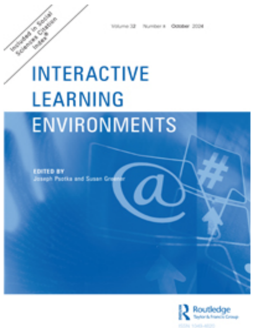

Interactive Learning Environments

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/nile20

A review of chatbot-assisted learning: pedagogical approaches, implementations, factors leading to effectiveness, theories, and future directions

Ruofei Zhang, Di Zou & Gary Cheng

INTERACTIVE LEARNING ENVIRONMENTS
2024, VOL. 32, NO. 8, 4529–4557
https://doi.org/10.1080/10494820.2023.2202704

Routledge
Taylor & Francis Group

REVIEW ARTICLE

Check for updates

A review of chatbot-assisted learning: pedagogical approaches, implementations, factors leading to effectiveness, theories, and future directions

Ruofei Zhang [a], Di Zou [b] and Gary Cheng [a]

[a]Department of Mathematics and Information Technology, The Education University of Hong Kong, Hong Kong SAR, People's Republic of China; [b]Department of English Language Education, The Education University of Hong Kong, Hong Kong SAR, People's Republic of China

ABSTRACT
The chatbot has been increasingly applied and investigated in education, along with many review studies from different aspects. However, few reviews have been conducted on chatbot-assisted learning from the pedagogical and implementational aspects, which may provide implications for future application and investigation of educational chatbots. To fill in the gaps, we reviewed relevant studies from the pedagogical and implementational aspects. Forty-six articles from Web of Science and Scopus databases were screened by predefined criteria and analysed step by step following the PRISMA framework. The finding showed diversified learning activities (i.e. exercise, instructions, role-playing activities, collaborative product design, independent writing, storytelling/book-reading, digital gameplay, and open-ended debates) that chatbots could support through presenting knowledge, facilitating practices, supervising and guiding learning activities, and providing emotional support. Chabot-assisted learning was applied in 14 disciplines, mostly in-class for one session, and had overall positive outcomes from academic and affective aspects. Based on the review results, we proposed a RAISE model of effective chatbot-assisted learning: Repetitiveness, Authenticity, Interactivity, Student-centredness, and Enjoyment. We identified eght theories that might be useful in analysing and supporting chatbot-assisted learning: constructivist theories, situated/contextualised learning theories, cognitive theories of multimedia learning, self-regulated learning theories, output hypotheses, flow theory, collaborative learning theories and motivation theories. Future studies on chatbot-assisted learning may be conducted on the use of theoretical frameworks, the application of various technological-pedagogical approaches and learning activities, and the long-term, out-of-class implementations in new areas.

ARTICLE HISTORY
Received 26 April 2022
Accepted 6 April 2023

KEYWORDS
Artificial intelligence; chatbot; chatbot in education; conversational agent; review; technology-enhanced learning

1. Introduction

The past decades witnessed an escalating growth of chatbots in various arenas of life, especially in education (Lee et al., 2020). A chatbot is a digital tool that can interact with humans through natural-language conversations (Ashfaque et al., 2020). Applied for educational purposes, it can interact with learners to offer rich instructional support (Huang et al., 2022), personalised learning schedules (Smutny & Schreiberova, 2020), and immediate feedback (Lee et al., 2020). Researchers have developed various chatbots for different academic subjects, such as Freudbot for psychology education

CONTACT Di Zou dizoudaisy@gmail.com

(Heller et al., 2005) and Cleverbot for English as a second language education (Fryer et al., 2017), and identified their overall usefulness in reducing teachers' workload (Pérez et al., 2020), minimising temporary and spatial constraints on learning (Huang et al., 2022), enhancing learners' affective states (Diachenko et al., 2019), and improving learning efficiency (Ashfaque et al., 2020).

Concurrent with the rapid development and increasing investigation of chatbots in education, researchers have conducted many review and synthesis studies in this field from different aspects. For example, Hwang and Chang (2021) systematically reviewed 1999–2000 Social Science Citation Index (SSCI) journal articles on chatbot-assisted learning from the aspects of contributing regions and journals, analysis methods, research design, and productive authors. Pérez et al. (2020) reviewed 80 studies on chatbot-assisted learning published from 2005 to May 2020, with foci on the chatbot types, chatbot affordances in student learning and service improvement, chatbot training, comparison between chatbots and human tutors, and evaluation of chatbot quality. Focusing on chatbots for language education, Huang et al. (2022) reviewed 25 studies published from 2010 to 2021 from the aspects of implementation contexts (e.g. target domains, learning modes), chatbot features (e.g. interface design, development and conversational capability), chatbot affordances (e.g. technological affordances, pedagogical affordances), influences of chatbot-assisted learning (e.g. social presence, open communication), and challenges to chatbot-assisted learning. Lee et al. (2020) synthesised chatbot-assisted language learning studies, focusing on the types of chatbot features, evaluation of chatbot appropriateness, and types of chatbot-assisted learning activities.

Despite the rich contributions, we identified two gaps in current review studies on chatbot-assisted learning. One concerns the pedagogical approaches. Previous reviews have identified a wide range of chatbot features useful in educational settings, such as personalising learning materials (Pérez et al., 2020) and giving learning recommendations (Huang et al., 2022), while it remained under-reviewed what specific types of learning activities the chatbot features had supported and how the features wielded influences in these activities. However, technological-pedagogical approaches are essential in technology-enhanced learning, serving as the mechanism by which the technology is implemented to construct knowledge and build cognitive structures (Hammad et al., 2020; Zou et al., 2018). Hence, it appears valuable to review the chatbot-assisted learning studies from the pedagogical aspect, providing reference to researchers and practitioners in applying chatbots in constructive ways.

The other research gap concerns the implementation of chatbot-assisted learning. A review of the implementational aspect of chatbot-assisted learning is likely to reveal the current trends and remaining gaps in this field, providing implications and inspirations for future implementation and investigation of chatbot-assisted learning. Evidence was found in Huang et al. (2022). They reviewed the contexts and influences of previous implementations of chatbot-assisted language learning and thereby identified research gaps and future directions in this field concerning the conduction of long-term research and the investigation of teacher perceptions of chatbots. However, a review as such remained few on chatbot-assisted learning across disciplines. Since the implementation and investigation of educational chatbots remained at its early stage (Hwang & Chang, 2021), it seems beneficial to review this technology in general education from the implementational aspect and imply directions for future extension of this burgeoning field.

To fill in the gaps, we reviewed empirical studies on chatbot-assisted learning from pedagogical and implementational aspects. By undertaking this review, we aim to (a) identify pedagogical approaches afforded by various chatbot features, (b) analyse the previous implementations of chatbot-assisted learning, (c) investigate the factors leading to effective chatbot-assisted learning, (d) suggest learning theories useful in supporting and analysing chatbot-assisted learning, and (e) imply future directions for chatbot-assisted learning research. Two questions guided this review:

RQ1: What were the pedagogical approaches in chatbot-assisted learning in previous studies?

RQ2: How were the implementations of chatbot-assisted learning in previous studies?

2. Literature review

2.1. Educational chatbots

A chatbot is a computer program that can simulate human conversations in text or voice (Ashfaque et al., 2020). Since its emergence around the 1950s, this technology has experienced the evolution of multiple generations and application in broadening fields (Ouatu & Gifu, 2021). Education is one of the central fields (Lee et al., 2020), in which researchers argued for the advantages of chatbot-assisted learning in interactivity, accessibility, and adaptability (Ouatu & Gifu, 2021). Ashfaque et al. (2020) combed through the history of educational chatbots and identified 19 representative ones, ranging from Turing Test to Woebot. Smutny and Schreiberova (2020) evaluated 47 educational chatbots and identified their overall high levels of teaching quality. They recommended ten educational chatbots to practitioners: Ask Frank, IFRSRookies, Wordsworth, English With Edwin, Feed. Mind, Erwin, Kuni, NELA, Mastermind, and TutorIce.

By combing through the history of educational chatbots, Smutny and Schreiberova (2020) contended that this technology remained "in its early stages to become artificial intelligence teaching assistants," in need of further investigation and development (p. 1). As for the future directions for chatbot investigation and development, researchers suggested further improving emotion detection and conversation skills, making the tool closer to a real friend and human tutor for students (Pérez et al., 2020).

2.2. Chabot-assisted learning

Researchers have conducted review studies related to educational chatbots, identifying this technology's overall usefulness and various affordances. For example, Hwang and Chang (2021) reviewed 29 SSCI journal articles on chatbot-assisted learning published from 1999 to 2020 while identifying the US as the most contributing country or region and statistical analysis as the most frequently used method in this field. They found that in most studies, students were required to use chatbots to complete specific learning tasks without any other learning activity or strategy. The researchers argued that the study of chatbot-assisted learning remained in an early stage, calling for more contributions to this field.

Pérez et al. (2020) conducted a systematic review of 80 studies on chatbot-assisted learning published from 2005 to May 2020, identifying different types of educational chatbots currently in use in various areas, such as UCM3 Library chatbot for developing computer science knowledge. The findings showed three main affordances of chatbots in education: providing support without temporary constrain, facilitating repetitive learning tasks, and personalising learning content. Chatbots might assist learning by improving educational services and enhancing the learning process like a human tutor, although a complete replacement of human teachers remained impossible.

Lee et al. (2020) focused on chatbots for language education, identifying two main pedagogical purposes of chatbot affordances. One was to support daily learning activities, such as presenting enquired learning materials. The other was to offer extended responses, such as providing immediate feedback on learners' academic performance. Chatbot quality for language education should be assessed based on vocabulary level, grammatical accuracy, and the conversation turns per session. The researchers proposed three language learning activities for which educational chatbots should be helpful: ubiquitous practices of speaking and listening skills, collaborative reading and writing activities, and practices of integrated language skills.

Huang et al. (2022) reviewed 25 studies on the application of chatbots in language learning published from 2010 to 2021, revealing three main features of chatbot-assisted language learning: timeliness, ease of use, and personalisation. Chatbots enhanced language learning via five approaches: (a) playing as a learning companion; (b) building authentic environments for speaking practising; (c) presenting learning materials; (d) facilitating information retrieval; and (e) giving learning recommendations. With these affordances, chatbots might encourage affective, open, and coherent communications among students and enhance their social presence. The researchers also reported three main challenges to chatbot-assisted language learning: technological limitations, the novelty effect, and cognitive load.

3. Method

We conducted a standard three-step method of review studies following PRISMA 2020 framework: (a) identification, that is to search articles using keywords and determine the pool from which the reviewed articles will be selected; (b) screening, that is to select eligible articles for review based on a set of predefined criteria; (c) data analysis, that is to examine and collect information from the eligible articles using predefined codes and coding methods.

3.1. Article identification

The data were searched in the Web of Science Core Collection and Scopus, using "2000-present" for the time span and "English" for the language. Two groups of keywords were used adapted from Pérez et al.'s (2020) keywords for searching articles on educational chatbots: (a) "chatbot," "conversational agent," and "conversational tutor," and (b) "educat," "learn," and "teach," with the AND operator between them. The search was conducted on April 10th, 2022, identifying 1176 articles and conference papers from Scopus and 299 from the Web of Science.

3.2. Article screening

After removing 108 duplicates and 75 articles without full texts available online, the authors screened the remaining 1292 articles based on four inclusion criteria (see Table 1). The screening began with the titles and abstracts based on two criteria. First, the article had to focus on human education. This criterion filtered out 1003 articles. Second, the article had to focus on chatbots. This criterion filtered out 20 more articles. The remaining 269 articles were then screened by the main texts based on two criteria. First, the article had to include explicit and detailed descriptions of the implementation of chatbot-assisted learning, which is relevant to RQ2. This criterion screened out 202 articles. Second, the article had to include explicit and detailed descriptions of the pedagogical approaches in chatbot-assisted learning, which is relevant to RQ1. This criterion screened out another 21 articles. The screening ended with 46 articles (see References marked by asterisks). Figure 1 illustrates the process and methods of data searching and selection, following PRISMA 2020 flow diagram.

3.3. Data analysis

The 46 articles were analysed from two aspects, corresponding to the two research questions.

1) *Pedagogical approaches in chatbot-assisted learning* This category fell into two sub-codes. One concerns the learning activities supported by chatbots, such as collaborative reading and

Table 1 . Criteria for article screening.

Screening phases	Inclusion criteria
Screening by titles and abstracts	• Focusing on human education • Focusing on chatbots
Screening by the main texts	• Including explicit and detailed descriptions of the implementation of chatbot-assisted learning • Including explicit and detailed descriptions of pedagogical approaches in chatbot-assisted learning

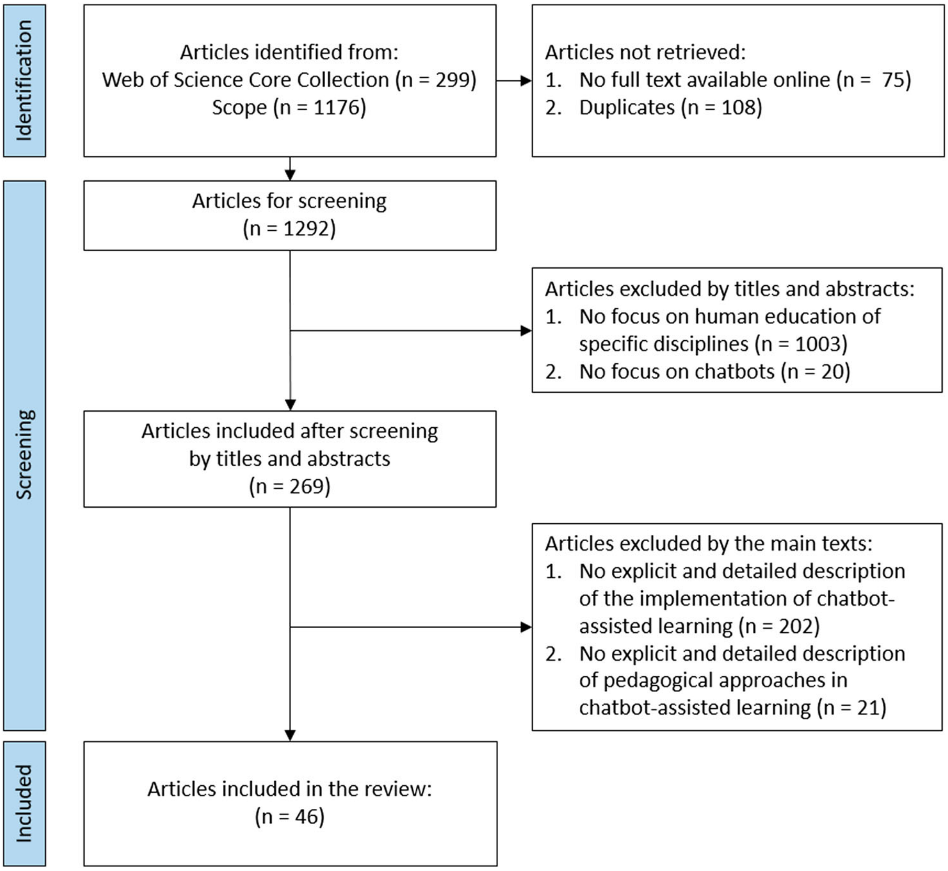

Figure 1 . Process and methods of data searching and selection.

writing activities and ubiquitous practises (Lee et al., 2020). The other sub-code concerned the chatbot features for pedagogical purposes, such as presenting learning materials, delivering recommendations, and building authentic environments for practice (Huang et al., 2022).

2) *Implementations of chatbot-assisted learning* This category consisted of four sub-codes. The first concerned the implementation context of chatbot-assisted learning, falling into three types: in-class, out-of-class, and unrestricted, following Chen (2022). The second sub-code regarded the implementation duration of chatbot-assisted learning, falling into four types: one-session, short-term (1 week – 4 weeks), intermediate-term (5 weeks – 10 weeks), and long-term (11 weeks –), following Chen (2022). The third sub-code was about the target disciplines of the implementation of chatbot-assisted learning, e.g. language, math and psychology. The fourth sub-code concerned the implementation outcomes of chatbot-assisted learning, encompassing the positive, negative, neutral, or mixed effects on learners' academic and affective aspects, following Zhang and Zou (2021). The researchers' explanations for the different implementation outcomes were also analysed.

The authors analysed five articles together to decide on the coding scheme and then analysed the remaining articles independently based on the scheme. The results of independent analyses were compared and reached satisfactory inter-rater reliability (Pearson's $r = 0.93$), with the remaining differences resolved via discussion.

4. Results

This section presents the results of this review from two aspects corresponding to the research questions: the pedagogical approaches in chatbot-assisted learning and the implementations of chatbot-assisted learning. The following two sub-sections present the details, and Appendix presents the summary.

4.1. Pedagogical approaches in chatbot-assisted learning

4.1.1. Chatbot-assisted learning activities

This review found eight main types of learning activities supported by chatbots in previous studies. As shown in Figure 2, exercises was applied most frequently (26 studies), followed by instructions (23 studies), role-playing activities (six studies), collaborative product design (two studies), independent writing (two studies), and storytelling/book-reading (two studies). In addition, Allameh and Zaman (2021) required students to play digital board gameplay scaffolded by chatbots to learn about board game rules; Tegos et al. (2019) used chatbots to support open-ended debates in pairs in computer-science classrooms. The total is greater than 46 because some chatbot-assisted learning studies involved more than one type of learning activity.

4.1.2. Chatbot features for pedagogical purposes

Nine main chatbot features supported diversified learning activities in the reviewed studies. As shown in Figure 3, "Presenting learning materials" was used most frequently (30 studies), followed by "evaluating students' performance in activities and providing immediate feedback" (24 studies), "asking guiding questions to trigger students' knowledge retrieval and application" (22 studies), "answering students' questions" (21 studies) and "presenting exercises" (21 studies), "making casual conversations and telling jokes" (12 studies), "encouraging/rewarding students" (eight studies), "explaining knowledge according to students' output" (seven studies), and "scoring/grading students' output" (five studies). The total is greater than 46 because all the reviewed studies investigated more than one chatbot feature.

We identified four main ways the nine chatbot features supported various learning activities, as shown in Figure 4. First, chatbots could facilitate practices in exercises (Cai et al., 2021), role-

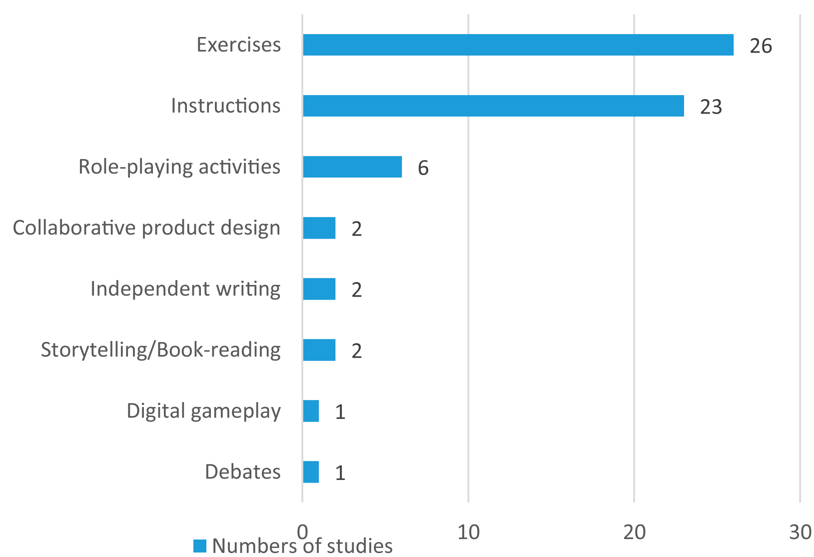

Figure 2. Learning activities in chatbot-assisted learning.

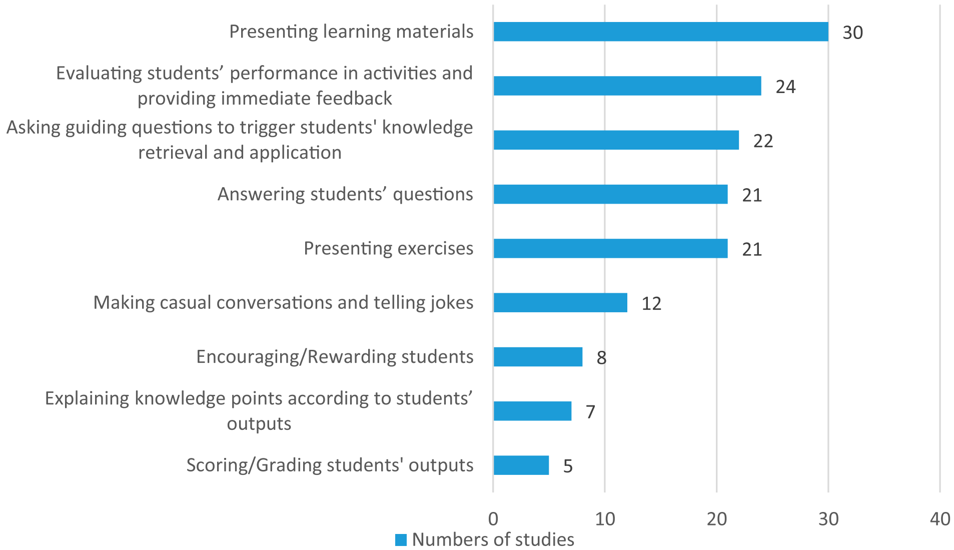

Figure 3 . Technological features of chatbots for pedagogical purposes.

playing activities (Cai et al., 2020), collaborative product design (Kumar, 2021) and independent writing (Wambsganss et al., 2021) by providing exercises, evaluating learner performance, giving immediate feedback, and explaining knowledge points. As found in the reviewed articles, chatbots could offer various types of exercises, including multiple-choice questions (Pereira, 2016) and brief-answer questions (Ruan et al., 2021), repeatedly according to students' needs (Chen, Vicki Widarso, et al., 2020). Learner performances in the exercises were evaluated by the similarity computation algorithm (Ruan et al., 2019a). Depending on the evaluation results, chatbots could score students' performance (Jeon, 2022), give immediate feedback (Hsieh, 2011), and provide explanations of related knowledge points (Diachenko et al., 2019). For example, Ruan et al. (2019a) required the participants to complete exercises about science, safety, and foreign language using a chatbot that could ask questions, provide hints, give feedback on students' answers, and present explanations about involved knowledge points. The results showed the significant effectiveness of chatbot-assisted exercises for knowledge development.

Second, chatbots could deliver knowledge in instructions (Chang et al., 2022), role-playing activities (Berns et al., 2018), storytelling (Bailey et al., 2021) and independent writing (Wambsganss et al., 2021) by providing learning materials and answering learners' questions. This review found diverse types of multimedia-enhanced learning materials that chatbots could provide depending on learners' needs and proficiency levels, such as picture handbooks (Tseng et al., 2020), reading materials (Bailey et al., 2021), and instructional video clips (Berns et al., 2018). Additionally, chatbots could answer some basic questions that learners ask by selecting among recommended questions (Kowalski et al., 2013) or sending keywords (Nadarzynski et al., 2021). For example, Hsieh (2011) reported a study of 12-week chatbot-assisted instruction that began with some warm-up questions. Based on students' answers to the questions, the chatbot provided related lectures and supplementary information. The results revealed the overall usefulness of chatbot-assisted learning for university students' development of computer science knowledge.

Third, chatbots could supervise and guide learning activities by scoring/rewarding their performance and asking guiding questions. In exercises (Vijayakumar et al., 2018), digital gameplay (Allameh & Zaman, 2021), collaborative product design (Kumar, 2021), independent writing (Lin & Chang, 2020), debates (Tegos et al., 2019) and role-playing activities (Kong et al., 2021), chatbots

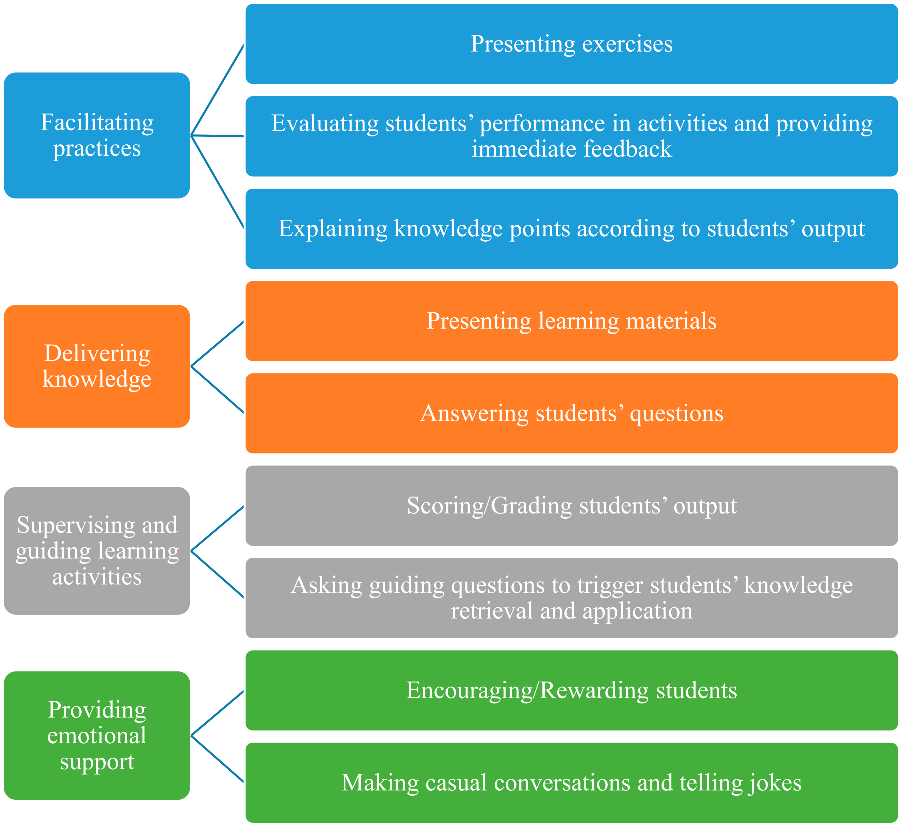

Figure 4 . Main pedagogical approaches in chatbot-assisted learning.

had monitored, analysed and scored students' output and behaviours (Cai et al., 2020) and asked guiding questions to trigger their retrieval and application of knowledge (Tandy et al., 2017), so as to improve learner performance and efficiency. For example, in Chien and Yao's (2020) study, engineering students were required to collaboratively design female self-defence products, with chatbots monitoring their design process, raising demands, and asking guiding questions from the perspective of product users. The results indicated the usefulness of chatbots in this collaborative learning project.

Fourth, chatbots could provide students with emotional support in storytelling (Bailey et al., 2021), independent writing (Wambsganss et al., 2021), collaborative product design (Kumar, 2021), instructions and exercises (Deveci Topal et al., 2021) by giving encouragement and rewards and making casual conversations and jokes. As found in the reviewed articles, chatbots could praise and congratulate students for their academic achievements (Vijayakumar et al., 2018), show empathy and encourage students when their performance was unsatisfying (Ruan et al., 2019a), and tell jokes and make casual conversations to entertain and relax students (Bailey et al., 2021). Chatbots may further strengthen the emotional support with vivid personas (Chien & Yao, 2020), embodiments/avatars (Ruan et al., 2019b), emojis (Fidan & Gencel, 2022) and diverse responses (Ruan et al., 2019a). For example, Ruan et al. (2020) required 72 elementary students to participate in chatbot-assisted instructions plus exercises in math. The chatbot, personified as a wizard, accompanied the students by sending them greetings, praising and encouraging, telling jokes and making casual talks. The results showed that most students enjoyed the chatbot's emotional support.

4.2. Implementation of chatbot-assisted learning

4.2.1. Context of the implementation of chatbot-assisted learning

As shown in Figure 5, this review found that most studies implemented chatbot-assisted learning in class (39 studies, 85%). Only four studies (9%) implemented out-of-class chatbot-assisted learning. Four studies did not specify the exact context of the implementation of chatbot-assisted learning, labelled as “n/a”.

4.2.2. Duration of the implementation of chatbot-assisted learning

As shown in Figure 6, one-session chatbot-assisted learning was implemented most frequently (18 studies, 39%), followed by the short-term one (13 studies, 28%), the intermediate-term one (five studies, 11%), long-term one (three studies, 7%) and the two-session one (three studies, 7%). Four studies did not specify the exact implementation duration of chatbot-assisted learning, labelled as “n/a”.

4.2.3. Disciplines of the implementation of chatbot-assisted learning

Chatbots were applied in 14 disciplines of education. As shown in Figure 7, foreign language was investigated most frequently (19 studies), followed by computer science (seven studies) and communication for special purposes (four studies), native language (three studies), education (two studies), clinical skills (two studies), science (two studies), math (two studies) and health literacy (two studies). The sum is greater than 46 because Ruan et al. (2019a) investigated foreign language, safety, and science.

Some studies focused on the academic outcomes of chatbot-assisted learning, some on the affective outcomes, and others on both. The following two sub-sections present the details of the academic and affective outcomes of the implementation of chatbot-assisted learning.

4.2.4. Academic outcomes of the implementation of chatbot-assisted learning

Figure 8 illustrates the 27 aspects of knowledge and skills investigated in previous studies on chatbot-assisted learning, with foreign language speaking investigated most frequently (six studies). All studies reported positive outcomes of the implementation of chatbot-assisted learning from the academic aspects, except Kowalski et al. (2013) who identified neutral effects on IT security

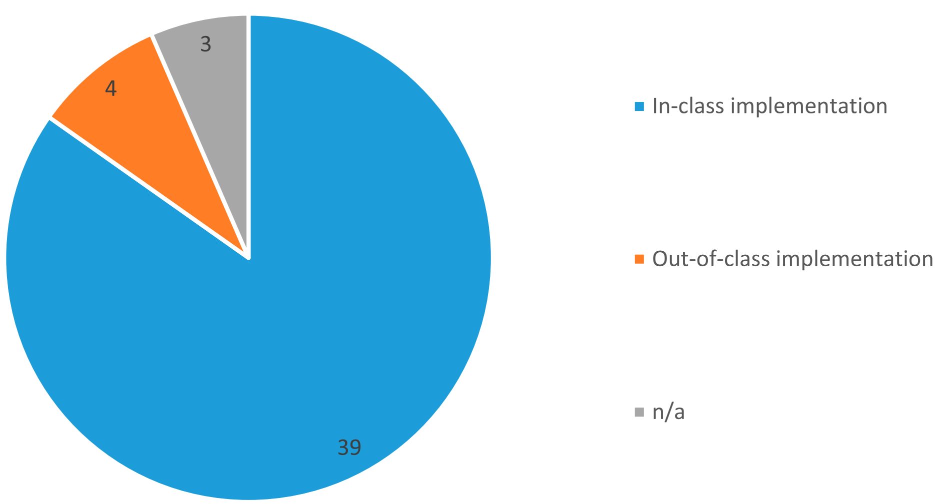

Figure 5 . Implementation context of chatbot-assisted learning.

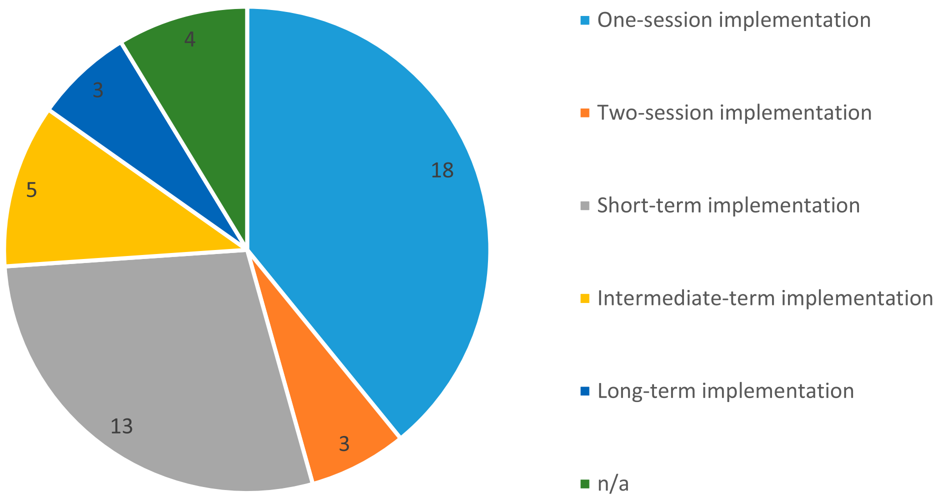

Figure 6 . Implementation duration of chatbot-assisted learning.

knowledge and Deveci Topal et al. (2021) who reported neutral effects on natural science knowledge.

We identified the overall effectiveness of chatbot-assisted learning in academic aspects of various domains and subjects. For example, Cai et al. (2020) assigned university students a one-month drama-playing activity with chatbots and identified the participants' significant progress in speaking proficiency after the activity. They found that the chatbots allowed students to practise repeatedly and make constant self-correction based on the chatbot feedback, helping them gradually enhance their accuracy and fluency of speaking. In another article, Tandy et al. (2017) reported the effectiveness of chatbots in developing communicative skills for special purposes. In this study, the student

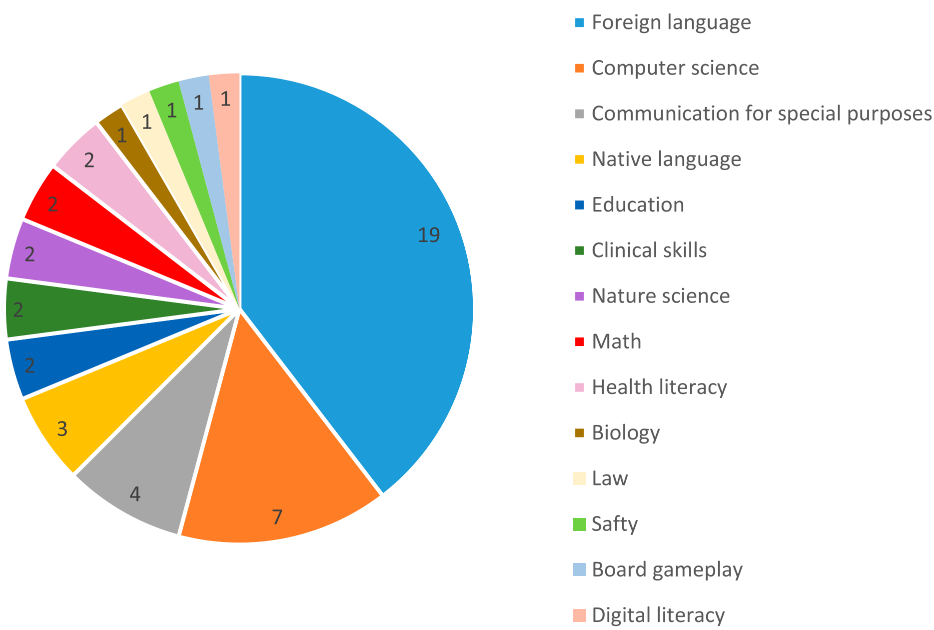

Figure 7 . Target subjects of the implementation of chatbot-assisted learning.

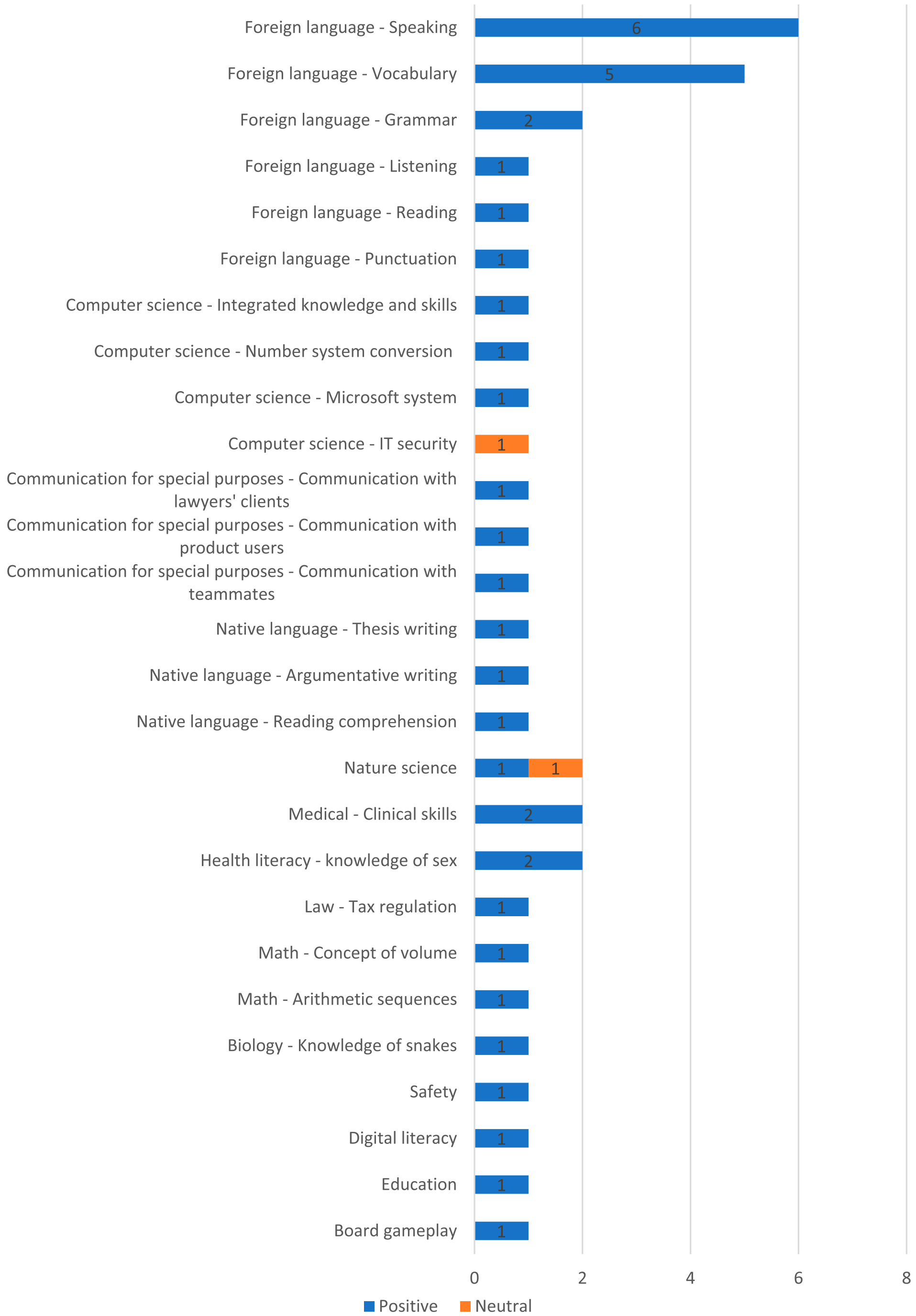

Figure 8 . Academic outcomes of the implementation of chatbot-assisted learning.

played as a lawyer, communicating with a chatbot that played as the client. The researchers found that the chatbot afforded a safe and supportive environment for practising where students could try different communicative strategies without any risk of embarrassing themselves or offending an actual human. Yin et al. (2021) required 99 university students to perform chatbot-assisted learning of number system conversion. They found that chatbots increased learning efficiency by enabling students to learn and practice knowledge at their own pace, depending on their needs.

However, chatbots did not always lead to enhanced knowledge and skills. For example, Deveci Topal et al. (2021) required 20 primary school students to use a chatbot in their out-of-class natural science learning for four weeks, only to find insignificant effects of this tool. A possible reason was that most students were unfamiliar with chatbot-assisted learning, so they could not use it efficiently. In another article, Kowalski et al. (2013) assigned the experimental group of participants to learn IT security knowledge using a chatbot and the control group to learn it in traditional ways, while finding no significant difference in learning outcomes between the two. The researchers argued that the chatbot-assisted learning of computer science might be too complex for beginning learners.

4.2.5. Affective outcomes of the implementation of chatbot-assisted learning

Chatbot-assisted learning was implemented to enhance four main affective aspects of learning: learning experiences (16 studies), motivation (nine studies), self-efficacy (seven studies), and learning interest (two studies), as shown in Figure 9. Most studies reported the positive outcomes of the implementation of chatbot-assisted learning from affective aspects. Nonetheless, Huang et al. (2019) reported mixed (positive and negative) effects on learning experiences; El Shazly (2021) reported negative effects on learning experiences; Kumar (2021) identified neutral effects on self-efficacy and motivation; Fryer et al. (2017) reported mixed (positive and neutral) effects on learning interest.

Learners tended to have overall positive affective states in chatbot-assisted learning, with enjoyable learning experiences (Tseng et al., 2020), strong motivation (Diachenko et al., 2019), high self-efficacy (Bailey et al., 2021), and intense learning interest (Cai et al., 2020). For example, Vijayakumar et al. (2018) surveyed 40 students about their experiences of doing chatbot-assisted exercises about computer science knowledge. As shown in their survey results, most students were unfamiliar with educational chatbots and felt a sense of freshness and excitement in using them. Vijayakumar et al. also observed that chatbots shared many features with games, such as interactivity and scoring/rewarding, which might have also contributed to learners' positive affective states. Additionally, Tandy et al. (2017) found that chatbots might improve immersive learning by making the learning context closer to the real world. In such context, students were likely to immerse in learning activities and have positive emotions.

However, chatbot-assist learning did not necessarily lead to positive affective outcomes. For example, El Shazly (2021) required 48 university students to complete speaking learning activities for four weeks using online chatbots. The results showed that the chatbots worsened learning experiences because they failed to adjust practice tasks to students' needs and interests.

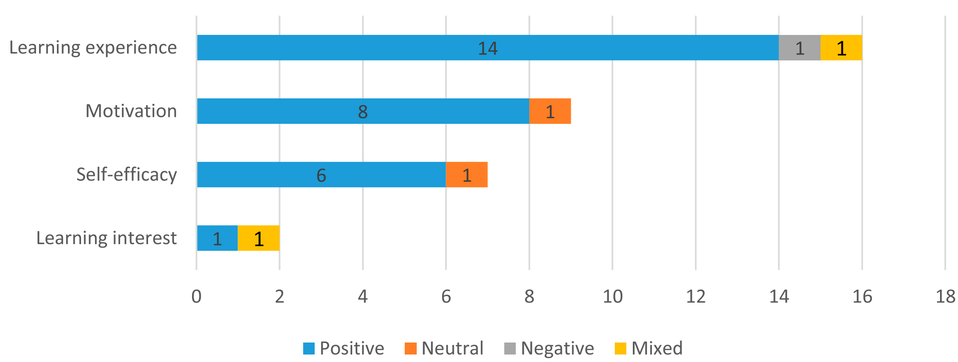

Figure 9. Affective outcomes of the implementation of chatbot-assisted learning.

Additionally, most students were unfamiliar with the chatbot, so they might feel unprepared for the new learning method. Another example was Huang et al. (2019), who required students to learn educational skills using chatbots. In post-interviews, the students expressed their awareness of the non-human nature of the chatbot and their feeling of isolation and loneliness in chatbot-assisted learning. They also pointed out that the chatbot could not understand them fully or answer any complex question, which could be annoying.

4.2.6. Challenges to the implementation of chatbot-assisted learning

Although most articles reported successful implementation of chatbot-assisted learning, we identified two main challenges to it. One concerns the limited intelligence of educational chatbots. Social interactivity is very complex, involving rich discernible human factors such as empathy, avoidance, and adaptability, which chatbots could neither accurately recognise nor fully provide at present (Huang et al., 2019). Additionally, due to their limited intelligence, chatbots could not always understand students' utterances accurately (Divekar et al., 2021), especially when "similar phrasing, synonyms, or grammatical errors" were involved (Lin & Chang, 2020, p. 83). Answering students' complex and open-ended questions was also beyond chatbots' intelligence (Bailey et al., 2021). In this way, the limited intelligence of chatbots might have negatively influenced the quality of human-chatbot interactivity and chatbot-assisted learning (El Shazly, 2021).

The other challenge regards students' familiarity with this learning method. As shown in the review results, most students had experienced strong senses of curiosity and freshness at the beginning stages of chatbot-assisted learning due to their unfamiliarity with chatbots, which might have resulted in their high motivation and deep engagement in learning (Wambsganss et al., 2021). However, the early stages of chatbot-assisted learning were not necessarily productive because students might have yet acquired sufficient experience and knowledge of the new tool to use it smoothly and efficiently (El Shazly, 2021). Along with their development of knowledge and experiences of chatbot-assisted learning, unfortunately, students were likely to lose their sense of freshness and interest and become disengaged in the learning over time (Yin et al., 2021).

5. Discussion

5.1. Factors that may lead to effective chatbot-assisted learning

Based on the analysis of the review results, we identified a RAISE model of effective chatbot-assisted learning that consisted of five factors: Repetitiveness, Authenticity, Interactivity, Student-centredness, and Enjoyment.

Firstly, the provision of repetitive instruction and practice may lead to effective chatbot-assisted learning. As shown in the results, chatbots could repeatedly provide vast amounts of learning materials, exercises, feedback, and explanations of knowledge points according to learners' needs (Chang et al., 2022), advantageous over traditional learning due to the limited time and effort of human teachers (Pérez et al., 2020). Given this advantage, students could retrieve learning materials to consolidate knowledge for as many times as they like and obtain lengthened knowledge retention in chatbot-assisted learning (Chen, Vicki Widarso, et al., 2020). Moreover, allowed with repeated access to exercises and unlimited attempts of output production, students could try different answers and conduct constant self-correction in chatbot-assisted learning (Yin et al., 2021). During the process of trying answers and conducting self-correction, students learn their problems (Cai et al., 2020), develop an awareness of progress (Tandy et al., 2017), continuously consolidate knowledge and skills with increasing accuracy, adeptness, and fluency (Divekar et al., 2021), and, thereby, achieve better learning outcomes (El Shazly, 2021). Hence, chatbots may result in long retention, deep consolidation and efficient acquisition of knowledge and skills by affording repeated learning and practising.

Secondly, the enhancement of authenticity in learning may lead to effective chatbot-assisted learning. Compared to the traditional learning environment, a chatbot-assisted learning environment could be closer to real-world situations (Wang et al., 2017) by affording students to interact with chatbots like "actually talking to someone" (Divekar et al., 2021, p. 22) and work on learning tasks like being "really there" (Tandy et al., 2017, p. 70). A strong sense of authenticity may help students deeply engage in learning tasks, leading to their high concentration in learning (Wang et al., 2017). Additionally, the authenticity of the learning environment may help students perceive learning contents with increased meaningfulness and relevance to real-life scenes, enabling them to understand and memorise the contents contextually and efficiently (Ruan et al., 2021). Also, due to the strong sense of authenticity, chatbot-assisted practices may appear as rehearsals for the real-life application of knowledge and skills, preparing students for authentic settings (Tai & Chen, 2020). Hence, chatbots may lead to deep engagement, contextualised comprehension, and prepared application of knowledge and skills by increasing the authenticity in learning.

Thirdly, the affordance of high-quantity, high-quality interactivity may lead to effective chatbot-assisted learning. In chatbot-assisted learning, learners tended to actively engage in human-chatbot interaction (Yin et al., 2021), considering it enjoyable (Tai & Chen, 2020) and close to real-world conversations with their human teachers and friends (Hsieh, 2011). Many students even preferred the chatbot to humans in content-related interactivity (Tandy et al., 2017) because the chatbot was always unjudgmental (Diachenko et al., 2019), patient (Tai & Chen, 2020), friendly (Ruan et al., 2020), and supportive (Ruan et al., 2020). When interacting with chatbots, students had no concern about embarrassing themselves (Tai & Chen, 2020) or bothering other humans (Tandy et al., 2017), so they tended to feel stress-free, more willing to produce output and ask questions (El Shazly, 2021). In this way, chatbots may contribute to better affective states, more learner engagement, and higher learning efficiency by affording rich, high-quality interaction (Ruan et al., 2019a).

The affordance of student-centredness may also lead to effective chatbot-assisted learning. Chatbot-assisted learning is usually student-centred (Katchapakirin et al., 2022). It is because chatbot-assisted learning consists of "a series of micro-learning units and tasks" that can be freely ordered, selected and adapted (Yin et al., 2021, p. 169), allowing learners to regulate their progress (Tandy et al., 2017) and contents (El Shazly, 2021) of learning according to individual needs and preferences. Additionally, chatbots can facilitate learners' critical thinking and question asking by presenting guiding questions (Tegos et al., 2019) and warm encouragement (Kowalski et al., 2013), which is conducive to learners' active and constructive engagement in learning (Ruan et al., 2020). As shown in the reviewed studies, by supporting student-centredness, chatbots helped students comprehend and memorise learning contents with high efficiency (Hsieh, 2011), high satisfaction (Hsieh, 2011), low cognitive loads (Yin et al., 2021), and a strong sense of control (Yin et al., 2021). Hence, chatbots may result in high efficiency and positive emotions in learning by centring students on learning.

Lastly, the increase in learner enjoyment may lead to effective chatbot-assisted learning. According to the review results, chatbot-assisted learning was overall enjoyable (Nghi et al., 2019), as students tended to find the human-chatbot interactivity fun, refreshing (Deveci Topal et al., 2021) and comforting (Hsieh, 2011). Moreover, chatbot-assisted learning was usually enhanced by various entertaining elements, such as embodiments (Divekar et al., 2021), multimedia (Berns et al., 2018), emojis (Pereira, 2016), and incentives (Vijayakumar et al., 2018). Those elements might further increase learners' enjoyment in chatbot-assisted learning (Lin & Chang, 2020).

5.2. Theoretical frameworks that may be useful in analysing and supporting chatbot-assisted learning

Pedagogies, implementation, and learning theories are closely connected with each other in technology-enhanced learning (Hammad et al., 2020). According to Zou et al.'s (2018) future TELL model, these three constructs interact with each other and consist the theoretical dimension of technology-enhanced learning: theories support pedagogies, and pedagogies are practised by technology implementation. Considering the dynamics between pedagogies, implementation and learning theories, we identified eight theoretical frameworks that may be useful in analysing and supporting chatbot-assisted learning based on our review results. Examples were also provided to illustrate how to conduct and analyse chatbot-assisted learning based on these frameworks.

Firstly, constructivist theories may be useful in analysing and supporting chatbot-assisted learning. As shown in the review results, chatbot-assisted learning was featured by a strong sense of authenticity (Divekar et al., 2021), which could make the situations for learning and practising vivid and meaningful and thereby facilitate learners' contextualised comprehension and memorisation of the target knowledge and skills (Ruan et al., 2021). This phenomenon is in the same vein with constructivism which argues for the usefulness of meaningful, content-rich situations in learning (Piaget, 1973). Constructivism contends that learners could proactively construct new knowledge by making sense of their external environments based on prior knowledge (Piaget, 1973). Based on constructivist frameworks, chatbots may assist learning by creating content-rich, vivid situations conducive to knowledge construction. For example, nursing classrooms may use chatbots based on constructivist theories to facilitate exercises in virtual patient-nurse communications. In this situation, the chatbot plays as the patient and asks guiding questions related to the target nursing knowledge; student nurses have to interact with the "patient" and use their prior knowledge to address its questions and needs. By engaging student nurses in the content-rich, vivid situations of patient-nurse communications, the chatbot may result in their proactive development of nursing knowledge.

Secondly, situated/contextualised learning theories may be useful in analysing and supporting chatbot-assisted learning. The review results showed that chatbots could make the environments for learning and practising similar to real-life situations (Wang et al., 2017). Due to the similarity, exercises in chatbot-assisted learning could be rehearsals for learners' real-life situations, preparing them for authentic application of what they had learned (Tai & Chen, 2020). This phenomenon is consistent with situated/contextualised learning theories. According to the theories, learning environments closely connected with the target knowledge and skills can serve as a clue to trigger the integration of the content into learners' long-term memory and the retrieval of the content from their memory (Brown et al., 1989). From this perspective, practitioners may use chatbots to create positive learning environments that are close to real-life situations and connected with the content knowledge. For example, chatbots may support business instructions based on situated/contextualised learning theories. When the teachers deliver business knowledge, the chatbots can play as business owners and create the virtual scene of a business meeting. In the chatbot-assisted instructions, learners may develop a mental connection between the business knowledge and the situation of communicating with business owners in a meeting. Thus, they may be able to efficiently memorise the content knowledge and quickly recall it when encountering real-life business meetings.

Thirdly, cognitive theories of multimedia learning may be useful in analysing and supporting chatbot-assisted learning. According to the theories, multimedia elements may activate multiple channels in learners' cognitive systems and result in high efficiency in integrating new information into their long-term memory (Mayer, 2001, 2014). Chatbots could present instructions and support storytelling activities with multimedia elements, such as images (Tseng et al., 2020), texts (Bailey et al., 2021) and videos (Berns et al., 2018). Hence, this technology can assist learning based on the cognitive theories of multimedia learning. For example, chatbots may be used for biology education to deliver instructions about animal. By presenting detailed textual explanations and vivid images and videos related to animal knowledge, chatbots may activate learners' cognitive systems and facilitate their understanding and memorisation of the content, leading to their high learning efficiency.

Fourthly, self-regulated learning theories may be useful in analysing and supporting chatbot-assisted learning. Self-regulated learning theories contend that the best learning efficiency can be achieved when learners can control the content and style of learning and actively engage in academic tasks (Reinders & White, 2016). According to the review results, chatbot-assisted learning can be highly self-regulated. By supporting personalised arrangement of academic tasks (Yin et al., 2021) and facilitating active and constructive engagement in learning (Ruan et al., 2020), chatbots may assist learning in the integration with the self-regulated learning frameworks, leading to high learning efficiency and positive emotions. For example, chatbots may be used in out-of-class self-regulated learning of math. The technology allows learners to decide their learning schedule and pace, engage in academic tasks whenever and wherever they like, and select learning contents according to individual needs and preferences. The chatbot can also present guiding questions and encouragement as prompts to encourage learners' performance of self-regulated learning strategies. In this way, learners may perform self-regulated math learning with the aid of chatbots and achieve satisfactory learning outcomes.

Fourthly, output hypotheses may be useful in analysing and supporting chatbot-assisted learning. This review identified students' overall strong willingness to produce output in human-chatbot interactions (El Shazly, 2021; Yin et al., 2021), in which they had unlimited attempts of output production (Divekar et al., 2021), received immediate feedback (Yin et al., 2021), and felt enjoyable (Tai & Chen, 2020), stress-free (Tandy et al., 2017) and supported (Ruan et al., 2020). By producing output in the interactions with chatbots, students check their knowledge, learn their problems (Cai et al., 2020), and continuously enhance their knowledge and skills (Divekar et al., 2021). This phenomenon is in line with Swain's output hypotheses (1985), which claims that learners can check their knowledge, notice and address their problems and weakness in learning, and thereby develop knowledge in the process of output production. Hence, based on the output hypothesis, chatbots may assist learning by creating positive human–computer interactions to encourage learner output. For example, in language classrooms, teachers may ask their students to practise speaking proficiency by interacting with chatbots. In the interactions, chatbots ask learners questions, recognise their utterances, provide immediate feedback and give emotional support. If students make mistakes in pronunciation, chatbots point out the mistakes, suggest possible correct pronunciation, ask students to make self-corrections, and encourage them to try again. Engaging in interactions as such, learners may have a solid willingness to produce oral output and address their problems in speaking, thereby achieving enhanced speaking proficiency.

Fifthly, the flow theory may be useful in analysing and supporting chatbot-assisted learning. Researchers identified learners' entrance of a flow state in chatbot-assisted learning (Wang et al., 2017) which is an experience of deep engagement in activities with high levels of concentration and excitement (Csikszentmihalyi, 1975). Learners are likely to enter a flow state when having rich human–computer interactions and high autonomy (Perttula et al., 2017; Zou et al., 2021), which, as shown in the review results, are affordable in chatbot-assisted learning (Tai & Chen, 2020; Tandy et al., 2017). According to the flow theory, learners experiencing a flow state tend to have high learning efficiency and positive affective states (Csikszentmihalyi, 1975), so chatbots may assist learning by facilitating learners' entrance to a flow state (Wang et al., 2017). For example, chatbots may support the astronomy class based on the flow theory. In the class, chatbots play as astronauts and have rich interactions with learners to deliver instructions, assign exercises, and ask and answer content-related questions. They can also afford students' autonomous engagement in and arrangement of academic tasks. In this way, chatbots may help students enter a flow state, leading to their positive emotions and high efficiency in astronomy learning.

Sixthly, collaborative learning theories may be useful in analysing and supporting chatbot-assisted learning. This review identified diversified chatbot-assisted learning activities that involved peer collaborations and communications, such as debates (Tegos et al., 2019), collaborative product design (Chien & Yao, 2020) and role-playing activities (Cai et al., 2020), in which chatbots facilitated the collaborations and communications by presenting encouragement (Kumar, 2021), guiding questions (Chien & Yao, 2020) and feedback on learner performance (Cai et al., 2020). From these chatbot-assisted collaborations and communications, learners developed content knowledge and skills (Chien & Yao, 2020), which is in line with the collaborative learning theories that define learning as the process of observing and interacting with others in collaborative tasks (Bruffee, 1984). Based on this framework, chatbots may assist learning by supporting peer collaborations in academic tasks. For example, chatbots may scaffold collaborative writing activities in writing classes by presenting encouragement, guiding questions and feedback. Scaffolded and supported by chatbots, students may deeply engage in collaboration in the writing tasks, thereby learning new knowledge and skills of writing from their peers efficiently.

Lastly, motivation theories may be useful in analysing and supporting chatbot-assisted learning. Motivation theories argue the positive correlation between learner motivation and learning outcomes (Petri & Govern, 2012). According to the review results, chatbot-assisted learning can bring learners with strong feelings of enjoyment (Deveci Topal et al., 2021), supportiveness (Ruan et al., 2020), secure (Tai & Chen, 2020), and freshness (Wambsganss et al., 2021), which may lead to high motivation in learning. Hence, chatbots may assist learning based on motivation theories by leading to high learner motivation. For example, chatbots may support physics class by improving learner motivation and enjoyment in learning. They may have friendly and interesting conversations with learners with vivid embodiments, emojis and multimedia elements. They may also give students encouragement and rewards for their learning progress. This way, chatbots may enhance learner motivations and their physics learning outcomes.

5.3. Contributions of this study and directions for future research

This study contributed to the field of chatbot-assisted learning from three main dimensions. One concerns the RAISE model of effective chatbot-assisted learning. In addition to the factors similar with Pérez et al.'s (2020) findings concerning the chatbot affordances in facilitating repetitive learning tasks and personalising learning content, this model demonstrated the positive effects of chatbots on learning by affording high authenticity in learning environment, human–computer interactions of high quality and quantity, and great learner enjoyment. The RAISE model is also consistent with Huang et al.'s (2022) findings in terms of the technological and pedagogical affordances of chatbots in affording synchronous human–computer interactions, supporting student-centred schedule and pace of learning, providing emotional supports as learning companions and building authentic environments. However, different from Huang et al.'s findings that were based on the review of chatbot-assisted language learning studies published from 2010 to 2021, the RAISE model is developed based on a review of 2000–2022 studies on chatbot-assisted learning across disciplines. Hence, the RAISE model may be more generalisable, applicable in other domains and disciplines than language learning. Researchers and educators in different disciplines may apply the RAISE model in their future development and evaluation of chatbot-assisted learning programmes.

The second dimension from which this study contributed to this field concerns the theoretical frameworks for chatbot-assisted learning, which were rarely explored in previous review studies. This study identified several learning theories that may be useful in supporting and analysing chatbot-assisted learning along with illustrating examples. Considering the importance of learning theories in technology-enhanced learning (Hammad et al., 2020), this dimension of contributions may address problems with the current chatbot-assisted learning studies reported by previous researchers and provide reference for future investigation and implementation of chatbot-assisted learning. For example, Hwang and Chang (2021) pointed out the insufficient application of learning strategy/pedagogy in current chatbot-assisted learning studies. However, with reference to the theories identified in this study, future researchers may conduct chatbot-assisted learning studies based on rigid theoretical frameworks, so they can design and apply appropriate learning strategies and pedagogies, wield the full influences of the technology in constructive ways, and eventually increase the effectiveness of chatbot-assisted learning.

As another example, Huang et al. (2022) identified heavy cognitive load as one major challenge to the effectiveness of chatbot-assisted learning, while this study suggested a solution to this challenge by identifying the possible usefulness of self-regulated learning theories in chatbot-assisted learning. Chatbot-assisted learning can be implemented based on the self-regulated learning frameworks, and self-regulated learning can alleviate learners' cognitive load (Hammad et al., 2020). Thus, learners may have reduced cognitive load in chatbot-assisted learning if the self-regulated learning frameworks are applied. Empirical evidence was also found in Yin et al. (2021). Since investigations in this direction remained few, future studies may be conducted on the effects of chatbot-assisted self-regulated learning on cognitive load.

The third dimension from which this study contributed to this field concerns the comprehensive picture of chatbot-assisted learning across domains from the pedagogical and implementational aspects. Overall positive effects of chatbot-assisted learning were identified across domains, in line with Pérez et al. (2020). From this comprehensive picture, we identified some new findings and directions in chatbot-assisted learning. For example, previous studies have found two major ways that chatbot features supported learning activities, "facilitating practise" and "delivering knowledge" (e.g. Huang et al., 2022; Lee et al., 2020), while this study identified another two ways: "guiding and supervising learning activities" and "improving learner emotions". The reviewed studies showed that the chatbot affordances of "guiding and supervising learning activities" (Chien & Yao, 2020) and "improving learner emotions" (Ruan et al., 2020) helped improve the efficiency and outcomes of learning. Thus, future studies may use chatbots in all four approaches in learning activities to take full advantage of this powerful technology.

Additionally, previous studies have identified the usefulness of chatbots in supporting exercises and instructions (e.g. Lee et al., 2020; Pérez et al., 2020), while this review found six additional types of learning activities that chatbots could support. These additional types of learning activities have demonstrated usefulness in developing academic and affective aspects of chatbot-assisted learning, such as role-playing activities in improving accuracy and fluency of speaking (Cai et al., 2020) and storytelling activities in enhancing self-efficacy (Bailey et al., 2021), so it appears valuable to apply these activities in chatbot-assisted learning. Moreover, the application of various learning activities may foster learners' intrinsic interest in learning, maintain their motivation and engagement, and thereby alleviate the negative influences of the novelty effects (see Zhang & Zou, 2022), which is identified as a significant challenge to chatbot-assisted learning by Huang et al. (2022). Hence, we recommend that researchers and practitioners apply various learning activities in chatbot-assisted learning with reference to the activities identified in this review.

Furthermore, some research gaps were revealed in the comprehensive picture of chatbot-assisted learning across domains and aspects. Firstly, current chatbot-assisted learning has been applied in a relatively small range of disciplines and aspects. Meanwhile, this review indicates the overall effectiveness of chatbot-assisted learning across domains, so it appears promising to apply educational chatbots in extended areas, for example, foreign language writing and cooking. Secondly, chatbot-assisted learning was implemented mostly in class. However, the review results showed that chatbots allowed engagement in academic tasks without temporal or spatial constraints (Chen, Vicki Widarso, et al., 2020). Hence, more investigations may be conducted on out-of-class or unrestricted chatbot-assisted learning. Thirdly, most implementations of chatbot-assisted learning were for one session or the short term. Considering the importance of long-term research in technology-enhanced education (Balacheff et al., 2009), we called for more scholarly attention to long-term chatbot-assisted learning.

6. Conclusion and limitations

This study presents a review of previous studies on chatbot-assisted learning from 2000 to April 2022, indicating the increasing application and investigation of this learning method. The findings showed diversified learning activities (i.e. exercise, instructions, role-playing activities, collaborative product design, independent writing, storytelling/book-reading, digital gameplay, and open-ended debates) that chatbots could support through presenting knowledge, facilitating practices, supervising and guiding learning activities, and providing emotional support. Chabot-assisted learning was implemented in 14 disciplines (i.e. foreign language, computer science, native language, communication for special purposes, math, biology, law, safety, education, health literacy, clinical skills, board game play, digital literacy, nature science), mostly in-class for one session. Overall positive outcomes of the implementation of chatbot-assisted learning were identified in both academic and affective aspects, despite a few challenges.

Based on the analysis of the review results, we proposed a RAISE model that consisted of five factors leading to effective chatbot-assisted learning: Repetitiveness, Authenticity, Interactivity, Student-centredness and Enjoyment. Future research may design and evaluate chatbot-assisted learning with reference to this model. In addition, eight learning theories were identified that may be useful in supporting and analysing chatbot-assisted learning: constructivist theories, situated/contextualised learning theories, cognitive theories of multimedia learning, self-regulated learning theories, output hypotheses, the flow theory, collaborative learning theories and motivation theories – along with illustrating examples. Based on the proposed theories, we called for chatbot-assisted learning studies based on rigid theoretical framework that may help address problems, like insufficient application of learning strategies/pedagogies and cognitive overload in chatbot-assisted learning. Additionally, this study may have made contributions by presenting a comprehensive picture of chatbot-assisted learning across domains from the pedagogical and implementational aspects. Based on this picture, we recommend that researchers and practitioners fully use all four technological-pedagogical approaches and apply various learning activities in chatbot-assisted learning. Long-term, out-of-class implementations of chatbot-assisted learning in new areas were also expected in future studies.

This study was not without its limitations. First, 75 articles were screened out in data selection due to their unavailability of online whole texts. Future research may conduct a more comprehensive review by including the 75 articles in the review list. Second, we did not conduct a meta-analysis because many reviewed articles did not involve quantitative analysis. Future studies may focus on the quantitative studies on chatbot-assisted learning, calculating the effect size for each study and conducting a statistical meta-analysis.

Finally, this review has revealed the educational value of chatbots in various disciplines and aspects through diversified approaches, despite a few challenges. Future research may make more contributions to this field, such as the supportive technologies and contexts for chatbot-assisted learning and the comparison of chatbot-assisted learning against other technology-enhanced learning methods.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Ruofei Zhang is a is a PhD candidate at the Education University of Hong Kong. Her research interests include technology-enhanced language learning, game-based language learning, and self-regulated language learning

Di Zou is the corresponding author of this paper. She is an Assistant Professor at the Education University of Hong Kong. Her research interests include technology-enhanced language learning, game-based language learning, and AI in English language education.

Dr Gary Cheng is an Associate Professor of the Department of Mathematics and Information Technology at The Education University of Hong Kong (EdUHK). His academic background is in computer science, but he has specialised in teaching Information Technology in education for over a decade. With substantial years of work experience in Hong Kong academia, Dr Cheng has built a wealth of knowledge and a network of support to unleash the potential of technology for teacher education.

ORCID

Ruofei Zhang http://orcid.org/0000-0001-5215-3306
Di Zou http://orcid.org/0000-0001-8435-9739
Gary Cheng http://orcid.org/0000-0002-5614-3348

References

References marked with an asterisk indicate studies included in the review and cited in the text.

*Allameh, M., & Zaman, L. (2021, October 18–21). *Jessy: A conversational assistant for tutoring digital board games*. In Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play (pp. 168–173). Virtual Event, Austria.

Ashfaque, M. W., Tharewal, S., Iqhbal, S., & Kayte, C. N. (2020, October). *A review on techniques, characteristics and approaches to an intelligent tutoring chatbot system*. In 2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC) (pp. 258–262). IEEE.

*Bailey, D., Southam, A., & Costley, J. (2021). Digital storytelling with chatbots: Mapping L2 participation and perception patterns. *Interactive Technology and Smart Education*, https://doi.org/10.1108/ITSE-08-2020-0170

Balacheff, N., Ludvigsen, S., De Jong, T., Lazonder, A., Barnes, S. A., & Montandon, L. (2009). *Technology-enhanced learning*. Springer.

*Berns, A., Mota, J. M., Ruiz-Rube, I., & Dodero, J. M. (2018, October). *Exploring the potential of a 360 video application for foreign language learning*. In Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality (pp. 776–780). doi: 10.1145/3284179.3284309

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–42. https://doi.org/10.3102/0013189X018001032

Bruffee, K. A. (1984). Collaborative learning and the "conversation of mankind". *College English*, *46*(7), 635–652. https://www.jstor.org/stable/pdf/376924.pdf https://doi.org/10.2307/376924

*Cai, M. Y., Wang, J. Y., Chen, G. D., Wang, J. H., & Yang, S. H. (2020, July). *A digital reality theater with the mechanisms of real-time spoken language evaluation and interactive switching of scenario & virtual costumes: Effects on motivation and learning performance*. In 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT) (pp. 295–299). IEEE. doi: 10.1109/ICALT49669.2020.00096

*Cai, W., Grossman, J., Lin, Z. J., Sheng, H., Wei, J. T. Z., Williams, J. J., & Goel, S. (2021). *Bandit algorithms to personalize educational chatbots*. *Machine Learning*, *110*(9), 2389–2418. https://doi.org/10.1007/s10994-021-05983-y

*Chang, C. Y., Hwang, G. J., & Gau, M. L. (2022). Promoting students' learning achievement and self-efficacy: A mobile chatbot approach for nursing training. *British Journal of Educational Technology*, *53*(1), 171–188. https://doi.org/10.1111/bjet.13158

*Chen, H. L., Vicki Widarso, G., & Sutrisno, H. (2020). A chatBot for learning Chinese: Learning achievement and technology acceptance. *Journal of Educational Computing Research*, *58*(6), 1161–1189. https://doi.org/10.1177/0735633120929622

Chen, N. S. (2022). The theory, pedagogy, technology and design issue in digital language learning (DLL). *Bilingualism: Language and Cognition*, *25*(3), 381–383. https://doi.org/10.1017/S1366728921000833

*Chen, S., Fang, Y., Shi, G., Sabatini, J., Greenberg, D., Frijters, J., & Graesser, A. C. (2021). An adversarial attack system for face recognition. *Journal on Artificial Intelligence*, *3*(1), 1–8. https://doi.org/10.32604/jai.2021.014175

Chen, Z., Chen, W., Jia, J., & An, H. (2020). The effects of using mobile devices on language learning: A meta-analysis. *Educational Technology Research and Development*, *68*(4), 1769–1789. https://doi.org/10.1007/s11423-020-09801-5

*Chien, Y. H., & Yao, C. K. (2020). Development of an ai userbot for engineering design education using an intent and flow combined framework. *Applied Sciences*, *10*(22), 7970. https://doi.org/10.3390/app10227970

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. Jossey-Bass.

*Deveci Topal, A., Dilek Eren, C., & Kolburan Geçer, A. (2021). Chatbot application in a 5th grade science course. *Education and Information Technologies*, *26*(5), 6241–6265. https://doi.org/10.1007/s10639-021-10627-8

*Diachenko, A. V., Morgunov, B. P., Melnyk, T. P., Kravchenko, O. I., & Zubchenko, L. V. (2019). The use of innovative pedagogical technologies for automation of the specialists' professional training. *International Journal of Higher Education*, *8*(6), 288–295. https://doi.org/10.5430/ijhe.v8n6p288

*Divekar, R. R., Drozdal, J., Chabot, S., Zhou, Y., Su, H., Chen, Y., … & Braasch, J. (2021). Foreign language acquisition via artificial intelligence and extended reality: Design and evaluation. *Computer Assisted Language Learning*, 1–29. https://doi.org/10.1080/09588221.2021.1879162

*El Shazly, R. (2021). Effects of artificial intelligence on English speaking anxiety and speaking performance: A case study. *Expert Systems*, *38*(3), e12667. https://doi.org/10.1111/exsy.12667

*Fidan, M., & Gencel, N. (2022). Supporting the instructional videos with chatbot and peer feedback mechanisms in online learning: The effects on learning performance and intrinsic motivation. *Journal of Educational Computing Research*, *07356331221077901*, 1–26. http://doi.org/10.1177/07356331221077901

*Fryer, L. K., Ainley, M., Thompson, A., Gibson, A., & Sherlock, Z. (2017). Stimulating and sustaining interest in a language course: An experimental comparison of chatbot and human task partners. *Computers in Human Behavior*, 461–468. https://doi.org/10.1016/j.chb.2017.05.045

Hammad, R., Khan, Z., Safieddine, F., & Ahmed, A. (2020). A review of learning theories and models underpinning technology-enhanced learning artefacts. *World Journal of Science, Technology and Sustainable Development*, *17*(4), 341–354. https://doi.org/10.1108/WJSTSD-06-2020-0062

Heller, B., Proctor, M., Mah, D., Jewell, L., & Cheung, B. (2005, June). Freudbot: An investigation of chatbot technology in distance education. In *EdMedia+ Innovate Learning* (pp. 3913–3918). Association for the Advancement of Computing in Education (AACE).

*Hsieh, S. W. (2011). Effects of cognitive styles on an MSN virtual learning companion system as an adjunct to classroom instructions. *Journal of Educational Technology & Society*, *14*(2), 161–174. https://doi.org/10.2307/jeductechsoci.14.2.161

*Hsu, M. H., Chen, P. S., & Yu, C. S. (2021). Proposing a task-oriented chatbot system for EFL learners speaking practice. *Interactive Learning Environments*, 1–12. https://doi.org/10.1080/10494820.2021.1960864

*Huang, W., Hew, K. F., & Gonda, D. E. (2019). Designing and evaluating three chatbot-enhanced activities for a flipped graduate course. *International Journal of Mechanical Engineering and Robotics Research*, *8*(5), 813–818. https://doi.org/10.18178/ijmerr.8.5.813-818

Huang, W., Hew, K. F., & Fryer, L. K. (2022). Chatbots for language learning—Are they really useful? A systematic review of chatbot-supported language learning. *Journal of Computer Assisted Learning*, *38*(1), 237–257. https://doi.org/10.1111/jcal.12610

Hwang, G. J., & Chang, C. Y. (2021). A review of opportunities and challenges of chatbots in education. *Interactive Learning Environments*, 1–14. https://doi.org/10.1080/10494820.2021.1952615

*Jeon, J. (2021). Chatbot-assisted dynamic assessment (CA-DA) for L2 vocabulary learning and diagnosis. *Computer Assisted Language Learning*, 1–27. https://doi.org/10.1080/09588221.2021.1987272

*Jeon, J. (2022). Exploring a self-directed interactive app for informal EFL learning: A self-determination theory perspective. *Education and Information Technologies*, 1–21. https://doi.org/10.1007/s10639-021-10839-y

*Katchapakirin, K., Anutariya, C., & Supnithi, T. (2022). ScratchThAI: A conversation-based learning support framework for computational thinking development. *Education and Information Technologies*, 1–28. https://doi.org/10.1007/s10639-021-10870-z

*Kong, J. S., See, B., Teo, Y. J., Lee, P., Bharath, A., Lee, E. J., & Sng, J. C. (2021). Virtual integrated patient: An AI supplementary tool for second-year medical students. *The Asia Pacific Scholar*, 87–90. https://doi.org/10.29060/TAPS.2021-6-3/SC2394

*Kowalski, S., Pavlovska, K., & Goldstein, M. (2013). Two case studies in using chatbots for security training. In R. C. Dodge Jr, & L. Futcher (Eds.), *Information assurance and security education and training* (pp. 265–272). Springer.

*Kumar, J. A. (2021). Educational chatbots for project-based learning: Investigating learning outcomes for a team-based design course. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–28. https://doi.org/10.1186/s41239-021-00302-w

Lee, J. H., Yang, H., Shin, D., & Kim, H. (2020). Chatbots. *ELT Journal*, *74*(3), 338–344. https://doi.org/10.1093/elt/ccaa035

*Lin, M. P. C., & Chang, D. (2020). Enhancing post-secondary writers' writing skills with a chatbot. *Journal of Educational Technology & Society*, *23*(1), 78–92. https://doi.org/10.2307/26915408

*Lin, C. J., & Mubarok, H. (2021). Learning analytics for investigating the mind Map-guided AI chatbot approach in an EFL flipped speaking classroom. *Educational Technology & Society*, *24*(4), 16–35. https://www.jstor.org/stable/48629242

Mayer, R. (2001). *Multimedia-enhanced learning*. Cambridge University Press.

Mayer, R. E. (2014). Multimedia instruction. In J. M. Spector, M. D. Merrill, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (pp. 375–399). Springer.

*Mellado-Silva, R., Faúndez-Ugalde, A., & Blanco-Lobos, M. (2020). Effective learning of tax regulations using different chatbot techniques. *Advances in Science, Technology and Engineering Systems Journal*, *5*(6), 439–446. https://doi.org/10.25046/aj050652

*Mokmin, N. A. M., & Ibrahim, N. A. (2021). The evaluation of chatbot as a tool for health literacy education among undergraduate students. *Education and Information Technologies*, *26*(5), 6033–6049. https://doi.org/10.1007/s10639-021-10542-y

*Nadarzynski, T., Puentes, V., Pawlak, I., Mendes, T., Montgomery, I., Bayley, J., … Newman, C. (2021). Barriers and facilitators to engagement with artificial intelligence (AI)-based chatbots for sexual and reproductive health advice: A qualitative analysis. *Sexual Health*, *18*(5), 385–393. https://doi.org/10.1071/SH21123

*Nghi, T. T., Phuc, T. H., & Thang, N. T. (2019). Applying AI chatbot for teaching a foreign language: An empirical research. *International Journal of Scientific and Technology Research*, *8*(12), 897–902. https://www.researchgate.net/profile/Tran-Nghi-4/publication/337965319_Applying_Ai_Chatbot_For_Teaching_A_Foreign_Language_An_Empirical_Research/links/5df8434f4585159aa482f4a2/Applying-Ai-Chatbot-For-Teaching-A-Foreign-Language-An-Empirical-Research.pdf

Ouatu, B. I., & Gifu, D. (2021). *Chatbot, the future of learning?* In Ó. Mealha, M. Dascalu, & T. Di Mascio (Eds.), *Ludic, co-design and tools supporting smart learning ecosystems and smart education* (pp. 263–268). Springer.

*Pereira, J. (2016, November). Leveraging chatbots to improve self-guided learning through conversational quizzes. In *Proceedings of the fourth international conference on technological ecosystems for enhancing multiculturality* (pp. 911–918). Salamanca, Spain. https://doi.org/10.1145/3012430.3012625

Pérez, J. Q., Daradoumis, T., & Puig, J. M. M. (2020). Rediscovering the use of chatbots in education: A systematic literature review. *Computer Applications in Engineering Education*, *28*(6), 1549–1565. https://doi.org/10.1002/cae.22326
Perttula, A., Kiili, K., Lindstedt, A., & Tuomi, P. (2017). Flow experience in game based learning – a systematic literature review. *International Journal of Serious Games*, *4*(1), 57–72. https://doi.org/10.17083/ijsg.v4i1.151
Petri, H. L., & Govern, J. M. (2012). *Motivation: Theory, research, and application*. Cengage Learning.
Piaget, J. (1973). *To understand is to invent: The future of education*. Grossman.
Reinders, H., & White, C. (2016). 20 years of autonomy and technology: How far have we come and where to next? *Language Learning & Technology*, *20*(2), 143–154. http://llt.msu.edu/issues/june2016/reinderswhite.pdf
*Ruan, S., Jiang, L., Xu, J., Tham, B. J. K., Qiu, Z., Zhu, Y., … Landay, J. A. (2019a, May). Quizbot: A dialogue-based adaptive learning system for factual knowledge. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (pp. 1–13). Glasgow, Scotland, UK. https://doi.org/10.1145/3290605.3300587
*Ruan, S., Willis, A., Xu, Q., Davis, G. M., Jiang, L., Brunskill, E., & Landay, J. A. (2019b, June). Book buddy: Turning digital materials into interactive foreign language lessons through a voice chatbot. In *Proceedings of the Sixth (2019) ACM Conference on Learning@ Scale* (pp. 1–4). Chicago, IL, USA. https://doi.org/10.1145/3330430.3333643
*Ruan, S., He, J., Ying, R., Burkle, J., Hakim, D., Wang, A., … Landay, J. A. (2020, June). Supporting children's math learning with feedback-augmented narrative technology. In *Proceedings of the Interaction Design and Children Conference* (pp. 567–580). London, UK. https://doi.org/10.1145/3392063.3394400
*Ruan, S., Jiang, L., Xu, Q., Liu, Z., Davis, G. M., Brunskill, E., & Landay, J. A. (2021, April). EnglishBot: An AI-Powered conversational system for second language learning. In *26th International Conference on Intelligent User Interfaces* (pp. 434–444). College Station, TX, USA. https://doi.org/10.1145/3397481.3450648
*Schouten, D. G., Deneka, A. A., Theune, M., Neerincx, M. A., & Cremers, A. H. (2022). An embodied conversational agent coach to support societal participation learning by low-literate users. *Universal Access in the Information Society*, 1–27. https://doi.org/10.1007/s10209-021-00865-5
Smutny, P., & Schreiberova, P. (2020). Chatbots for learning: A review of educational chatbots for the Facebook messenger. *Computers & Education*, *151*, 103862. https://doi.org/10.1016/j.compedu.2020.103862
Swain, M. (1985). Communicative competence: Some roles of comprehensible input and comprehensible output in its development. In S. Gass, & C. Madden (Eds.), *Input and second language acquisition* (pp. 165–179). Newbury House.
*Tai, T. Y., & Chen, H. H. J. (2020). The impact of google assistant on adolescent EFL learners' willingness to communicate. *Interactive Learning Environments*, 1–18. https://doi.org/10.1080/10494820.2020.1841801
*Tandy, C., Vernon, R., & Lynch, D. (2017). Teaching note—teaching student interviewing competencies through second life. *Journal of Social Work Education*, *53*(1), 66–71. https://doi.org/10.1080/10437797.2016.1198292
*Tegos, S., Demetriadis, S., Psathas, G., & Tsiatsos, T. (2019, November). A configurable agent to advance peers' productive dialogue in MOOCs. In A. Følstad, T. Araujo, S. Papadopoulos, E.L.C. Law, O Granmo, E. Luger, & P.B. Brandtzaeg (Eds.), *International workshop on chatbot research and design* (pp. 245–259). Springer.
*Tseng, H. T., Huang, L. K., & Hsieh, C. C. (2020, July). No more fear of every snake: Applying chatbot-Based learning system for snake knowledge promotion improvement: A regional snake knowledge learning system. In 2020 *IEEE 20th International Conference on Advanced Learning Technologies (ICALT)* (pp. 72–76). IEEE. https://doi.org/10.1109/ICALT49669.2020.00029
*Vázquez-Cano, E., Mengual-Andrés, S., & López-Meneses, E. (2021). Chatbot to improve learning punctuation in Spanish and to enhance open and flexible learning environments. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–20. https://doi.org/10.1186/s41239-021-00269-8
*Vijayakumar, B., Höhn, S., & Schommer, C. (2018, December). Quizbot: Exploring formative feedback with conversational interfaces. In *International Conference on Technology Enhanced Assessment* (pp. 102–120). Springer, Cham.
*Wambsganss, T., Küng, T., Söllner, M., & Leimeister, J. M. (2021, May 8–13). Arguetutor: an adaptive dialog-based learning system for argumentation skills. In *Proceedings of the 2021 CHI conference on human factors in computing systems* (pp. 1–13), Yokohama, Japan.
*Wang, Y. F., Petrina, S., & Feng, F. (2017). VILLAGE—virtual immersive language learning and gaming environment: Immersion and presence. *British Journal of Educational Technology*, *48*(2), 431–450. https://doi.org/10.1111/bjet.12388
*Yin, J., Goh, T. T., Yang, B., & Xiaobin, Y. (2021). Conversation technology with micro-learning: The impact of chatbot-based learning on students' learning motivation and performance. *Journal of Educational Computing Research*, *59*(1), 154–177. https://doi.org/10.1177/0735633120952067
*Yuan, C. C., Li, C. H., & Peng, C. C. (2021). Development of mobile interactive courses based on an artificial intelligence chatbot on the communication software LINE. *Interactive Learning Environments*, 1–15. https://doi.org/10.1080/10494820.2021.1937230
Zhang, R., & Zou, D. (2022). Types, purposes, and effectiveness of state-of-the-art technologies for second and foreign language learning. *Computer Assisted Language Learning*, 1–47. https://doi.org/10.1080/09588221.2020.1744666
Zhang, R., & Zou, D. (2021). Digital multimodal composing in post-secondary L2 settings: A review of the empirical landscape. *Computer Assisted Language Learning*, 1–28. https://doi.org/10.1080/09588221.2021.1942068

Zou, D., Xie, H., & Wang, F. L. (2018). Future trends and research issues of technology-enhanced language learning: A technological perspective. *Knowledge Management & E-Learning: An International Journal*, *10*(4), 426–440. https://files.eric.ed.gov/fulltext/EJ1247632.pdf

Zou, D., Zhang, R., Xie, H., & Wang, F. L. (2021). Digital game-based learning of information literacy: Effects of gameplay modes on university students' learning performance, motivation, self-efficacy and flow experiences. *Australasian Journal of Educational Technology*, *37*(2), 152–170. https://doi.org/10.14742/ajet.6682

Appendix. Pedagogies and implementations of chatbot-assisted learning in the reviewed studies.

Authors	Pedagogical approaches in chatbot-assisted learning		Implementations of chatbot-assisted learning			
	Chatbot features	Learning activities	Lengths	Contexts	Discipline	Outcomes
Allameh and Zaman (2021)	Answering students' questions; Presenting learning materials (suggestions and recommendations) according to students' performance.	Digital board game play	One session	In-class learning	Digital Board Games	Chatbot enhanced learning experiences and knowledge of board game rules.
Bailey et al. (2021)	Presenting learning materials (library of stories of various genres) according to students' output; Asking guiding questions to facilitate students' output; Answering students' questions; Telling jokes.	Autonomous storytelling	Intermediate-term (five weeks)	Out-of-class learning	Foreign language (English)	Chatbots enhanced learner self-efficacy.
Berns et al. (2018)	Asking guiding questions to facilitate students' output; Presenting learning materials (instructional videos) according to students' output; Making casual conversations.	Roleplaying activity in an immersive learning environment	One session	In-class immersive learning	Foreign language (German)	Chatbots enhanced learning experiences.
Cai et al. (2020)	Evaluating students' performance in activities and providing immediate feedback; Scoring students.	Drama playing activity	Short-term (four weeks)	In-class immersive learning	Foreign language (Japanese)	Chatbots enhanced speaking proficiency, motivation, and learning interest.
Cai et al. (2021)	Asking content-related questions to trigger students' knowledge retrieval and application; Presenting exercises and quizzes according to students' output; Evaluating students' performance in activities and providing immediate feedback; Encouraging and rewarding students.	Instruction plus exercises	One session	n/a	Math (arithmetic sequences)	Chatbot enhanced math knowledge, although not statistically significant.
Chang et al. (2022)	Presenting learning materials; Answering students' questions	Instruction	One session	In-class learning	Medical (Nursing)	Chatbots enhanced vaccine knowledge and self-efficacy.
Chen, Chen, et al. (2020)	Presenting learning materials (vocabulary lists) according to students' output; Presenting different levels of exercises according to students' output; Evaluating students' performance in exercises and providing immediate feedback.	Instruction plus exercises	Short-term (four weeks)	In-class learning with teacher scaffolding	Foreign language (Chinese)	Chatbots enhanced vocabulary knowledge and learning experiences.
Chen et al. (2021)	Presenting learning materials according to students' output; Presenting different levels of exercises according to students' output; Asking content-related questions to trigger students' knowledge retrieval and application; Evaluating students' performance in activities and providing immediate feedback according to students' output.	Instruction plus exercises	n/a (30 lessons for about 100 hours)	In-class learning	Native language (reading comprehension)	Chatbots enhanced reading comprehension skills.

Chien and Yao (2020)	Asking design-related questions to trigger students' knowledge retrieval and application; Answering students' questions.	Collaborative product design exercise in groups of four	One session	In-class learning	Communication for special purposes	Chatbots enhanced communication skills, design proficiency, and learning engagement.
Deveci Topal et al. (2021)	Presenting learning materials (reading materials, instructional videos, etc.); Making casual conversations and telling jokes; Answering students' questions.	Instruction plus exercises	n/a (30 lessons for about 100 hours)	Out-of-class learning	Nature Science (Physics)	Chatbots enhanced learning experiences. Chatbots had no significant effects on physics knowledge.
Diachenko et al. (2019)	Presenting learning materials (vocabulary lists and grammatical knowledge points) and suggestions for future study; Presenting exercises and quizzes; Evaluating students' performance in exercises and quizzes and providing immediate feedback; Explaining knowledge points with different levels according to students' output; Answering students' questions; Encouraging and rewarding students.	Instruction plus exercises	n/a (ten lessons)	In-class learning	Foreign language (Latin)	Chatbots enhanced grammar and vocabulary knowledge, reading proficiency, and motivation.
Divekar et al. (2021)	Asking content-related questions to trigger students' knowledge retrieval and application; Answering students' questions.	Roleplaying activities in pairs in an immersive learning environment.	Two sessions	In-class immersive learning	Foreign language (Chinese)	Chatbots enhanced vocabulary, listening, comprehension, conversational proficiency, self-efficacy, and learning experience.
El Shazly (2021)	Presenting learning materials; Asking guiding questions to facilitate students' output; Answering students' questions.	Instruction plus exercises (practising speaking via interactions with chatbots)	Short-term (four weeks)	In-class learning	Foreign language (English)	Chatbots enhanced speaking proficiency but worsened learner anxiety.
Fidan and Gencel (2022)	Presenting learning materials (suggestions and guidance) according to students' output; Asking content-related questions to trigger students' knowledge retrieval and application; Evaluating students' performance in exercises and providing immediate feedback; Answering students' questions.	Instructions	Short-term (four weeks)	In-class learning	Education	Chatbots enhanced knowledge about education and intrinsic motivation.
Fryer et al. (2017)	Asking guiding questions to facilitate students' output; Answering students' questions.	Exercises (practising speaking via interactions with chatbots)	Short-term (three weeks)	In-class learning	Foreign language (English)	Chatbots enhanced learning interest but only for a short time.
Hsieh (2011)	Presenting learning materials and related learning resources (a webpage of supplementary related materials); Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback.	Instructions	Long-term (12 weeks)	In-class learning	Computer science	Chatbots enhanced knowledge about Microsoft systems.

(*Continued*)

Continued.

Authors	Pedagogical approaches in chatbot-assisted learning		Implementations of chatbot-assisted learning			
	Chatbot features	Learning activities	Lengths	Contexts	Discipline	Outcomes
Hsu et al. (2021)	Presenting learning materials (live broadcasts); Presenting exercises according to students' output; Evaluating students' performance in exercises and providing immediate feedback.	Instruction plus exercises	Long-term (16 weeks)	In-class learning	Foreign language (English)	Chatbots enhanced speaking proficiency and reduced anxiety.
Huang et al. (2019)	Presenting exercises and quizzes; Evaluating students' performance in exercises and quizzes and providing immediate feedback; Explaining knowledge points according to students' output; Encouraging students; Asking guiding questions to trigger students' knowledge retrieval and application; Answering students' questions.	Exercises	One session	In-class learning	Education	Chatbots had mixed (positive and negative) effects on learning experiences.
Jeon (2021)	Presenting learning materials; Asking guiding questions to facilitate students' output; Presenting exercises and quizzes depending on learners' output; Evaluating students' performance in exercises and quizzes and providing immediate feedback.	Exercises	Two sessions	In-class learning	Foreign language (English)	Chatbots enhanced vocabulary knowledge
Jeon (2022)	Presenting exercises and quizzes; Evaluating students' performance in exercises and providing immediate feedback; Scoring and ranking students; Encouraging and praising students according to students' output; Making casual conversations and telling jokes.	Exercises (practising speaking via interactions with chatbots)	Intermediate-term (eight weeks)	In-class learning	Foreign language (English)	Chatbots enhanced perceived speaking proficiency and learning experiences (perceived relatedness).
Katchapakirin et al. (2022)	Presenting learning materials and suggestions according to students' output; Presenting exercises and quizzes depending on learners' output; Evaluating students' performance in exercises and quizzes and providing immediate feedback; Making casual conversations and telling jokes.	Instruction plus exercises	Short-term (two days)	In-class learning	Computational thinking (Scratch coding)	Chatbots enhanced coding knowledge, motivation, and engagement in learning.
Kong et al. (2021)	Asking guiding questions to trigger students' knowledge retrieval and application; Answering students' questions.	Roleplaying activity	Short-term (three weeks)	In-class learning	Medical (Clinical skills)	Chatbots enhanced clinical skills and confidence in learning.
Kowalski et al. (2013)	Answering students' questions; Presenting learning materials.	Instructions	Short-term (two weeks)	n/a	Computer science	Chatbots had neutral effects on the development of IT security knowledge.
Kumar (2021)	Explaining knowledge points according to students' output; Asking guiding questions to facilitate students' output; Evaluating students'	Collaborative product design activity	Intermediate-term (ten weeks)	In-class learning	Communication for special purposes (team-based design)	Chatbots enhanced communication in team-based design projects.

	performance in exercises and quizzes and providing immediate feedback; Encouraging students.					Chatbots had neutral effects on motivation and self-efficacy.
Lin and Chang (2020)	Presenting learning materials and suggestions according to students' output; Asking guiding questions to trigger students' knowledge retrieval and application; Answering students' questions.	Writing project	Short-term (two weeks)	In-class learning scaffolded by peer feedback and teacher support	Writing	Chatbots enhanced writing proficiency and learning experiences.
Lin and Mubarok (2021)	Presenting learning materials; Recording practising process; Asking guiding questions to trigger students' knowledge retrieval and application; Making casual conversations.	Exercises (practising speaking via interactions with chatbots)	Intermediate-term (five weeks)	Out-of-class learning	Foreign language (English)	Chatbots enhanced speaking proficiency.
Mellado-Silva et al. (2020)	Presenting learning materials; Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback.	Instruction plus exercises	One session	In-class learning	Law	Chatbots enhanced knowledge of tax regulation.
Mokmin and Ibrahim (2021)	Presenting learning materials.	Instructions	Intermediate-term (eight weeks)	In-class learning	Health literacy	Chatbots enhanced health knowledge.
Nadarzynski et al. (2021)	Presenting instructional materials. Answering students' questions.	Instruction plus exercises	One session	n/a	Health literacy	Chatbots enhanced knowledge about sexual health.
Nghi et al. (2019)	Presenting learning materials.	Instructions	n/a (ten lessons)	In-class learning	Foreign language (English)	Chatbots enhanced grammar knowledge (proposition) and learning experiences.
Pereira (2016)	Presenting exercises according to students' output; Evaluating students' performance in exercises and providing immediate feedback; Explaining knowledge points according to students' output.	Exercises	Long-term (15 weeks)	In-class learning	Computer science	Chatbots enhanced integrated knowledge and skills of computer science and learning engagement.
Ruan et al. (2019a)	Presenting learning materials and learning resources according to students' output; Presenting exercises according to students' output; Evaluating students' performance in exercises and providing immediate feedback; Encouraging and praising students according to students' output; Telling jokes; Making casual conversations.	Exercises	One session	In-class learning	Science, safety, foreign language (English)	Chatbots enhanced knowledge and skills of science and safety, vocabulary knowledge, and learning engagement.
Ruan et al. (2019b)	Presenting learning materials according to students' output; Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback; Answering students' questions.	Book reading activity	One session	In-class learning	Foreign language (English)	Chatbots enhanced learning experiences and learning engagement.

(Continued)

Continued.

Authors	Pedagogical approaches in chatbot-assisted learning		Implementations of chatbot-assisted learning			
	Chatbot features	Learning activities	Lengths	Contexts	Discipline	Outcomes
Ruan et al. (2020)	Presenting learning materials and suggestions; Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback; Asking guiding questions to trigger students' knowledge retrieval and application; Encouraging students; Making casual conversations.	Instruction plus exercises	Two sessions	In-class learning	Math	Chatbots enhanced knowledge of volume and learning experiences.
Ruan et al. (2021)	Presenting learning materials (vocabulary lists); Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback; Scoring students.	Instruction plus exercises (practising speaking via interactions with chatbots)	Short-term (six days)	In-class learning	Foreign language (English)	Chatbots enhanced speaking proficiency, self-efficacy, motivation, and learning engagement.
Schouten et al. (2022)	Presenting learning materials and suggestions according to students' output; Presenting exercises; Explaining knowledge points according to students' output; Encouraging students.	Instruction plus exercise in an immersive learning environment	One session	In-class learning	Communication for special purposes (online banking)	Chatbots enhanced learning experiences (self-efficacy, affective states).
Tai and Chen (2020)	Asking guiding questions to facilitate students' output; Answering students' questions.	Exercise (via human-computer interactions)	Short-term (two weeks)	In-class learning	Foreign language (English)	Chatbots enhanced the wiliness to communicate and learning engagement.
Tandy et al. (2017)	Asking guiding questions to trigger students' knowledge retrieval and application; Answering students' questions.	Roleplaying activity in an immersive learning environment	One session	In-class learning	Communication for special purposes	Chatbots enhanced communication skills and learning experiences.
Tegos et al. (2019)	Asking guiding questions to facilitate students' output.	Open-ended debates in pairs	One session	In-class learning	Computer science	Chatbots enhanced learning experiences.
Tseng et al. (2020)	Presenting learning materials and learning sources according to students' output; Answering students' questions; Asking guiding questions to trigger students' knowledge retrieval and application.	Instruction plus exercises	One session	In-class learning scaffolded by teachers	Biology	Chatbots enhanced knowledge of snakes and learning experiences.
Vázquez-Cano et al. (2021)	Presenting exercises and quizzes depending on learners' output; Evaluating students' performance in exercises and providing immediate feedback.	Instruction plus exercises	Short-term (two weeks)	Blended learning	Foreign language (Spanish)	Chatbots enhanced punctuation knowledge and motivation.
Vijayakumar et al. (2018)	Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback; Asking guiding questions to facilitate students' output; Encouraging and praising students according to students' output; Score students.	Exercises	One session	In-class learning	Computer science	Chatbots enhanced learner motivation.

Wambsganss et al. (2021)	Presenting learning materials; Presenting exercises; Evaluating students' performance in exercises and providing immediate feedback; Explaining knowledge points according to students' output; Scoring students; Making casual conversations and telling jokes.	Writing project	One session	In-class learning	Writing (argumentation skills)	Chatbots enhanced writing proficiency from the argumentative aspect.
Wang et al. (2017)	Answering students' questions.	Roleplaying game-based learning activity in an immersive environment	One session	In-class learning	Foreign language (English)	Chatbots enhanced learning experiences (flow experiences in learning).
Yin et al. (2021)	Presenting learning materials (instructional videos) according to students' output; Presenting exercises according to students' output; Evaluating students' performance in exercises and providing immediate feedback; Answering students' questions; Encouraging and praising students according to students' output.	Instruction plus exercises	One session	In-class learning	Computer science	Chatbots enhanced knowledge of number system conversion and motivation.
Yuan et al. (2021)	Presenting learning materials; Asking guiding questions to trigger students' knowledge retrieval and application; Evaluating students' performance in exercises and providing immediate feedback; Explaining knowledge points according to students' output; Encouraging and awarding students.	Instruction plus exercises	Short-term (two to three weeks)	In-class learning	Digital literacy	Chatbots enhanced knowledge of aircraft maintenance.