. and Q.L., resources, X.G. and J.H.; data curation, X.Z. and X.G.; writing—original draft preparation, X.G. and M.S.; writing—review and editing, X.Z. and F.W.; visualization, X.G., M.S. and Z.Y.; supervision, X.Z. and F.W.; project administration, X.Z. and F.W.; funding acquisition, X.Z. and F.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research is funded in part by the State-Level Innovation and Entrepreneurship Training Program for College Students of the People's Republic of China, grant number 202210351054: Design of digital twins for analog parking meter systems; the Wenzhou University Innovation and Entrepreneurship Training Program for College Students, grant number JWXC2022162: Material handling intelligent vehicle based on high precision tracking algorithm; the Wenzhou University's College of Electrical and Electronic Engineering 2023 "Challenge Cup" college students extracurricular academic, scientific, and technological works program grant number DZDQTZB202301007: Ultra-low-power self-driving smart car based on MSP430 microcontroller; the Wenzhou university open laboratory project, grant number JWSK2022075: Design of counting robots; and the second batch of projects for teachers' education innovation experimental area of Zhejiang Province, China, under contract number [2022] 200-36: Theories, practice and effectiveness of AI empowered personalized instruction.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data can be obtained by sending request e-mails to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Summary of the reviewed studies.

	Authors and Years	Journal	Author's Nationalities	Learning Domains	Participants	Equipment	Research Methods	Learning Theories	Learners' Characteristic
1	Pütten, Astrid, et al. (2020) [15]	*FRONTIERS IN PSYCHOLOGY*	Germany	Vocabulary learning (L2)	Working adults	Computer	Quantitative	Dual coding theory	Learning achievement/memory
2	Lee, et al. (2015) [46]	*ROYAL SOCIETY OPEN SCIENCE*	Japan	Second language(Korean)	Higher education students	Eye tracker	Quantitative	social agency theory	Learning achievement
3	Hong et al. (2014) [37]	*COMPUTER ASSISTED LANGUAGE LEARNING*	Taiwan, China	Primary school English	Elementary school students	Computer/projector	Mixed	Central teaching theory/social agency theory/cognitive theory of multimedia learning	Learning achievement
4	Davis et al. (2021) [7]	*INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION*	South Korea	Declarative knowledge of foreign language	Higher education students	Computer/projector	Quantitative	Social agency theory	Learning achievement
5	Hassani, Nahvi, et al. (2016) [38]	*INTERACTIVE LEARNING ENVIRONMENTS*	Iran	Spoken English	Higher education students	Computer/virtual reality equipment	Quantitative	Dominant learning theory	Learning achievement
6	Davis and Vincent (2019) [43]	*BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY*	South Korea	English listening	Higher education students	Computer/projector	Quantitative	Cognitive theory of multimedia learning	Social presence/memory/learning achievement
7	Carlotto, Jaques (2016) [6]	*INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES*	Brazil	Second language(English)	Higher education students	Computer	Quantitative	Social agency theory/cognitive theory of multimedia learning	Learning achievement
8	Graesser, Forsyth et al. (2017) [42]	*TEACHERS COLLEGE RECORD*	United States of America	English reading	Mixed	Computer	Qualitative	Cognitive theory of multimedia learning	Critical thinking/learning experience/learning achievement/cognitive and affective states
9	Davis, Vincent et al. (2019) [39]	*COMPUTERS & EDUCATION*	South Korea	Spoken English	Higher education students	Computer	Quantitative	Social agency theory/cognitive load/cognitive theory of multimedia learning	Social presence/cognitive load
10	Ahmadi, Sahragard, et al. (2017) [17]	*COMPUTER ASSISTED LANGUAGE LEARNING*	Iran	English idiom teaching	Higher education students	Computer	Mixed	Social agency theory/cognitive load/cognitive theory of multimedia learning/dual coding theory	Learning achievement
11	Davis, Wan et al. (2021) [41]	*ETR&D-EDUCATIONAL TECHNOLOGY RESEARCH AND DEVELOPMENT*	South Korea	English listening	Higher education students	Computer	Mixed	Prosodic pulse theory	Learning satisfaction/learning achievement/memory
12	Kim (2013) [44]	*EDUCATIONAL TECHNOLOGY & SOCIETY*	United States of America	English reading	Elementary school students	Computer	Quantitative	Social cognitive theory	Social presence
13	Gonulal, Talip (2021) [45]	*INTERACTIVE LEARNING ENVIRONMENTS*	Turkey	English	Not specified	Mobile equipment	Mixed	Language acquisition theory	Relevance
14	Tsuji, Jincho, et al. (2020) [40]	*JOURNAL OF EXPERIMENTAL CHILD PSYCHOLOGY*	Japan	Japanese	Preschool education	Tobii XL	Mixed	Language acquisition theory/natural education theory	Attention
15	Ayedoun, Hayashi et al. (2019) [25]	*INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE IN EDUCATION*	Japan	Second language learning	Higher education students	Computer	Mixed	Social agency theory	Learning experience/learning achievement

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