

A Systematic Literature Review of Language Learning Research Based on Teaching Agents

Xinyan Gu

Wen Zhou University, China
gxywzu@163.com

Yuanbo Huang

Chonnam National University in South Korea, South Korea
huangyuanbo@wku.edu.cn

YuYu

Chonnam National University in South Korea, South Korea
Catyu1122@gmail.com

Feng Wang

Wen Zhou University, China
wangfengwf@163.com

Xiaoli Zheng*

Wen Zhou University, China
tilly222@163.com

This study reviews publications in the field of agent-based language learning research in the Web of Science SSCI Core Collection database for the period 2012-2021. The purpose of this study was to investigate hot topics and trends in the field of agent-based language learning research from major journals and literature, including publication trends, country and regional distribution, participants, research methods, research platforms, roles of teaching agents, language proficiency, learner characteristics, and theoretical foundations of learning. Clustering and co-occurrence analysis in VOS viewer software were used to analyze the links between country and regional distributions, keywords, and terms, revealing the hot topics and research frontiers in the study of teaching agent-based language learning research. The findings show that the most extensive theoretical basis is social agency theory and multimedia cognitive theory; and the learner characteristics that scholars focus on most are learning effectiveness, memory performance, social presence and so on. The results of the co-occurrence analysis clustered eight clusters of language learning research based on teaching agents, namely, anthropomorphic teaching agents, impact produced by teaching agents, social interaction of teaching agents, animated teaching agents and language achievement, gestures of teaching agents, impact produced by teaching agents on learner characteristics, computer-assisted learning, and design of teaching agents.

Keywords: Teaching agents; Cluster analysis; Language learning based on teaching agents; Anthropomorphism; Research hotspots

Introduction

The ability of instructional agents to interact with learners in a natural, human-like manner will make learning easier, more engaging, and more motivating, and this deeper engagement will lead to better learning outcomes (Johnson, & Lester, 2018). Anthropomorphic agents provide a unique opportunity to increase the social and emotional quality of the tutoring environment (Kim, 2016). Previous research has demonstrated the positive effects of instructional agents in terms of learner effectiveness, motivation, and social and emotional support for learners (Martin, 2016; Serkan, 2017). Lan et al. (2020) showed that students who perform actions by watching their 3D avatars, rather than producing actions or silence by moving their bodies, would have a more positive effect on the learning outcome of second language vocabulary. Anne (2020) in a study on the effect of social fidelity on presence and learning in virtual agents confirmed that when agents were used, students invested more time on the task, improved correctness, and had better learning gains in their recall of the learning material. Instructional 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 (Carlotto, 2016). Lifelike teaching agents living alongside students in the learning environment, creating rich face-to-face learning interactions, open up exciting new possibilities (Davis, 2021). With the increasing use of teaching agents in disciplinary education due to the development of artificial

intelligence technologies, research on teaching 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 (Johnson, & Lester, 2018). Despite these efforts, the current state of the field and future trends remain unclear. Therefore, this study reviewed publications in the field of agent-based language learning research in the Web of Science SSCI Core Collection database for the period 2012 - 2021 with the aim of narrowing this gap in the literature by providing an overview of the development and current state of agent-based language learning research. gaps. Specifically, this study reveals the dynamic growth of publications and citations in agent-based language learning research, as well as the major journals and most influential studies in the field. In addition, the leading authors, institutions and contributing countries in the field and the scientific collaboration networks among them are identified. The study also describes the hot topics and research frontiers in teaching agent-based language learning research.

Research Design & Methods

Research Design

This paper analyzes the major journal and publication trends, national and regional distribution, participants, research methods, research platforms, roles of teaching agents, language proficiency, learner characteristics, theoretical foundations of learning, research themes and trends in teaching agent-based language learning research to understand the status, advantages, and future trends in the application of teaching agents to language learning research. Based on the above objectives, the following research questions were proposed.

RQ1: What are the major journals and papers on language learning research based on teaching agents from 2012 to 2021, and from which countries/regions?

RQ2: Who are the participants in the research on teaching agent-based language learning from 2012 to 2021? What language learning abilities and learner characteristics of learners have been explored?

RQ3: What research methods have been used to conduct agent-based language learning research from 2012 to 2021?

RQ4: What are the main platforms and roles of teaching agents used in agent-based language learning research from 2012 to 2021?

RQ5: What are the theoretical foundations of learning for agent-based language learning research from 2012 to 2021?

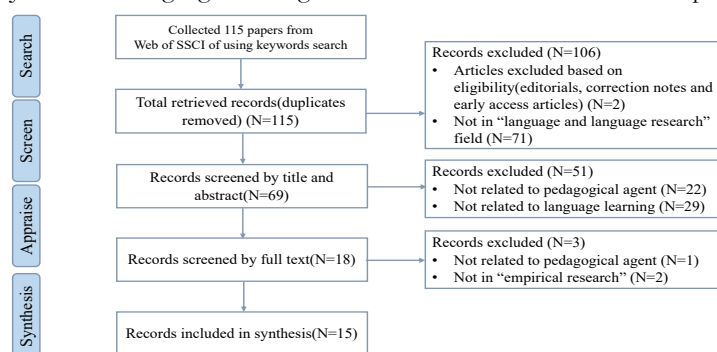
RQ6: What are the research themes and trends in agent-based language learning research from 2012 to 2021?

Literature search and screening

In the first stage of literature search, "Pedagogical Agents", "Teaching agents" and "Animation teaching agent" were used as keywords in the Web of Science SSCI core collection database. "Animation teaching agent" were used as keywords, and "Language learning", "Foreign language learner", "secular agent" and "teaching agent" were used as keywords. learner", "second language learner", "EFL students", "L2 learners " were used to qualify the search for literature published in the field of education and educational research between 2012 and 2021, and a total of 115 high-quality literature related to educational intelligences were searched. After two researchers in the second phase downloaded and read the full text of 115 literature, the empirical research literature that matched the research topic and content was screened (see Figure 1), and 15 empirical studies that met the criteria were finally identified (see Table 1).

Figure 1

Journals of language learning research baWOS database search steps



Analysis tools

This study will use VOS viewer version 1.6.17 as a tool for cluster analysis, co-occurrence analysis, and co-citation analysis. VOS viewer 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, citation, bibliographic coupling, or co-citation links (van Eck & Waltman, 2019). each node connection graph created by VOS viewer typically represents a bibliometric network containing only one type of object (Su, Peng, & Li, 2021). Meanwhile, VOS viewer provides three types of visualization maps: network visualization, overlay visualization, and density visualization.

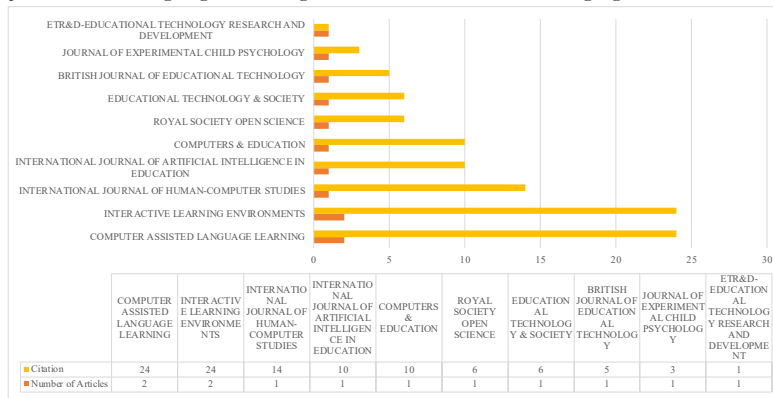
Results

Publication trends

The number of publications and citations is a good indicator of the development of a field or discipline. By analyzing the language learning research based on teaching agents published from the Web of science-SSCI database, 15 publications came from 13 journals, as shown in Figure 2, among which, two articles on language learning research based on teaching agents were published in *Computer Assisted Language Teaching* and *Interactive Learning Environments*, respectively, which topped the list. In addition, the citations of literature published from these two journals also ranked high, indicating the forward-looking status of these literatures in the research on teaching agent-based language learning.

Figure 2

Journals of language learning research based on teaching agents, 2012 - 2021

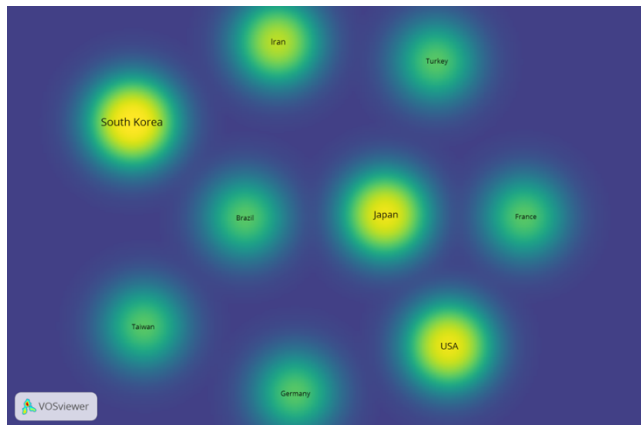


Country and regional distribution

Based on the search results, the analysis regarding publication trends and country (region) distribution, the language learning research based on teaching agents from 2012 to 2021 comes from eight countries (regions) around the world. As shown in Figure 3, the four labels of Korea, Japan, the United States, and Iran are shown prominently in the visual map. Also, Taiwan, China, Brazil, Germany, and Turkey are visible in other locations in the map. The color range in the figure is blue to green to yellow from outside to inside at once. The more items in the neighborhood of a point, the higher the weight of the adjacent items, and the closer the color of the point is to yellow. Conversely, the lower the number of items in the neighborhood of a point and the lower the weight of neighboring items, the closer the color of that point is to blue. As shown in Figure 3, centered on each country (region), the color of each region depends on the number of publications in that country (region), and the higher the number, the more obvious the yellow region is.

Figure 3

2012-2021 Visualization of the density of the main distribution countries (regions) of language learning research based on teaching agents

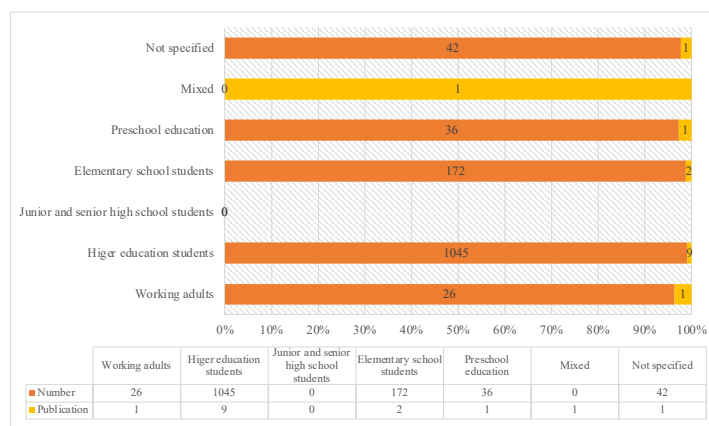


Participants

The participants' education levels were divided into preschool, elementary education, secondary education (including middle and high school), higher education (including undergraduate and graduate students), and adult education (i.e., adults receiving language training), and no designated participant other. As can be seen in Figure 4, research on language learning based on instructional agents is concentrated in the areas of higher education (number of participants = 1045, publications = 9) and elementary education (number of participants = 172, publications = 2). This is followed by in preschool education (number of participants = 36, publication = 1) and adult education (number of participants = 26, publication = 1). In addition, few studies were conducted in the area of secondary education (both middle and high school), as indicated by the statistical results.

Figure 4

2012-2021 Statistics of key players in teaching agent-based language learning research



Research Methods

The main research methods used in the study of language learning based on teaching agents during 2012 - 2021 contain quantitative research, qualitative research and mixed research. Among them, the largest proportion is quantitative research (47%) and mixed research (47%), and qualitative research only accounts for 7%. During the period 2012 - 2021, a total of 7 papers (publication = 7) used quantitative studies, 7 papers (publication = 7) used mixed studies, and only 1 paper (publication = 1) used qualitative studies.

Table 1 illustrates the data analysis methods used in the studies on language learning based on teaching agents from 2012 - 2021. Among these studies, descriptive statistical analysis (reporting frequency, mean, percentage, etc.) was used most frequently (publication = 14), followed by ANOVA (publication = 10). In addition, there was a trend toward diversification of data analysis methods for language learning studies based on instructional agents, which included linear mixed effects models (publication=2), independent t-tests (publication=1), regression models (publication=2), Levene's test (publication=1), and growth curve analysis (publication=1) in addition to descriptive statistical analysis

and ANOVA. All of the scales and questionnaires used in the studies to conduct data collection and processing were tested for reliability.

Table 1

Main analysis methods of language learning research based on teaching agents, 2012-2021

| | Descriptive statistical analysis | Analysis of variance | Linear mixed effects model | Independ ent T test | The regressio n model | Levin inspection | Growth curve analysis |
|------------------|--|----------------------------|-------------------------------------|------------------------|-----------------------------|---------------------|-----------------------------|
| Research Methods | 14 | 10 | 2 | 1 | 2 | 1 | 1 |

Device Analysis

Table 2 shows the use of devices in the 2012-2021 study of instructional agent-based language learning, including computers (publication=12), projectors (publication=3), virtual reality devices (publication=1), eye trackers (publication=1), mobile devices (publication=1), and Tobii XL (Publication=1). Most studies of teaching agent-based language learning have used a combination of computers and new technologies (e.g., computers and virtual reality devices, computers, and projectors, etc.) to provide learners with diverse multimedia learning environments. In a study exploring the impact of the gesture frequency of teaching agents on English language learning for advanced foreign language users, Davis (2019) used IClone 7.1 to create an animated teaching agent image with animated teaching agent images with gestures to create a virtual interactive multimedia learning environment for learners. Hassani (2016) used a combination of computer and virtual reality devices to enable students to learn English grammar and phonetics in a virtual world to improve oral proficiency. Tsuji & Sho (2020) used interactive screen media to explore the effect of cues on infants' and toddlers' Japanese vocabulary learning.

Table 2

A statistical list of devices in language learning research based on teaching agents, 2012-2021

| | computers | projectors | virtual reality devices | eye trackers | mobile devices | Tobii XL |
|--------------|-----------|------------|----------------------------|--------------|-------------------|----------|
| Publications | 12 | 3 | 1 | 1 | 1 | 1 |

The Role of Teaching Agents

As can be seen in Table 3, in language learning research based on teaching agents during 2012 - 2021, teaching agents played the role of intelligent tutors, virtual peers, or a combination of intelligent tutor and virtual peer roles. Among the three common roles, the intelligent tutor is the most common role of the teaching agent. In total, teaching agents played the role of intelligent tutors in 10 of the 15 studies screened for this paper. Also, in four other studies, the teaching agent played the role of both an intelligent tutor and a peer in the learning process. In addition, in one study, the teaching agent functioned as a peer of the learner, and Puetten and Astrid (2020), in an investigation of the effects of different learning strategies on the learning effectiveness of second language learners, found that changes in the gestures of the teaching agent as an intelligent tutor had a positive effect on learning effectiveness and memory performance. In virtual reality context-based English listening instruction, the normal gesture frequency of the avatar enhances learners' learning satisfaction and the inclusion of the agent improves learning outcomes (Davis, 2021). The results of Hassani (2016) showed that in a virtual reality teaching context, the teaching agent as a virtual companion improves English learners' grammar learning and increases learners' proficiency and speaking proficiency. In English reading courses, teaching agents appearing in the role of teachers or students can improve students' learning outcomes and improve their mood (Graesser, & Arthur, 2017). During interaction, communicative strategies based on animated agents can empower conversational subjects and increase the likelihood of L2 learners' participation in communication (Ayedoun, & Emmanuel, 2019).

Table 3

A statistical list of devices in language learning research based on teaching agents, 2012-2021

| | intelligent tutors | intelligent tuto r& virtual peer | virtual peers |
|-----------------|--------------------|-------------------------------------|---------------|
| Characteristics | 10 | 4 | 1 |

Research Themes

In order to understand the hot topics in language learning based on teaching agents from 2012 - 2021, this study used Vos viewer for keyword co-occurrence analysis. The keyword co-occurrence analysis of teaching agent-based language learning research is presented in the form of a network map, as in Figure 11. In the overlay visual network map, items are represented by circles. Each circle represents a keyword, and the size of the node circles is determined by the number of keyword occurrences. The thicker the line linking two keywords, the more frequently the two keywords appear together. In the language learning study based on teaching agents, there are a total of 51 author keywords, and after merging synonyms, a total of 32 keywords are presented in the superimposed visual network map. After Vos viewer co-occurrence analysis, the 32 author keywords were divided into six clusters, the first cluster of teaching agent's voice (keyword=7), the second cluster of teaching agent's gaze (keyword=6), the third cluster of teaching agent's supported learning (keyword=6), the fourth cluster of teaching agent's gesture (keyword=5), the fifth cluster of teaching agent's supported lesson type (keyword=5), and Sixth cluster of anthropomorphism of teaching agents (keyword=3). The Vos viewer results allow to conclude that the most frequently used keywords are teaching agents (f=6), contingent actions (f=2), anthropomorphization of teaching agents (f=2), computer-assisted learning (f=2), and anthropomorphized teaching agents (f=2). Furthermore, it is also evident from the figure that the relationship between teaching agents and anthropomorphism is stronger, followed by computer-assisted learning, gestures of teaching agents and contingent actions. In this study, Vos viewer was used to analyze the interrelationships and trends in language learning research based on teaching agents. Cooccurrence analysis was performed using Vos viewer for all keywords from 15 documents. As seen in Figure 12, the themes of teaching agent-based language learning research were divided into eight clusters (shown by red, orange, yellow, green, cyan, blue, purple, and brown, respectively): teaching agent (yellow), impact of teaching agent (cyan), social interaction (red), language learning (brown), gestures of teaching agent (green), second language acquisition (blue) computer-assisted learning (orange), and anthropomorphism of the teaching agent (purple). There is a significant correlation between each clustering keyword.

The essence of the yellow clusters is the anthropomorphic teaching agent in language learning research. In the yellow clusters, keywords such as phonological, emotional, motivational, and cognitive load theories are included. Also, the yellow clusters cover five clusters: red, green, cyan, purple, and brown. In the process of learners learning a second language, the voice of the teaching agent has a significant role in increasing motivation, concentration, learning satisfaction, and enhancing learners' confidence in learning (Carlotto, Talvan, 2016). Animated agents are virtual characters that embody life-like behaviors, demonstrating the facial expressions, gestures, movements, and voice of the agent can facilitate student engagement in the learning environment and promote social interactions Hong (2014). Davis and Robert (2019) showed that improvements in the voice of the teaching agent, with the development of technology, can promote learners' social perceptual skills, influence learners' cognitive load and improve learners' academic performance.

Cyan clustering is the influence produced by teaching agents in language learning research and encompasses gender, contribution, and instruction. Kim's (2013) 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 clusters are social interactions of teaching agents and contain 22 keywords such as contingency, tools, and educational technology. Findings suggest that enriching nonhuman teachers (teaching agents) with communication cues not only elicits gaze following but also supports infant learning (Tsuji & Jincho, 2020).

The brown clusters contained a total of five keywords: language, animated teaching agent, computer-assisted learning, and language achievement and system. In an intelligent virtual reality learning environment, learners' learners' grammatical errors were reduced by 3%, pronunciation duration was reduced by 16%, and learners' proficiency was increased by 11% with the aid of instructional agent support (Hassani & Kaveh, 2016). Gonulal and Talip (2021) showed that human-computer interaction with a voice-activated agent can improve learners' overall English proficiency and discrete language skills, which can provide more assistance to English learners.

The green clusters are the gestures of the teaching agent and contain 15 keywords such as memory, imagery, and concreteness. Animated teaching agent-based demonstrations have a positive effect on foreign language vocabulary memorization (Puetten & Astrid, 2020).

Blue clustering is a participant in the study of language learning based on teaching agents and contains 15 keywords such as learning attitudes, emotions, communication strategies, learner competence, level of body language communication, and willingness to learn. The role of the animated teaching agents in the English reading course varies by role type. The experimental results showed that the application of teaching agents can help students learn and control learner emotions (Graesser, 2017). To reduce second language learners' English learning anxiety, scholars have proposed two teaching methods based on animated teaching agents' communication strategies and emotional backchanneling to help students increase motivation and engagement (Ayedoun, 2019).

The orange cluster is computer-assisted learning and contains 10 keywords such as animated teaching agent, agent-based guided learning, agent's morphology, and social perception. Kim (2013) studied that teaching agent peers can improve learners' social perception of peers and comprehension of texts. The findings suggest that gesture type and frequency play a crucial role in agent perception and foreign language user learning. (Davis, 2021)

The purple cluster contains 12 keywords including agent, learning environment, gesture and gesture frequency, representing the anthropomorphic design of the teaching agent. Davis' (2021) findings suggest that the use of teaching agent gestures significantly enhances the agent's role and improves learners' cue recall and recognition. In the process of second language acquisition, gestural imitation by animated teaching agents was particularly helpful in learning nouns, while pictures were most helpful in remembering verbs. The findings suggest that animated teaching agents are realistic virtual characters that enhance learning (Lee & Hanju, 2015).

When the learning group consists of foreign language students, instructional 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 this group's lack of language listening skills (Davis, 2019). The results of the study showed that participants learned better with anthropomorphic-based instructional agents compared to non-anthropomorphic agents and were effective in teaching English idioms (Ahmadi & Sahragard 2017).

Figure 8

Co-occurrence analysis of keywords in language learning research based on teaching agents (2012-2021)



English language skills improvement

From the research on language learning based on teaching agents from 2012 - 2021, it can be found that the research directions are diverse and involve various aspects of language learning, including not only English language knowledge, but also English language skills such as listening, reading, and writing. The most researched direction of language learning is reading (percentage = 47%), followed by vocabulary (percentage = 40%), and third is speaking (percentage = 33%). Among the English language skills, listening and writing accounted for 13% and 7%, respectively. Among English language knowledge, grammar accounted for 13% and phonetics only accounted for 7%. In addition, 7% of the studies in the literature are about overall English language proficiency. From these results, it is clear that research on language learning based on teaching agents focuses on reading, vocabulary, and speaking instruction. The languages

were mainly English (publication=13), followed by Japanese (publication=1) and Korean (publication=1). English learning performance and overall proficiency can be improved through the instruction of an XML-based animated agent (Hong, Chen & Lan, 2014). Experimental results indicate that the application of instructional agents can promote students' English reading and improve learning achievement (Kim, 2013; Graesser, 2017). Davis (2019) noted that the use of instructional agents gesture frequency on learners can improve English learners' listening skills. Findings suggest that enriching non-human teachers (teaching agents) with communicative cues can support infants' Japanese vocabulary learning (Tsuji & Jincho, 2020). Animated teaching agent-based presentations have a positive effect on Korean vocabulary memory (Puetten & Astrid, 2020).

Teaching agents and learner characteristics

The studies on teaching agent-based language learning from 2012 - 2021 addressed a wide range of learner characteristics, including learning effectiveness, memory performance, social presence, learning experience, and learning motivation. Among them, six studies have explored the effect of teaching agents on language learning performance, four studies have explored memory performance of language learners based on teaching agents, and four studies have explored learners' social perceptions in teaching agent environments. In addition, scholars have explored the effects of teaching agents on learning experience (Publication = 3), learning motivation (Publication = 2), learning satisfaction (Publication = 2), attention (Publication = 1), relatedness (Publication = 1), self-confidence (Publication = 1), critical thinking (Publication = 1), cognitive and affective states (Publication = 1), cognitive load (Publication = 1), and English learning anxiety (Publication = 1). As can be seen in Figure 12, during the period 2012 - 2021, there is a trend of diversification in the topics discussed in language learning research based on instructional agents, mainly assessing learners' learning effectiveness, memory performance, social presence and learning experience, as well as motivation and learning satisfaction. Puetten & Astrid (2020), in their study, explored the effects of animated teaching agent-based presentations 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 memorizing verbs. In the process of second language acquisition, gestural imitation by animated teaching agents was particularly helpful in learning nouns, while pictures were most helpful in remembering verbs. The findings suggest that animated teaching agents are realistic virtual characters that enhance learning (Lee & Hanju, 2015).

Table 4

Study and analysis of learner characteristics in language learning based on teaching Agent, 2012-2021

| Learner characteristics | Publications | Learner characteristics | Publications |
|--------------------------------|---------------------|--------------------------------|---------------------|
| learning effectiveness | 6 | learning satisfaction | 1 |
| memory performance | 4 | attention | 1 |
| social presence | 4 | relatedness | 1 |
| learning experience | 3 | self-confidence | 1 |
| learning motivation | 2 | critical thinking | 1 |
| learning motivation | 2 | cognitive and affective states | 1 |
| cognitive load | 1 | English learning anxiety | 1 |

Analysis of the theoretical basis of learning

Table 5 shows the theoretical foundations involved in the research on language learning based on teaching agents from 2012 - 2021. Among them, the most used theories are social agent theory (f=7) and multimedia cognitive theory (f=5). This was followed by cognitive load theory (f=3), dual coding theory (f=2), and language acquisition theory (f=2). In addition, among the 15 papers screened for this paper, some studies were conducted with social cognitive theory (f=1), natural education theory (f=1), dominant learning theory (f=1), central instruction theory (f=1), and rhythmic impulse theory (f=1) as theories (see Table 6). Most of the studies built the theoretical framework of the study based on social agency theory and multimedia cognitive theory. According to social agency theory, the social cues of the instructional 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 influence of the instructional agent on learner motivation (Mayer, DaPra, 2012). The cognitive theory of multimedia learning assumes that the human information processing system consists of two channels for processing information: the auditory channel and the visual channel. Since the information capacity of these channels is limited, in order to maximize the learning process, information should be distributed over both channels to avoid additional cognitive load (Mayer & Moreno, 2003).

Table 5*An analysis of learning theory in language learning research based on teaching Agent, 2012-2021*

| Learning Theory | Publications | Learning Theory | Publications |
|-----------------------------|--------------|----------------------------|--------------|
| social agent theory | 7 | social cognitive theory | 1 |
| multimedia cognitive theory | 5 | natural education theory | 1 |
| cognitive load theory | 3 | dominant learning theory | 1 |
| dual coding theory | 2 | central instruction theory | 1 |
| language acquisition theory | 2 | rhythmic impulse theory | 1 |

Discussion & Conclusion

In this paper, we conducted a visual bibliometric analysis of research related to instructional agent-based language learning from 2012 - 2021. We constructed a series of scientific maps showing publication trends, national and regional distribution, participants, research methods, research platform analysis, roles of teaching agents, language proficiency, learner characteristics, and theoretical foundations of learning. In addition, we used the visualization tool Vos viewer to conduct literature co-citation analysis and keyword co-occurrence analysis on the screened 15 papers to explore the research hotspots and frontiers between 2012 - 2021. The main findings are as follows.

- (1) Between 2012 and 2021, the articles published in Computer Assisted Language Teaching and Interactive Learning Environments on research on teaching agents in language learning and the number of citations ranked the highest. And, there are increasing opportunities for research on language learning based on teaching agents to be published in various journals.
- (2) During 2012 - 2021, the authors of research on teaching agent-based language learning are distributed across a wide range of countries/regions, with major concentrations in Japan, Korea, and the United States. The top four countries/regions in terms of article citations are Iran, Japan, Brazil, and Taiwan, China. Other countries, such as Germany and Turkey, have also made important contributions to the field of teaching agents in language learning research.
- (3) Language learning research based on teaching agents is mainly concentrated in the field of higher education and primary education. This is followed by the preschool and adult education levels. In addition, few studies have focused on the use of teaching agents in secondary language education (including middle and high school), as indicated by the statistical results.
- (4) The main research methods used in language learning research based on teaching agents during 2012 - 2021 contain quantitative, qualitative, and mixed research. Among them, the most used are quantitative research and mixed research, and few scholars use qualitative research methods. The research analysis methods mainly focus on using descriptive statistical analysis and ANOVA, while the learning behavior characteristics of the participants will be recorded.
- (5) In the field of instructional agent-based language learning research, most of the studies have used computers or computers and new technologies (e.g., computers and virtual reality devices, computers and projectors, etc.) to provide learners with multimedia learning environments.
- (6) In language learning research based on teaching agents, intelligent tutors are the most common role of teaching agents. In addition, some studies have also explored the role of teaching agents as peers, juggling the role types of tutors and peers in language learning education.
- (7) The main research objectives of the research on teaching agent-based language learning between 2012 - 2021 were to investigate the impact of the characteristics of the teaching agent itself on learners, the impact of the teaching agent on learner characteristics during participation in the language learning process, and to assess the role of the teaching agent in the language learning process. After a cluster analysis of all the keywords in the study of teaching agent-based language learning between 2012 - 2021, it was found that the study was divided into eight clusters, namely, anthropomorphic teaching agent, influence produced by teaching agent, social interaction of teaching agent, animated teaching agent and language achievement, teaching agent's gestures, the impact of teaching agents on learner characteristics, computer-assisted learning, and the design of teaching agents.
- (8) The disciplinary directions of agent-based language learning research between 2012 and 2021 show a comprehensive trend: the most researched language learning directions are reading, vocabulary, and speaking, followed by listening, writing, grammar, and phonological knowledge.

- (9) The main learner characteristics studied in agent-based language learning research include learning effectiveness, memory performance, social presence, learning experience, and learning motivation. Also, scholars have focused on the effects of instructional 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.
- (10) Among all the theoretical foundations of instructional agent-based language learning research, the most studies are 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 have focused on the guiding role of social cognitive theory, nature education theory, dominant learning theory, central instruction theory, and rhyming pulse theory in the application of instructional agents.

It is worth noting that this research still has some limitations. This paper reviews publications related to agent-based language learning research in the Web of Science SSCI Core Collection database from 2012-2021 (the type of literature is limited to "articles"). The findings of this paper may be affected by classification and coding. Based on the findings of this study, the following recommendations are made for future research on teaching agents in language learning.

- (1) The majority of participants in language learning research based on teaching agents were higher education students and elementary school students. However, research on teaching agents in education is rich and diverse. Therefore, it would be a worthwhile problem to investigate how instructional agents affect language learning of middle and high school students in instructional agent-based language learning research.
- (2) Currently, more and more scholars are focusing on the application of teaching agents in the field of education and trying to evaluate the influence of teaching agents in the educational process by means of empirical studies. For future research, richer research methods, such as qualitative research (discourse analysis, qualitative summary, etc.) can be added to explore the issues related to teaching agents in the field of education in a more in-depth and comprehensive way.
- (3) Animated agent-based communication strategies have a positive effect on the oral communication competence of second language learners, and more effective learning strategies can be considered for teaching agent-based language learning. For example, different learning strategies, such as task- or game-based strategies to help young children learn foreign language vocabulary, are used.
- (4) Research on instructional agent-based language learning has been pressured by various aspects from academic pressure, length of instruction, and technological maturity. In future research, the effectiveness of teaching agent-based language learning should be improved by combining 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 teaching agents and learning outcomes. Currently, most students are being exposed to instructional agents for the first time in language teaching and learning; therefore, it is unclear whether the novelty factor of the research agent will have an effect on the findings.
- (6) The use of artificial intelligence as a tool for assessing interactions between teaching agents and people in the field of developmental psychology has great advantages. Current research is limited by technology, and AI has tremendous potential to open up new possibilities for accurate and cost-effective assessment of subtle human behaviors.

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