Discover Education

A systematic literature review of empirical research on ChatGPT in education

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Abstract

Over the last four decades, studies have investigated the incorporation of Artificial Intelligence (AI) into education. A recent prominent AI-powered technology that has impacted the education sector is ChatGPT. This article provides a systematic review of 14 empirical studies incorporating ChatGPT into various educational settings, published in 2022 and before the 10th of April 2023—the date of conducting the search process. It carefully followed the essential steps outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, as well as Okoli's (Okoli in Commun Assoc Inf Syst, 2015) steps for conducting a rigorous and transparent systematic review. In this review, we aimed to explore how students and teachers have utilized ChatGPT in various educational settings, as well as the primary findings of those studies. By employing Creswell's (Creswell in Educational research: planning, conducting, and evaluating quantitative and qualitative research [Ebook], Pearson Education, London, 2015) coding techniques for data extraction and interpretation, we sought to gain insight into their initial attempts at ChatGPT incorporation into education. This approach also enabled us to extract insights and considerations that can facilitate its effective and responsible use in future educational contexts. The results of this review show that learners have utilized ChatGPT as a virtual intelligent assistant, where it offered instant feedback, on-demand answers, and explanations of complex topics. Additionally, learners have used it to enhance their writing and language skills by generating ideas, composing essays, summarizing, translating, paraphrasing texts, or checking grammar. Moreover, learners turned to it as an aiding tool to facilitate their directed and personalized learning by assisting in understanding concepts and homework, providing structured learning plans, and clarifying assignments and tasks. However, the results of specific studies (n = 3, 21.4%) show that overuse of ChatGPT may negatively impact innovative capacities and collaborative learning competencies among learners. Educators, on the other hand, have utilized ChatGPT to create lesson plans, generate quizzes, and provide additional resources, which helped them enhance their productivity and efficiency and promote different teaching methodologies. Despite these benefits, the majority of the reviewed studies recommend the importance of conducting structured training, support, and clear guidelines for both learners and educators to mitigate the drawbacks. This includes developing critical evaluation skills to assess the accuracy and relevance of information provided by ChatGPT, as well as strategies for integrating human interaction and collaboration into learning activities that involve AI tools. Furthermore, they also recommend ongoing research and proactive dialogue with policymakers, stakeholders, and educational practitioners to refine and enhance the use of AI in learning environments. This review could serve as an insightful resource for practitioners who seek to integrate ChatGPT into education and stimulate further research in the field.

Keywords Artificial intelligence · Large language models · ChatGPT · Education · Educational technology · Systematic review

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Abbreviations

AI	Artificial intelligence
AIEd	AI in education
LLM	Large language model
ANNs	Artificial neural networks
ChatGPT	Chat Generative Pre-Trained Transformer
RNNs	Recurrent neural networks
LSTM	Long short-term memory
RLHF	Reinforcement learning from human feedback
NLP	Natural language processing
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

1 Introduction

Educational technology, a rapidly evolving field, plays a crucial role in reshaping the landscape of teaching and learning [82]. One of the most transformative technological innovations of our era that has influenced the field of education is Artificial Intelligence (AI) [50]. Over the last four decades, AI in education (AIEd) has gained remarkable attention for its potential to make significant advancements in learning, instructional methods, and administrative tasks within educational settings [11]. In particular, a large language model (LLM), a type of AI algorithm that applies artificial neural networks (ANNs) and uses massively large data sets to understand, summarize, generate, and predict new content that is almost difficult to differentiate from human creations [79], has opened up novel possibilities for enhancing various aspects of education, from content creation to personalized instruction [35]. Chatbots that leverage the capabilities of LLMs to understand and generate human-like responses have also presented the capacity to enhance student learning and educational outcomes by engaging students, offering timely support, and fostering interactive learning experiences [46].

The ongoing and remarkable technological advancements in chatbots have made their use more convenient, increasingly natural and effortless, and have expanded their potential for deployment across various domains [70]. One prominent example of chatbot applications is the Chat Generative Pre-Trained Transformer, known as ChatGPT, which was introduced by OpenAI, a leading AI research lab, on November 30th, 2022. ChatGPT employs a variety of deep learning techniques to generate human-like text, with a particular focus on recurrent neural networks (RNNs). Long short-term memory (LSTM) allows it to grasp the context of the text being processed and retain information from previous inputs. Also, the transformer architecture, a neural network architecture based on the self-attention mechanism, allows it to analyze specific parts of the input, thereby enabling it to produce more natural-sounding and coherent output. Additionally, the unsupervised generative pre-training and the fine-tuning methods allow ChatGPT to generate more relevant and accurate text for specific tasks [31, 62]. Furthermore, reinforcement learning from human feedback (RLHF), a machine learning approach that combines reinforcement learning techniques with human-provided feedback, has helped improve ChatGPT's model by accelerating the learning process and making it significantly more efficient.

This cutting-edge natural language processing (NLP) tool is widely recognized as one of today's most advanced LLMs-based chatbots [70], allowing users to ask questions and receive detailed, coherent, systematic, personalized, convincing, and informative human-like responses [55], even within complex and ambiguous contexts [63, 77]. ChatGPT is considered the fastest-growing technology in history: in just three months following its public launch, it amassed an estimated 120 million monthly active users [16] with an estimated 13 million daily queries [49], surpassing all other applications [64]. This remarkable growth can be attributed to the unique features and user-friendly interface that ChatGPT offers. Its intuitive design allows users to interact seamlessly with the technology, making it accessible to a diverse range of individuals, regardless of their technical expertise [78]. Additionally, its exceptional performance results from a combination of advanced algorithms, continuous enhancements, and extensive training on a diverse dataset that includes various text sources such as books, articles, websites, and online forums [63], have contributed to a more engaging and satisfying user experience [62]. These factors collectively explain its remarkable global growth and set it apart from predecessors like Bard, Bing Chat, ERNIE, and others.

In this context, several studies have explored the technological advancements of chatbots. One noteworthy recent research effort, conducted by Schöbel et al. [70], stands out for its comprehensive analysis of more than 5,000 studies on communication agents. This study offered a comprehensive overview of the historical progression and future prospects

of communication agents, including ChatGPT. Moreover, other studies have focused on making comparisons, particularly between ChatGPT and alternative chatbots like Bard, Bing Chat, ERNIE, LaMDA, BlenderBot, and various others. For example, O'Leary [53] compared two chatbots, LaMDA and BlenderBot, with ChatGPT and revealed that ChatGPT outperformed both. This superiority arises from ChatGPT's capacity to handle a wider range of questions and generate slightly varied perspectives within specific contexts. Similarly, ChatGPT exhibited an impressive ability to formulate interpretable responses that were easily understood when compared with Google's feature snippet [34]. Additionally, ChatGPT was compared to other LLMs-based chatbots, including Bard and BERT, as well as ERNIE. The findings indicated that ChatGPT exhibited strong performance in the given tasks, often outperforming the other models [59].

Furthermore, in the education context, a comprehensive study systematically compared a range of the most promising chatbots, including Bard, Bing Chat, ChatGPT, and Ernie across a multidisciplinary test that required higher-order thinking. The study revealed that ChatGPT achieved the highest score, surpassing Bing Chat and Bard [64]. Similarly, a comparative analysis was conducted to compare ChatGPT with Bard in answering a set of 30 mathematical questions and logic problems, grouped into two question sets. Set (A) is unavailable online, while Set (B) is available online. The results revealed ChatGPT's superiority in Set (A) over Bard. Nevertheless, Bard's advantage emerged in Set (B) due to its capacity to access the internet directly and retrieve answers, a capability that ChatGPT does not possess [57]. However, through these varied assessments, ChatGPT consistently highlights its exceptional prowess compared to various alternatives in the ever-evolving chatbot technology.

The widespread adoption of chatbots, especially ChatGPT, by millions of students and educators, has sparked extensive discussions regarding its incorporation into the education sector [64]. Accordingly, many scholars have contributed to the discourse, expressing both optimism and pessimism regarding the incorporation of ChatGPT into education. For example, ChatGPT has been highlighted for its capabilities in enriching the learning and teaching experience through its ability to support different learning approaches, including adaptive learning, personalized learning, and self-directed learning [58, 60, 91]), deliver summative and formative feedback to students and provide real-time responses to questions, increase the accessibility of information [22, 40, 43], foster students' performance, engagement and motivation [14, 44, 58], and enhance teaching practices [17, 18, 64, 74].

On the other hand, concerns have been also raised regarding its potential negative effects on learning and teaching. These include the dissemination of false information and references [12, 23, 61, 85], biased reinforcement [47, 50], compromised academic integrity [18, 40, 66, 74], and the potential decline in students' skills [43, 61, 64, 74]. As a result, ChatGPT has been banned in multiple countries, including Russia, China, Venezuela, Belarus, and Iran, as well as in various educational institutions in India, Italy, Western Australia, France, and the United States [52, 90].

Clearly, the advent of chatbots, especially ChatGPT, has provoked significant controversy due to their potential impact on learning and teaching. This indicates the necessity for further exploration to gain a deeper understanding of this technology and carefully evaluate its potential benefits, limitations, challenges, and threats to education [79]. Therefore, conducting a systematic literature review will provide valuable insights into the potential prospects and obstacles linked to its incorporation into education. This systematic literature review will primarily focus on ChatGPT, driven by the aforementioned key factors outlined above.

However, the existing literature lacks a systematic literature review of empirical studies. Thus, this systematic literature review aims to address this gap by synthesizing the existing empirical studies conducted on chatbots, particularly ChatGPT, in the field of education, highlighting how ChatGPT has been utilized in educational settings, and identifying any existing gaps. This review may be particularly useful for researchers in the field and educators who are contemplating the integration of ChatGPT or any chatbot into education. The following research questions will guide this study:

- What are students' and teachers' initial attempts at utilizing ChatGPT in education?
- What are the main findings derived from empirical studies that have incorporated ChatGPT into learning and teaching?

2 Methodology

To conduct this study, the authors followed the essential steps of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) and Okoli's [54] steps for conducting a systematic review. These included identifying the study's purpose, drafting a protocol, applying a practical screening process, searching the literature, extracting relevant data, evaluating the quality of the included studies, synthesizing the studies, and ultimately writing the review. The subsequent section provides an extensive explanation of how these steps were carried out in this study.

2.1 Identify the purpose

Given the widespread adoption of ChatGPT by students and teachers for various educational purposes, often without a thorough understanding of responsible and effective use or a clear recognition of its potential impact on learning and teaching, the authors recognized the need for further exploration of ChatGPT's impact on education in this early stage. Therefore, they have chosen to conduct a systematic literature review of existing empirical studies that incorporate ChatGPT into educational settings. Despite the limited number of empirical studies due to the novelty of the topic, their goal is to gain a deeper understanding of this technology and proactively evaluate its potential benefits, limitations, challenges, and threats to education. This effort could help to understand initial reactions and attempts at incorporating ChatGPT into education and bring out insights and considerations that can inform the future development of education.

2.2 Draft the protocol

The next step is formulating the protocol. This protocol serves to outline the study process in a rigorous and transparent manner, mitigating researcher bias in study selection and data extraction [88]. The protocol will include the following steps: generating the research question, predefining a literature search strategy, identifying search locations, establishing selection criteria, assessing the studies, developing a data extraction strategy, and creating a timeline.

2.3 Apply practical screen

The screening step aims to accurately filter the articles resulting from the searching step and select the empirical studies that have incorporated ChatGPT into educational contexts, which will guide us in answering the research questions and achieving the objectives of this study. To ensure the rigorous execution of this step, our inclusion and exclusion criteria were determined based on the authors' experience and informed by previous successful systematic reviews [21]. Table 1 summarizes the inclusion and exclusion criteria for study selection.

2.4 Literature search

We conducted a thorough literature search to identify articles that explored, examined, and addressed the use of ChatGPT in Educational contexts. We utilized two research databases: Dimensions.ai, which provides access to a large number of research publications, and lens.org, which offers access to over 300 million articles, patents, and other research outputs from diverse sources. Additionally, we included three databases, Scopus, Web of Knowledge, and ERIC, which contain relevant research on the topic that addresses our research questions. To browse and identify relevant articles, we used the following search formula: ("ChatGPT" AND "Education"), which included the Boolean operator "AND" to get more specific results. The subject area in the Scopus and ERIC databases were narrowed to "ChatGPT" and "Education" keywords, and in the WoS database was limited to the "Education" category. The search was conducted between the 3rd and 10th of April 2023, which resulted in 276 articles from all selected databases (111 articles from Dimensions.ai, 65 from Scopus, 28 from Web of Science, 14 from ERIC, and 58 from Lens.org). These articles were imported into the Rayyan web-based system for analysis. The duplicates were identified automatically by the system. Subsequently, the first author manually reviewed the duplicated articles ensured that they had the same content, and then removed them, leaving us with 135 unique articles. Afterward, the titles, abstracts, and keywords of the first 40 manuscripts were scanned and reviewed by

	Criterion	Inclusion	Exclusion
Table 1 Inclusion and exclusion criteria for article selection	Article Topic	Incorporate ChatGPT into educational contexts	Don't incorporate ChatGPT into educational contexts
	Article Type	Empirical Studies	Non-empirical studies, editorials, commentaries, conference abstracts, and opinion papers
	Article Publication	Published and peer-reviewed	Unpublished or pre-printed
	Article Availability	Available as full text	Not available
	Article Language	English	Non-english

the first author and were discussed with the second and third authors to resolve any disagreements. Subsequently, the first author proceeded with the filtering process for all articles and carefully applied the inclusion and exclusion criteria as presented in Table 1. Articles that met any one of the exclusion criteria were eliminated, resulting in 26 articles. Afterward, the authors met to carefully scan and discuss them. The authors agreed to eliminate any empirical studies solely focused on checking ChatGPT capabilities, as these studies do not guide us in addressing the research questions and achieving the study's objectives. This resulted in 14 articles eligible for analysis.
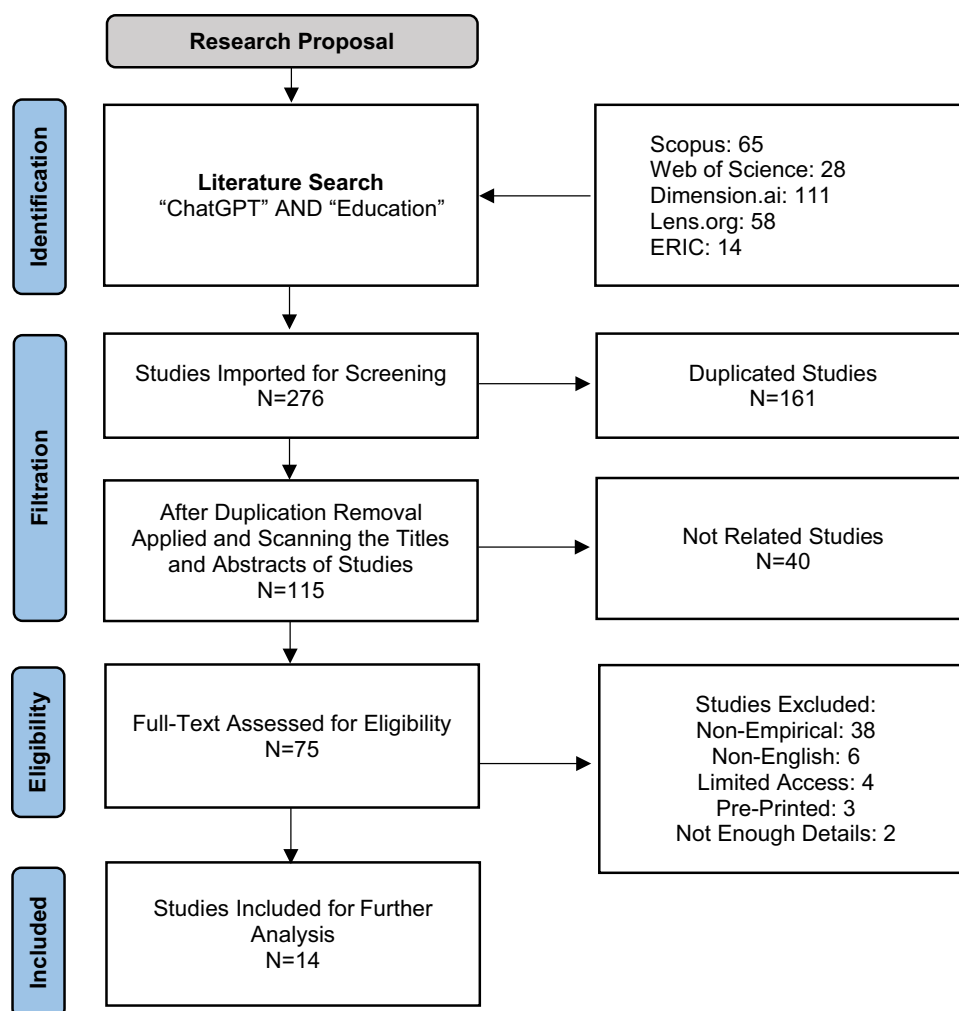
2.5 Quality appraisal

The examination and evaluation of the quality of the extracted articles is a vital step [9]. Therefore, the extracted articles were carefully evaluated for quality using Fink's [24] standards, which emphasize the necessity for detailed descriptions of methodology, results, conclusions, strengths, and limitations. The process began with a thorough assessment of each study's design, data collection, and analysis methods to ensure their appropriateness and comprehensive execution. The clarity, consistency, and logical progression from data to results and conclusions were also critically examined. Potential biases and recognized limitations within the studies were also scrutinized. Ultimately, two articles were excluded for failing to meet Fink's criteria, particularly in providing sufficient detail on methodology, results, conclusions, strengths, or limitations. The review process is illustrated in Fig. 1.

2.6 Data extraction

The next step is data extraction, the process of capturing the key information and categories from the included studies. To improve efficiency, reduce variation among authors, and minimize errors in data analysis, the coding categories were constructed using Creswell's [15] coding techniques for data extraction and interpretation. The coding process involves three sequential steps. The initial stage encompasses *open coding*, where the researcher examines the data, generates codes to describe and categorize it, and gains a deeper understanding without preconceived ideas. Following open coding is *axial coding*, where the interrelationships between codes from open coding are analyzed to establish more comprehensive categories or themes. The process concludes with *selective coding*, refining and integrating categories or themes to identify core concepts emerging from the data. The first coder performed the coding process, then engaged in discussions with the second and third authors to finalize the coding categories for the first five articles. The first coder then proceeded to code all studies and engaged again in discussions with the other authors to ensure the finalization of the coding process. After a comprehensive analysis and capturing of the key information from the included studies, the data extraction and interpretation process yielded several themes. These themes have been categorized and are presented in Table 2. It is important to note that open coding results were removed from Table 2 for aesthetic reasons, as it included many generic aspects, such as words, short phrases, or sentences mentioned in the studies.

2.7 Synthesize studies

In this stage, we will gather, discuss, and analyze the key findings that emerged from the selected studies. The synthesis stage is considered a transition from an author-centric to a concept-centric focus, enabling us to map all the provided information to achieve the most effective evaluation of the data [87]. Initially, the authors extracted data that included general information about the selected studies, including the author(s)' names, study titles, years of publication, educational levels, research methodologies, sample sizes, participants, main aims or objectives, raw data sources, and analysis methods. Following that, all key information and significant results from the selected studies were compiled using Creswell's [15] coding techniques for data extraction and interpretation to identify core concepts and themes emerging from the data, focusing on those that directly contributed to our research questions and objectives, such as the initial utilization of ChatGPT in learning and teaching, learners' and educators' familiarity with ChatGPT, and the main findings of each study. Finally, the data related to each selected study were extracted into an Excel spreadsheet for data processing. The Excel spreadsheet was reviewed by the authors, including a series of discussions to ensure the finalization of this process and prepare it for further analysis. Afterward, the final result being analyzed and presented in various types of charts and graphs. Table 4 presents the extracted data from the selected studies, with each study labeled with a capital 'S' followed by a number.

Fig. 1 The study selection process

3 Results

This section consists of two main parts. The first part provides a descriptive analysis of the data compiled from the reviewed studies. The second part presents the answers to the research questions and the main findings of these studies.

3.1 Part 1: descriptive analysis

This section will provide a descriptive analysis of the reviewed studies, including educational levels and fields, participants distribution, country contribution, research methodologies, study sample size, study population, publication year, list of journals, familiarity with ChatGPT, source of data, and the main aims and objectives of the studies. Table 4 presents a comprehensive overview of the extracted data from the selected studies.

3.1.1 The number of the reviewed studies and publication years

The total number of the reviewed studies was 14. All studies were empirical studies and published in different journals focusing on Education and Technology. One study was published in 2022 [S1], while the remaining were published in 2023 [S2]-[S14]. Table 3 illustrates the year of publication, the names of the journals, and the number of reviewed studies published in each journal for the studies reviewed.

Table 2 Categories and main themes from the included studies

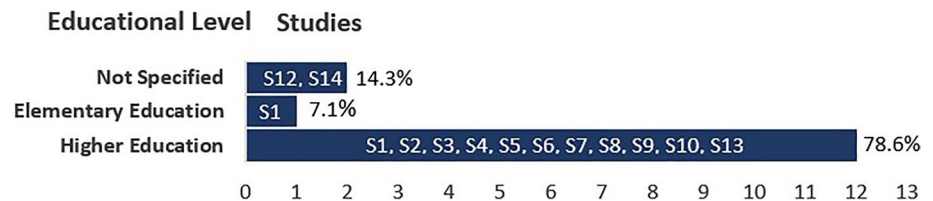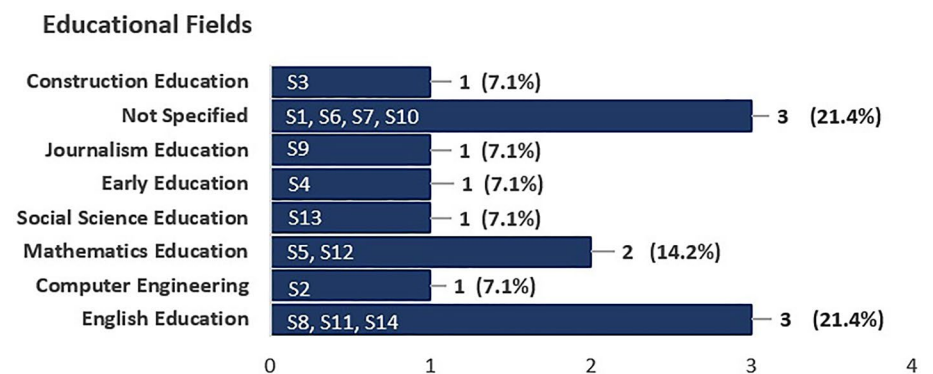| Study id	Axial coding (Categories)	Selective coding (main themes)
[S1]-[S6], [S8], [S10]-[S12]	Providing Immediate Feedback Providing On-demand Answers Providing Learning Resources Providing Guidance Online	Virtual Intelligent Assistant
[S4], [S6], [S8], [S9], [S11], [S14]	Support Writing (Generate Ideas, Essays, Summaries, and Textbooks) Assist in Language (Translation, Conversation, Grammars, Paraphrasing)	Writing and Language Proficiency Assistant
[S4], [S6], [S8], [S9], [S11]-[S13]	Aiding in Collaborative Learning Facilitating Self-Directed Learning Supporting Personalized Learning	Valuable Resource for Learning Approaches
[S4]-[S6], [S8], [S9], [S12]-[S14]	Improving Reasoning Skills Affecting Problem-Solving Skills Improving Soft Skills Improving Writing Skills	Enhancing Students' Competencies
[S2], [S3], [S5], [S7], [S8]-[S12]	Facilitate the Understanding of Concepts and Homework Providing Well-Structured Learning Plans Providing Explanations to Tasks, etc	Supporting Students' Academic Success
[S1], [S4], [S11], [S2]	Assist with Educational Content and Plans Generating Activities and Assignments Answering Question/Locate Information	Valuable Resource for Teaching
[S6], [S10], [S11], [S13], [S14]	Aiding in Managing Tasks Reducing Teacher Workload Reducing Time Consuming	Improving Productivity and Efficiency
[S4], [S5], [S11]-[S13]	Developing New Effective Learning Strategies Adapting Teaching Strategies and Methodologies Adopting New Educational Philosophies and Approaches	Catalyzing New Teaching Methodologies
[S1], [S3]-[S6], [S8], [S9]-[S12], [S14]	Providing Teachers with Trainings Support Teachers Establishing Clear Rules and Regulations Policymakers and Stakeholders Collaboration	Effective Utilization of ChatGPT in Teaching

3.1.2 Educational levels and fields

The majority of the reviewed studies, 11 studies, were conducted in higher education institutions [S1]-[S10] and [S13]. Two studies did not specify the educational level of the population [S12] and [S14], while one study focused on elementary education [S11]. However, the reviewed studies covered various fields of education. Three studies focused on Arts and Humanities Education [S8], [S11], and [S14], specifically English Education. Two studies focused on Engineering Education, with one in Computer Engineering [S2] and the other in Construction Education [S3]. Two studies focused on Mathematics Education [S5] and [S12]. One study focused on Social Science Education [S13]. One study focused on Early Education [S4]. One study focused on Journalism Education [S9]. Finally, three studies did not specify the field of education [S1], [S6], and [S7]. Figure 2 represents the educational levels in the reviewed studies, while Fig. 3 represents the context of the reviewed studies.

3.1.3 Participants distribution and countries contribution

The reviewed studies have been conducted across different geographic regions, providing a diverse representation of the studies. The majority of the studies, 10 in total, [S1]-[S3], [S5]-[S9], [S11], and [S14], primarily focused on participants from single countries such as Pakistan, the United Arab Emirates, China, Indonesia, Poland, Saudi Arabia, South Korea, Spain, Tajikistan, and the United States. In contrast, four studies, [S4], [S10], [S12], and [S13], involved participants from multiple countries, including China and the United States [S4], China, the United Kingdom, and the United States [S10], the United Arab Emirates, Oman, Saudi Arabia, and Jordan [S12], Turkey, Sweden, Canada, and Australia [13]. Figures 4

Table 3 Distribution of reviewed studies by publication year, journal name, and number of publications per journal

Publication year	Journal name	Study id
2022	Global Journal for Management and Administrative Sciences	S1
2023	IEEE Access. IEEE Education Society Section	S2
	Sustainability	S3
	Early Education and Development	S4
	Applied Sciences	S5
	Buletin Edukasi Indonesia	S6
	Interactive Learning Environments	S7
	Education and Information Technologies	S8
	Global Social Sciences Review	S9
	Smart Learning Environments	S10
	Education and Information Technologies	S11
	Journal of Mathematics, Science and Technology Education	S12
	Journal of Applied Learning & Teaching	S13
	Journal of English Studies in Arabia Felix	S14

Fig. 2 Educational levels in the reviewed studies

Fig. 3 Context of the reviewed studies

and 5 illustrate the distribution of participants, whether from single or multiple countries, and the contribution of each country in the reviewed studies, respectively.

3.1.4 Study population and sample size

Four study populations were included: university students, university teachers, university teachers and students, and elementary school teachers. Six studies involved university students [S2], [S3], [S5] and [S6]-[S8]. Three studies focused on university teachers [S1], [S4], and [S6], while one study specifically targeted elementary school teachers [S11]. Additionally, four studies included both university teachers and students [S10] and [12–14], and among them, study [S13] specifically included postgraduate students. In terms of the sample size of the reviewed studies, nine studies included a small sample size of less than 50 participants [S1], [S3], [S6], [S8], and [S10]-[S13]. Three studies had 50–100 participants [S2], [S9], and [S14]. Only one study had more than 100 participants [S7]. It is worth mentioning that study [S4] adopted a mixed methods approach, including 10 participants for qualitative analysis and 110 participants for quantitative analysis.

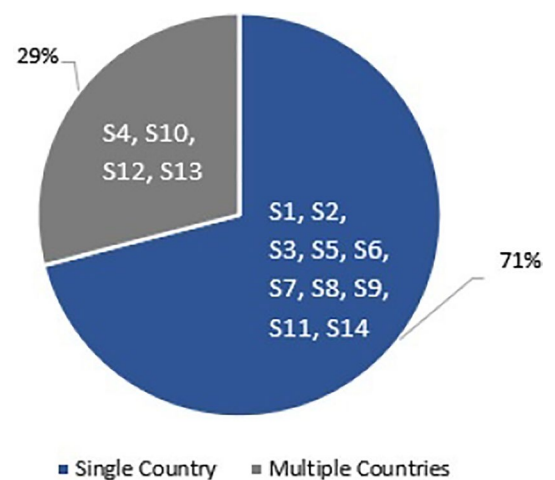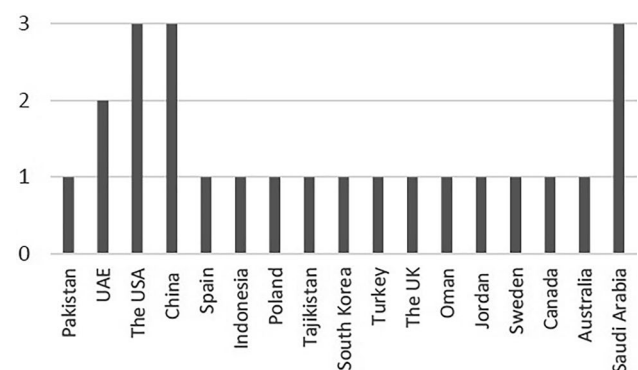**Fig. 4** The reviewed studies conducted in single or multiple countries

Fig. 5 The Contribution of each country in the studies

3.1.5 Participants' familiarity with using ChatGPT

The reviewed studies recruited a diverse range of participants with varying levels of familiarity with ChatGPT. Five studies [S2], [S4], [S6], [S8], and [S12] involved participants already familiar with ChatGPT, while eight studies [S1], [S3], [S5], [S7], [S9], [S10], [S13] and [S14] included individuals with differing levels of familiarity. Notably, one study [S11] had participants who were entirely unfamiliar with ChatGPT. It is important to note that four studies [S3], [S5], [S9], and [S11] provided training or guidance to their participants before conducting their studies, while ten studies [S1], [S2], [S4], [S6]-[S8], [S10], and [S12]-[S14] did not provide training due to the participants' existing familiarity with ChatGPT.

3.1.6 Research methodology approaches and source(S) of data

The reviewed studies adopted various research methodology approaches. Seven studies adopted qualitative research methodology [S1], [S4], [S6], [S8], [S10], [S11], and [S12], while three studies adopted quantitative research methodology [S3], [S7], and [S14], and four studies employed mixed-methods, which involved a combination of both the strengths of qualitative and quantitative methods [S2], [S5], [S9], and [S13].

In terms of the source(s) of data, the reviewed studies obtained their data from various sources, such as interviews, questionnaires, and pre-and post-tests. Six studies relied on interviews as their primary source of data collection [S1], [S4], [S6], [S10], [S11], and [S12], four studies relied on questionnaires [S2], [S7], [S13], and [S14], two studies combined the use of pre-and post-tests and questionnaires for data collection [S3] and [S9], while two studies combined the use of questionnaires and interviews to obtain the data [S5] and [S8]. It is important to note that six of the reviewed studies were quasi-experimental [S3], [S5], [S8], [S9], [S12], and [S14], while the remaining ones were experimental studies [S1], [S2], [S4], [S6], [S7], [S10], [S11], and [S13]. Figures 6 and 7 illustrate the research methodologies and the source (s) of data used in the reviewed studies, respectively.

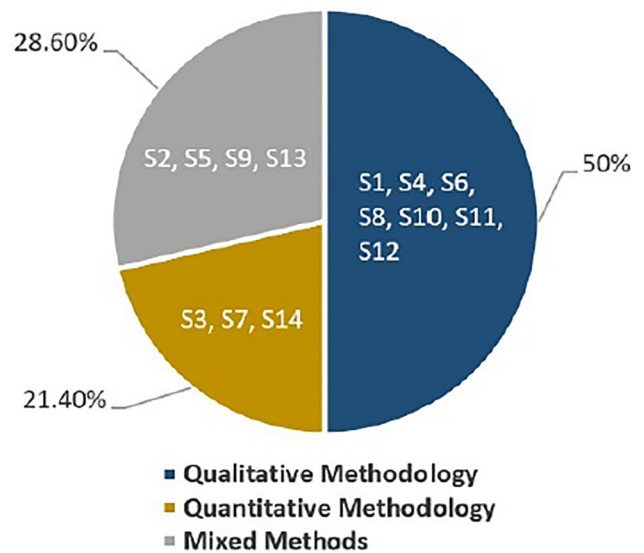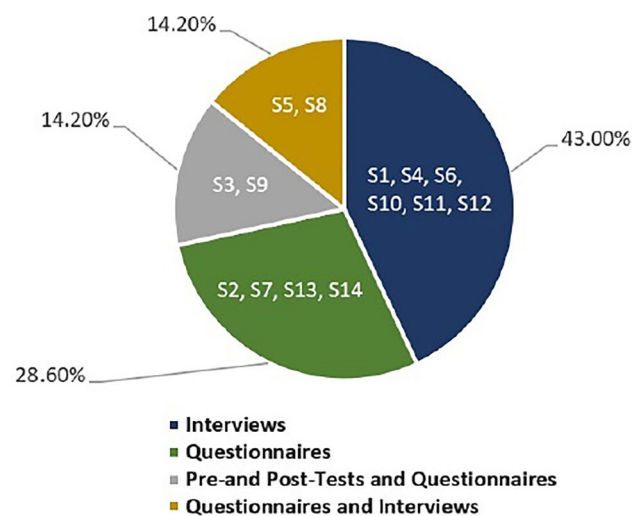**Fig. 6** Research methodologies in the reviewed studies

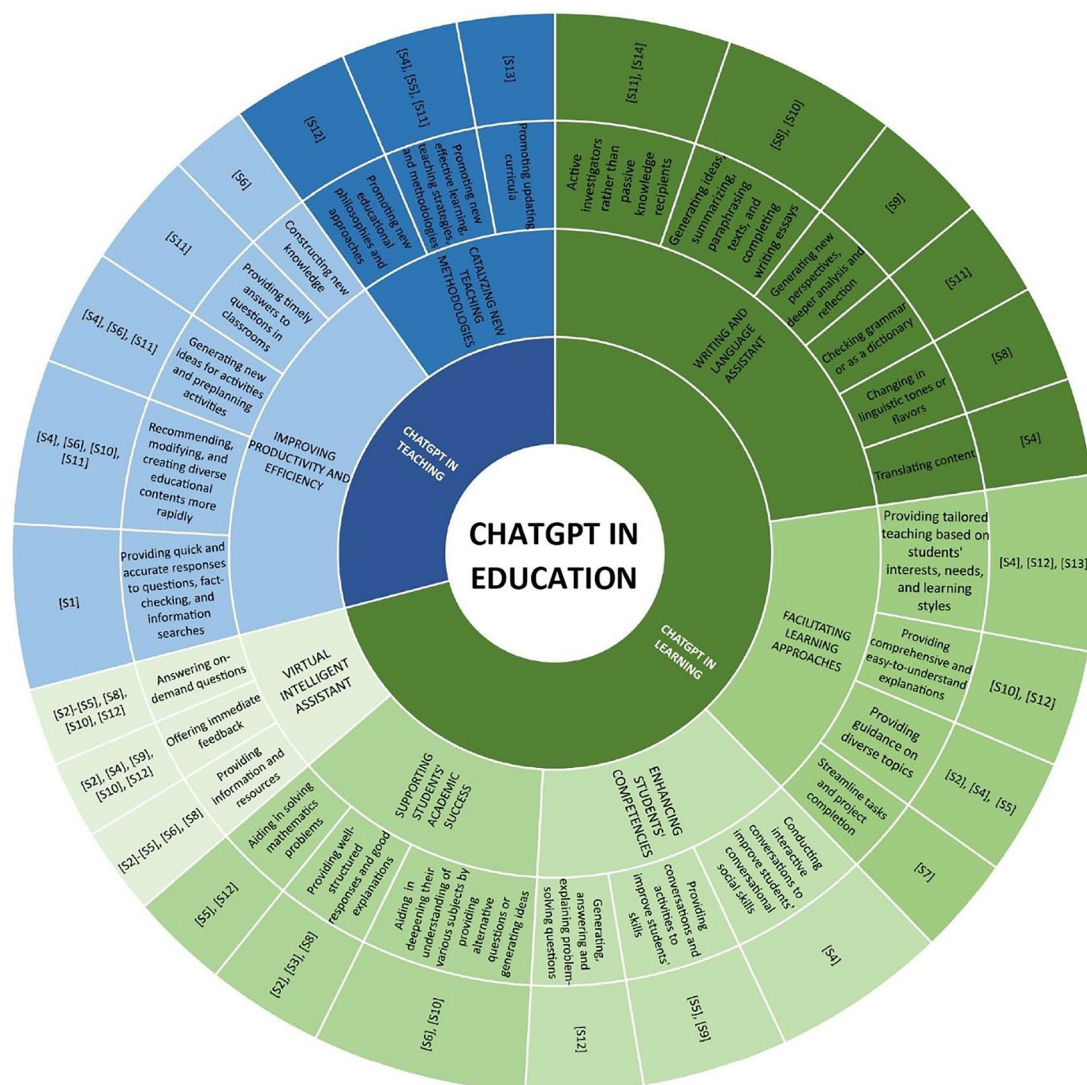**Fig. 7** Source of data in the reviewed studies

3.1.7 The aim and objectives of the studies

The reviewed studies encompassed a diverse set of aims, with several of them incorporating multiple primary objectives. Six studies [S3], [S6], [S7], [S8], [S11], and [S12] examined the integration of ChatGPT in educational contexts, and four studies [S4], [S5], [S13], and [S14] investigated the various implications of its use in education, while three studies [S2], [S9], and [S10] aimed to explore both its integration and implications in education. Additionally, seven studies explicitly explored attitudes and perceptions of students [S2] and [S3], educators [S1] and [S6], or both [S10], [S12], and [S13] regarding the utilization of ChatGPT in educational settings.

3.2 Part 2: research questions and main findings of the reviewed studies

This part will present the answers to the research questions and the main findings of the reviewed studies, classified into two main categories (learning and teaching) according to AI Education classification by [36]. Figure 8 summarizes the main findings of the reviewed studies in a visually informative diagram. Table 4 provides a detailed list of the key information extracted from the selected studies that led to generating these themes.

Layer 1: Represents the domains of the findings.   Layer 2: Represents the categories within the domains.
Layer 3: Provides examples of how ChatGPT is used.   Layer 4: Indicates the studies that revealed these findings.

Fig. 8 The main findings in the reviewed studies

4 Students' initial attempts at utilizing ChatGPT in learning and main findings from students' perspective

4.1 Virtual intelligent assistant

Nine studies demonstrated that ChatGPT has been utilized by students as an intelligent assistant to enhance and support their learning. Students employed it for various purposes, such as answering on-demand questions [S2]-[S5], [S8], [S10], and [S12], providing valuable information and learning resources [S2]-[S5], [S6], and [S8], as well as receiving immediate feedback [S2], [S4], [S9], [S10], and [S12]. In this regard, students generally were confident in the accuracy of ChatGPT's responses, considering them relevant, reliable, and detailed [S3], [S4], [S5], and [S8]. However, some students indicated the need for improvement, as they found that answers are not always accurate [S2], and that misleading information may have been provided or that it may not always align with their expectations [S6] and [S10]. It was also observed by the students that the accuracy of ChatGPT is dependent on several factors, including the quality and specificity of the user's input, the complexity of the question or topic, and the scope and relevance of its training data [S12]. Many students felt that ChatGPT's answers were not always accurate and most of them believed that it requires good background knowledge to work with.

4.2 Writing and language proficiency assistant

Six of the reviewed studies highlighted that ChatGPT has been utilized by students as a valuable assistant tool to improve their academic writing skills and language proficiency. Among these studies, three mainly focused on English education, demonstrating that students showed sufficient mastery in using ChatGPT for generating ideas, summarizing, paraphrasing texts, and completing writing essays [S8], [S11], and [S14]. Furthermore, ChatGPT helped them in writing by making students active investigators rather than passive knowledge recipients and facilitated the development of their writing skills [S11] and [S14]. Similarly, ChatGPT allowed students to generate unique ideas and perspectives, leading to deeper analysis and reflection on their journalism writing [S9]. In terms of language proficiency, ChatGPT allowed participants to translate content into their home languages, making it more accessible and relevant to their context [S4]. It also enabled them to request changes in linguistic tones or flavors [S8]. Moreover, participants used it to check grammar or as a dictionary [S11].

4.3 Valuable resource for learning approaches

Five studies demonstrated that students used ChatGPT as a valuable complementary resource for self-directed learning. It provided learning resources and guidance on diverse educational topics and created a supportive home learning environment [S2] and [S4]. Moreover, it offered step-by-step guidance to grasp concepts at their own pace and enhance their understanding [S5], streamlined task and project completion carried out independently [S7], provided comprehensive and easy-to-understand explanations on various subjects [S10], and assisted in studying geometry operations, thereby empowering them to explore geometry operations at their own pace [S12]. Three studies showed that students used ChatGPT as a valuable learning resource for personalized learning. It delivered age-appropriate conversations and tailored teaching based on a child's interests [S4], acted as a personalized learning assistant, adapted to their needs and pace, which assisted them in understanding mathematical concepts [S12], and enabled personalized learning experiences in social sciences by adapting to students' needs and learning styles [S13]. On the other hand, it is important to note that, according to one study [S5], students suggested that using ChatGPT may negatively affect collaborative learning competencies between students.

4.4 Enhancing students' competencies

Six of the reviewed studies have shown that ChatGPT is a valuable tool for improving a wide range of skills among students. Two studies have provided evidence that ChatGPT led to improvements in students' critical thinking, reasoning skills, and hazard recognition competencies through engaging them in interactive conversations or activities and providing responses related to their disciplines in journalism [S5] and construction education [S9]. Furthermore, two studies focused on mathematical education have shown the positive impact of ChatGPT on students' problem-solving abilities

in unraveling problem-solving questions [S12] and enhancing the students' understanding of the problem-solving process [S5]. Lastly, one study indicated that ChatGPT effectively contributed to the enhancement of conversational social skills [S4].

4.5 Supporting students' academic success

Seven of the reviewed studies highlighted that students found ChatGPT to be beneficial for learning as it enhanced learning efficiency and improved the learning experience. It has been observed to improve students' efficiency in computer engineering studies by providing well-structured responses and good explanations [S2]. Additionally, students found it extremely useful for hazard reporting [S3], and it also enhanced their efficiency in solving mathematics problems and capabilities [S5] and [S12]. Furthermore, by finding information, generating ideas, translating texts, and providing alternative questions, ChatGPT aided students in deepening their understanding of various subjects [S6]. It contributed to an increase in students' overall productivity [S7] and improved efficiency in composing written tasks [S8]. Regarding learning experiences, ChatGPT was instrumental in assisting students in identifying hazards that they might have otherwise overlooked [S3]. It also improved students' learning experiences in solving mathematics problems and developing abilities [S5] and [S12]. Moreover, it increased students' successful completion of important tasks in their studies [S7], particularly those involving average difficulty writing tasks [S8]. Additionally, ChatGPT increased the chances of educational success by providing students with baseline knowledge on various topics [S10].

5 Teachers' initial attempts at utilizing ChatGPT in teaching and main findings from teachers' perspective

5.1 Valuable resource for teaching

The reviewed studies showed that teachers have employed ChatGPT to recommend, modify, and generate diverse, creative, organized, and engaging educational contents, teaching materials, and testing resources more rapidly [S4], [S6], [S10] and [S11]. Additionally, teachers experienced increased productivity as ChatGPT facilitated quick and accurate responses to questions, fact-checking, and information searches [S1]. It also proved valuable in constructing new knowledge [S6] and providing timely answers to students' questions in classrooms [S11]. Moreover, ChatGPT enhanced teachers' efficiency by generating new ideas for activities and preplanning activities for their students [S4] and [S6], including interactive language game partners [S11].

5.2 Improving productivity and efficiency

The reviewed studies showed that participants' productivity and work efficiency have been significantly enhanced by using ChatGPT as it enabled them to allocate more time to other tasks and reduce their overall workloads [S6], [S10], [S11], [S13], and [S14]. However, three studies [S1], [S4], and [S11], indicated a negative perception and attitude among teachers toward using ChatGPT. This negativity stemmed from a lack of necessary skills to use it effectively [S1], a limited familiarity with it [S4], and occasional inaccuracies in the content provided by it [S10].

5.3 Catalyzing new teaching methodologies

Five of the reviewed studies highlighted that educators found the necessity of redefining their teaching profession with the assistance of ChatGPT [S11], developing new effective learning strategies [S4], and adapting teaching strategies and methodologies to ensure the development of essential skills for future engineers [S5]. They also emphasized the importance of adopting new educational philosophies and approaches that can evolve with the introduction of ChatGPT into the classroom [S12]. Furthermore, updating curricula to focus on improving human-specific features, such as emotional intelligence, creativity, and philosophical perspectives [S13], was found to be essential.

5.4 Effective utilization of CHATGPT in teaching

According to the reviewed studies, effective utilization of ChatGPT in education requires providing teachers with well-structured training, support, and adequate background on how to use ChatGPT responsibly [S1], [S3], [S11], and [S12]. Establishing clear rules and regulations regarding its usage is essential to ensure it positively impacts the teaching and learning processes, including students' skills [S1], [S4], [S5], [S8], [S9], and [S11]-[S14]. Moreover, conducting further research and engaging in discussions with policymakers and stakeholders is indeed crucial for the successful integration of ChatGPT in education and to maximize the benefits for both educators and students [S1], [S6]-[S10], and [S12]-[S14].

6 Discussion

The purpose of this review is to conduct a systematic review of empirical studies that have explored the utilization of ChatGPT, one of today's most advanced LLM-based chatbots, in education. The findings of the reviewed studies showed several ways of ChatGPT utilization in different learning and teaching practices as well as it provided insights and considerations that can facilitate its effective and responsible use in future educational contexts. The results of the reviewed studies came from diverse fields of education, which helped us avoid a biased review that is limited to a specific field. Similarly, the reviewed studies have been conducted across different geographic regions. This kind of variety in geographic representation enriched the findings of this review.

In response to **RQ1**, "What are students' and teachers' initial attempts at utilizing ChatGPT in education?", the findings from this review provide comprehensive insights. Chatbots, including ChatGPT, play a crucial role in supporting student learning, enhancing their learning experiences, and facilitating diverse learning approaches [42, 43]. This review found that this tool, ChatGPT, has been instrumental in enhancing students' learning experiences by serving as a virtual intelligent assistant, providing immediate feedback, on-demand answers, and engaging in educational conversations. Additionally, students have benefited from ChatGPT's ability to generate ideas, compose essays, and perform tasks like summarizing, translating, paraphrasing texts, or checking grammar, thereby enhancing their writing and language competencies. Furthermore, students have turned to ChatGPT for assistance in understanding concepts and homework, providing structured learning plans, and clarifying assignments and tasks, which fosters a supportive home learning environment, allowing them to take responsibility for their own learning and cultivate the skills and approaches essential for supportive home learning environment [26–28]. This finding aligns with the study of Saqr et al. [68, 69] who highlighted that, when students actively engage in their own learning process, it yields additional advantages, such as heightened motivation, enhanced achievement, and the cultivation of enthusiasm, turning them into advocates for their own learning.

Moreover, students have utilized ChatGPT for tailored teaching and step-by-step guidance on diverse educational topics, streamlining task and project completion, and generating and recommending educational content. This personalization enhances the learning environment, leading to increased academic success. This finding aligns with other recent studies [26–28, 60, 66] which revealed that ChatGPT has the potential to offer personalized learning experiences and support an effective learning process by providing students with customized feedback and explanations tailored to their needs and abilities. Ultimately, fostering students' performance, engagement, and motivation, leading to increase students' academic success [14, 44, 58]. This ultimate outcome is in line with the findings of Saqr et al. [68, 69], which emphasized that learning strategies are important catalysts of students' learning, as students who utilize effective learning strategies are more likely to have better academic achievement.

Teachers, too, have capitalized on ChatGPT's capabilities to enhance productivity and efficiency, using it for creating lesson plans, generating quizzes, providing additional resources, generating and preplanning new ideas for activities, and aiding in answering students' questions. This adoption of technology introduces new opportunities to support teaching and learning practices, enhancing teacher productivity. This finding aligns with those of Day [17], De Castro [18], and Su and Yang [74] as well as with those of Valtonen et al. [82], who revealed that emerging technological advancements

have opened up novel opportunities and means to support teaching and learning practices, and enhance teachers' productivity.

In response to **RQ2**, "What are the main findings derived from empirical studies that have incorporated ChatGPT into learning and teaching?", the findings from this review provide profound insights and raise significant concerns. Starting with the insights, chatbots, including ChatGPT, have demonstrated the potential to reshape and revolutionize education, creating new, novel opportunities for enhancing the learning process and outcomes [83], facilitating different learning approaches, and offering a range of pedagogical benefits [19, 43, 72]. In this context, this review found that ChatGPT could open avenues for educators to adopt or develop new effective learning and teaching strategies that can evolve with the introduction of ChatGPT into the classroom. Nonetheless, there is an evident lack of research understanding regarding the potential impact of generative machine learning models within diverse educational settings [83]. This necessitates teachers to attain a high level of proficiency in incorporating chatbots, such as ChatGPT, into their classrooms to create inventive, well-structured, and captivating learning strategies. In the same vein, the review also found that teachers without the requisite skills to utilize ChatGPT realized that it did not contribute positively to their work and could potentially have adverse effects [37]. This concern could lead to inequity of access to the benefits of chatbots, including ChatGPT, as individuals who lack the necessary expertise may not be able to harness their full potential, resulting in disparities in educational outcomes and opportunities. Therefore, immediate action is needed to address these potential issues. A potential solution is offering training, support, and competency development for teachers to ensure that all of them can leverage chatbots, including ChatGPT, effectively and equitably in their educational practices [5, 28, 80], which could enhance accessibility and inclusivity, and potentially result in innovative outcomes [82, 83].

Additionally, chatbots, including ChatGPT, have the potential to significantly impact students' thinking abilities, including retention, reasoning, analysis skills [19, 45], and foster innovation and creativity capabilities [83]. This review found that ChatGPT could contribute to improving a wide range of skills among students. However, it found that frequent use of ChatGPT may result in a decrease in innovative capacities, collaborative skills and cognitive capacities, and students' motivation to attend classes, as well as could lead to reduced higher-order thinking skills among students [22, 29]. Therefore, immediate action is needed to carefully examine the long-term impact of chatbots such as ChatGPT, on learning outcomes as well as to explore its incorporation into educational settings as a supportive tool without compromising students' cognitive development and critical thinking abilities. In the same vein, the review also found that it is challenging to draw a consistent conclusion regarding the potential of ChatGPT to aid self-directed learning approach. This finding aligns with the recent study of Baskara [8]. Therefore, further research is needed to explore the potential of ChatGPT for self-directed learning. One potential solution involves utilizing learning analytics as a novel approach to examine various aspects of students' learning and support them in their individual endeavors [32]. This approach can bridge this gap by facilitating an in-depth analysis of how learners engage with ChatGPT, identifying trends in self-directed learning behavior, and assessing its influence on their outcomes.

Turning to the significant concerns, on the other hand, a fundamental challenge with LLM-based chatbots, including ChatGPT, is the accuracy and quality of the provided information and responses, as they provide false information as truth—a phenomenon often referred to as "hallucination" [3, 49]. In this context, this review found that the provided information was not entirely satisfactory. Consequently, the utilization of chatbots presents potential concerns, such as generating and providing inaccurate or misleading information, especially for students who utilize it to support their learning. This finding aligns with other findings [6, 30, 35, 40] which revealed that incorporating chatbots such as ChatGPT, into education presents challenges related to its accuracy and reliability due to its training on a large corpus of data, which may contain inaccuracies and the way users formulate or ask ChatGPT. Therefore, immediate action is needed to address these potential issues. One possible solution is to equip students with the necessary skills and competencies, which include a background understanding of how to use it effectively and the ability to assess and evaluate the information it generates, as the accuracy and the quality of the provided information depend on the input, its complexity, the topic, and the relevance of its training data [28,

49, 86]. However, it's also essential to examine how learners can be educated about how these models operate, the data used in their training, and how to recognize their limitations, challenges, and issues [79].

Furthermore, chatbots present a substantial challenge concerning maintaining academic integrity [20, 56] and copyright violations [83], which are significant concerns in education. The review found that the potential misuse of ChatGPT might foster cheating, facilitate plagiarism, and threaten academic integrity. This issue is also affirmed by the research conducted by Basic et al. [7], who presented evidence that students who utilized ChatGPT in their writing assignments had more plagiarism cases than those who did not. These findings align with the conclusions drawn by Cotton et al. [13], Hisan and Amri [33] and Sullivan et al. [75], who revealed that the integration of chatbots such as ChatGPT into education poses a significant challenge to the preservation of academic integrity. Moreover, chatbots, including ChatGPT, have increased the difficulty in identifying plagiarism [47, 67, 76]. The findings from previous studies [1, 84] indicate that AI-generated text often went undetected by plagiarism software, such as Turnitin. However, Turnitin and other similar plagiarism detection tools, such as ZeroGPT, GPTZero, and Copyleaks, have since evolved, incorporating enhanced techniques to detect AI-generated text, despite the possibility of false positives, as noted in different studies that have found these tools still not yet fully ready to accurately and reliably identify AI-generated text [10, 51], and new novel detection methods may need to be created and implemented for AI-generated text detection [4]. This potential issue could lead to another concern, which is the difficulty of accurately evaluating student performance when they utilize chatbots such as ChatGPT assistance in their assignments. Consequently, the most LLM-driven chatbots present a substantial challenge to traditional assessments [64]. The findings from previous studies indicate the importance of rethinking, improving, and redesigning innovative assessment methods in the era of chatbots [14, 20, 64, 75]. These methods should prioritize the process of evaluating students' ability to apply knowledge to complex cases and demonstrate comprehension, rather than solely focusing on the final product for assessment. Therefore, immediate action is needed to address these potential issues. One possible solution would be the development of clear guidelines, regulatory policies, and pedagogical guidance. These measures would help regulate the proper and ethical utilization of chatbots, such as ChatGPT, and must be established before their introduction to students [35, 38, 39, 41, 89].

In summary, our review has delved into the utilization of ChatGPT, a prominent example of chatbots, in education, addressing the question of how ChatGPT has been utilized in education. However, there remain significant gaps, which necessitate further research to shed light on this area.

7 Conclusions

This systematic review has shed light on the varied initial attempts at incorporating ChatGPT into education by both learners and educators, while also offering insights and considerations that can facilitate its effective and responsible use in future educational contexts. From the analysis of 14 selected studies, the review revealed the dual-edged impact of ChatGPT in educational settings. On the positive side, ChatGPT significantly aided the learning process in various ways. Learners have used it as a virtual intelligent assistant, benefiting from its ability to provide immediate feedback, on-demand answers, and easy access to educational resources. Additionally, it was clear that learners have used it to enhance their writing and language skills, engaging in practices such as generating ideas, composing essays, and performing tasks like summarizing, translating, paraphrasing texts, or checking grammar. Importantly, other learners have utilized it in supporting and facilitating their directed and personalized learning on a broad range of educational topics, assisting in understanding concepts and homework, providing structured learning plans, and clarifying assignments and tasks. Educators, on the other hand, found ChatGPT beneficial for enhancing productivity and efficiency. They used it for creating lesson plans, generating quizzes, providing additional resources, and answers learners' questions, which saved time and allowed for more dynamic and engaging teaching strategies and methodologies.

However, the review also pointed out negative impacts. The results revealed that overuse of ChatGPT could decrease innovative capacities and collaborative learning among learners. Specifically, relying too much on Chat-GPT for quick answers can inhibit learners' critical thinking and problem-solving skills. Learners might not engage deeply with the material or consider multiple solutions to a problem. This tendency was particularly evident in group

projects, where learners preferred consulting ChatGPT individually for solutions over brainstorming and collaborating with peers, which negatively affected their teamwork abilities. On a broader level, integrating ChatGPT into education has also raised several concerns, including the potential for providing inaccurate or misleading information, issues of inequity in access, challenges related to academic integrity, and the possibility of misusing the technology.

Accordingly, this review emphasizes the urgency of developing clear rules, policies, and regulations to ensure ChatGPT's effective and responsible use in educational settings, alongside other chatbots, by both learners and educators. This requires providing well-structured training to educate them on responsible usage and understanding its limitations, along with offering sufficient background information. Moreover, it highlights the importance of rethinking, improving, and redesigning innovative teaching and assessment methods in the era of ChatGPT. Furthermore, conducting further research and engaging in discussions with policymakers and stakeholders are essential steps to maximize the benefits for both educators and learners and ensure academic integrity.

It is important to acknowledge that this review has certain limitations. Firstly, the limited inclusion of reviewed studies can be attributed to several reasons, including the novelty of the technology, as new technologies often face initial skepticism and cautious adoption; the lack of clear guidelines or best practices for leveraging this technology for educational purposes; and institutional or governmental policies affecting the utilization of this technology in educational contexts. These factors, in turn, have affected the number of studies available for review. Secondly, the utilization of the original version of ChatGPT, based on GPT-3 or GPT-3.5, implies that new studies utilizing the updated version, GPT-4 may lead to different findings. Therefore, conducting follow-up systematic reviews is essential once more empirical studies on ChatGPT are published. Additionally, long-term studies are necessary to thoroughly examine and assess the impact of ChatGPT on various educational practices.

Despite these limitations, this systematic review has highlighted the transformative potential of ChatGPT in education, revealing its diverse utilization by learners and educators alike and summarized the benefits of incorporating it into education, as well as the forefront critical concerns and challenges that must be addressed to facilitate its effective and responsible use in future educational contexts. This review could serve as an insightful resource for practitioners who seek to integrate ChatGPT into education and stimulate further research in the field.

Declarations

Competing interests The authors declare no competing interests.

Appendix

See Table 4

Table 4 Primary Studies Included in this Systematic Review

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S1	Iqbal et al. [37]	Exploring Teachers' Attitudes Towards Using ChatGPT	The study aimed to investigate faculty members' perspectives regarding the utilization of ChatGPT	Pakistan	University Teachers	20	Different Level of Familiarity	Not specified
S2	Shoufan and Abdulhadi [71]	Exploring Students' Perceptions of ChatGPT: Thematic Analysis and Follow-Up Survey	The study aimed to explore students' perceptions of ChatGPT and evaluate its possibilities and difficulties	United Arab of Emirates	University Senior Students	56	Familiar with ChatGPT	Computer Engineering Education
S3	Uddin [81]	Leveraging ChatGPT to Aid Construction Hazard Recognition and Support Safety Education and Training	The study aimed to investigate how the utilization of ChatGPT in the curriculum affects students' hazard recognition	USA	University Students	42	Different Level of Familiarity	Engineering Education (Construction Education)
S4	Luo [48]	Aladdin's Genie or Pandora's Box for Early Childhood Education? Experts Chat on the Roles, Challenges, and Developments of ChatGPT	The study aimed to explore the optimal roles, pressing challenges, and future developments of ChatGPT in early childhood education	China and USA	Experts Professors	6	Used ChatGPT for more than two months	Early Education

Table 4 (continued)

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S5	Ruiz [65]	ChatGPT Challenges Blended Learning Methodologies in Engineering Education: A Case Study in Mathematics	The study aimed to explore the potential impact of the ChatGPT on b-learning methodologies in engineering education, specifically in mathematics	Spain	University Students	120	70% of the participants were familiar with using ChatGPT	Mathematics Education
S6	Firaina [25]	Exploring the Usage of ChatGPT in Higher Education: Frequency and Impact on Productivity	The study aimed to investigate how instructors utilize ChatGPT in their teaching and the factors influencing their decisions to adopt or avoid it	Indonesia	University Teachers	5	Familiar with ChatGPT	Not specified
S7	Strzeleck [73]	To Use or not to Use ChatGPT in Higher Education? A Study of Students' Acceptance and Use of Technology	The study aimed to examine the utilization of ChatGPT among higher education students	Poland	University Students	534	Different Level of Familiarity	Not specified

Table 4 (continued)

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S8	Yan and Da [89]	Impact of ChatGPT on Learners in a L2 Writing Practicum: An Exploratory Investigation	The study aimed to examine the potential applicability ChatGPT in L2 writing pedagogy	China	University Students	43	Familiar with ChatGPT	EFL Education (English Education)
S9	Irfan [38]	Integration of Artificial Intelligence in Academia: A Case Study of Critical Teaching and Learning in Higher Education	The study aimed to examine the use of ChatGPT in enhancing critical reasoning and journalistic writing competencies among journalism students	Tajikistan	University Sophomore Students	50	Different Level of Familiarity	Journalism Education
S10	Tlili [80]	What if the Devil is my Guardian Angel: ChatGPT as a Case Study of Using Chatbots in Education	The study aimed to examine the use of ChatGPT in educational settings	China, USA, and, UK	University Teachers and Students	22	Different level of Familiarity	Not specified

Table 4 (continued)

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S11	Jeon [39]	Large Language Models in Education: A Focus on the Complementary Relationship between Human Teachers and ChatGPT	The study aimed to investigate how ChatGPT and teachers complement each other in the context of education	South Africa	Elementary Teachers	11	Not Familiar with ChatGPT	English Education
S12	Wardat [86]	ChatGPT: A Revolutionary Tool for Teaching and Learning Mathematics	The study aimed to examine the use of ChatGPT in teaching mathematics	Not Mentioned	Teachers and Students	30	Familiar with ChatGPT	Mathematical Education
S13	Firat [26, 27]	What ChatGPT Means for Universities: Perceptions of Scholars and Students	The study aimed to examine the educational implications of ChatGPT from the viewpoints of both educators and students	Turkey, Sweden, Canada, and Australia	University Teachers and PhD Students	21	Different Level of Familiarity	Social Science Education
S14	Ali [2]	Impact of ChatGPT on Learning Motivation: Teachers and Students' Voices	The study aimed to examine how ChatGPT impacts learning English	Saudi Arabia	Teachers and Students	80	Different Level of Familiarity	EFL Education (English Education)
S1	Higher Education	Qualitative Research	Semi-structured interviews (All Interviews were Recorded, Transcribed, and Analyzed)	No Training was provided	Thematic Analysis	Facilitating in quick and accurate responses to questions, fact-checking, and information searches		

Table 4 (continued)

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S2	Higher Education	Mixed-Methods	Questionnaire Interviews	No Training was provided	Thematic Analysis 5-Point Likert Scale Average Rate	Answering on-demand questions; Providing immediate feedback; Providing learning resources and guidance; Providing well-structured responses and explanations		
S3	Higher Education	Quantitative Research	16 Case Images Pre- and Post-Tests Text-Questions Questionnaire	Training and guidance were provided	Skewness and Kurtosis test t-Test	Answering on-demand questions; Providing information and learning resources; Aiding in writing reports		
S4	Higher Education	Qualitative Research	Semi-Structured Interviews	Experts (Not needed)	A Content Analysis Approach	Answering on-demand questions; Providing information and learning resources; Providing immediate feedback; Translating contents; Providing learning resources and guidance; Delivering age-appropriate conversations; Aiding in conversational social skills; Generating and recommending educational contents, teaching materials, and testing resources; Generating and preplanning new ideas for activities		
S5	Higher Education	Mixed-Methods	Questionnaire Interviews	Instructions was provided on how to ask ChatGPT	A Cronbach's Alpha Shapiro–Wilk and Kolmogorov–Smirnov	Answering on-demand questions; Providing information and learning resources; Offering step-by-step guidance; Providing interactive conversations, activities or responses		
S6	Higher Education	Qualitative Research	Interviews	No Training was provided	Descriptive Statistics Content Analysis	Providing information and learning resources; Finding information, generating ideas, translating texts, and providing alternative questions; Generating and recommending educational contents, teaching materials, and testing resources; Constructing new knowledge; Generating and preplanning new ideas for activities; Reducing teachers' overall workloads		
S7	Higher Education	Quantitative Research	Questionnaire	No Training was provided	Partial-Least Squares Unified Theory of Acceptance and Use of Technology (UTAUT2)	Facilitating task and project completion; Finding information, generating ideas, translating texts, and providing alternative questions		
S8	Higher Education	Qualitative Research	Questionnaire Interviews Learning Logs	No Training was provided	Observation Method Document Analysis Thematic Analysis	Answering on-demand questions; Providing information and learning resources; Generating ideas, summarizing, paraphrasing texts, and completing writing essays; Editing linguistic tones of flavors; Aiding in composing written tasks		
S9	Higher Education	Mixed-Methods	Pre-and-Post-Test Semi-Structured Interviews	Training and guidance were provided	NA	Providing immediate feedback; Generating unique ideas and perspectives; Providing interactive conversations, activities or responses		
S10	Higher Education	Qualitative Research	Social Network Analysis Interviews Hands-on Experiences	No Training was provided	A Cross-Sectional Analysis (SNA) t-SNE Analysis Content Analysis Hands-on Experiences	Answering on-demand questions; Providing immediate feedback; Providing explanations on various subjects and baseline knowledge on various topics; Generating and recommending educational contents, teaching materials, and testing resources; Reducing teachers' overall workloads		

Table 4 (continued)

No	Study id	Study title	Aim of study	Country	Participants	Number of participants	Familiarity with ChatGPT	Context
S11	Elementary Education	Qualitative Research	Semi-Structured Interviews Chatbot-Use Logs	Training and guidance were provided	NA	Generating ideas, summarizing, paraphrasing texts, checking grammars, and completing writing essays Generating and recommending educational contents, teaching materials, and testing resources Providing timely answers to students' questions Generating and preplanning new ideas for activities Reducing teachers' overall workloads		
S12	NA	Qualitative Research	Interviews	No Training was provided	Content Analysis	Answering on-demand questions Providing immediate feedback Aiding in studying		
S13	Higher Education	Mixed-Methods	Questionnaire Interviews	No Training was provided	Content Analysis Descriptive Statistics	Providing tailored learning styles Reducing teachers' overall workloads		
S14	Higher Education	Quantitative Research	Questionnaire	No Training was provided	ANOVA for Comparative Analysis	Generating ideas, summarizing, paraphrasing texts, and completing writing essays Reducing teachers' overall workloads		

The process of synthesizing the data presented in Table 4 involved identifying the relevant studies through a search process of databases (ERIC, Scopus, Web of Knowledge, Dimensions.ai, and lens.org) using specific keywords "ChatGPT" and "education". Following this, inclusion/exclusion criteria were applied, and data extraction was performed using Creswell's [15] coding techniques to capture key information and identify common themes across the included studies.

References

1. AlAfnan MA, Dishari S, Jovic M, Lomidze K. ChatGPT as an educational tool: opportunities, challenges, and recommendations for communication, business writing, and composition courses. J Artif Intell Technol. 2023. https://doi.org/10.37965/jait.2023.0184.
2. Ali JKM, Shamsan MAA, Hezam TA, Mohammed AAQ. Impact of ChatGPT on learning motivation. J Engl Stud Arabia Felix. 2023;2(1):41–9. https://doi.org/10.56540/jesaf.v2i1.51.
3. Alkaissi H, McFarlane SI. Artificial hallucinations in ChatGPT: implications in scientific writing. Cureus. 2023. https://doi.org/10.7759/cureus.35179.
4. Anderson N, Belavý DL, Perle SM, Hendricks S, Hespanhol L, Verhagen E, Memon AR. AI did not write this manuscript, or did it? Can we trick the AI text detector into generated texts? The potential future of ChatGPT and AI in sports & exercise medicine manuscript generation. BMJ Open Sport Exerc Med. 2023;9(1): e001568. https://doi.org/10.1136/bmjsem-2023-001568.
5. Ausat AMA, Massang B, Efendi M, Nofirman N, Riady Y. Can chat GPT replace the role of the teacher in the classroom: a fundamental analysis. J Educ. 2023;5(4):16100–6.
6. Baidoo-Anu D, Ansah L. Education in the Era of generative artificial intelligence (AI): understanding the potential benefits of ChatGPT in promoting teaching and learning. Soc Sci Res Netw. 2023. https://doi.org/10.2139/ssrn.4337484.
7. Basic Z, Banovac A, Kruzic I, Jerkovic I. Better by you, better than me, chatgpt3 as writing assistance in students essays. 2023. *arXiv preprint arXiv:2302.04536*.
8. Baskara FR. The promises and pitfalls of using chat GPT for self-determined learning in higher education: an argumentative review. Prosiding Seminar Nasional Fakultas Tarbiyah dan Ilmu Keguruan IAIM Sinjai. 2023;2:95–101. https://doi.org/10.47435/sentikjar.v2i0.1825.
9. Behera RK, Bala PK, Dhir A. The emerging role of cognitive computing in healthcare: a systematic literature review. Int J Med Inform. 2019;129:154–66. https://doi.org/10.1016/j.ijmedinf.2019.04.024.
10. Chaka C. Detecting AI content in responses generated by ChatGPT, YouChat, and Chatsonic: the case of five AI content detection tools. J Appl Learn Teach. 2023. https://doi.org/10.37074/jalt.2023.6.2.12.
11. Chiu TKF, Xia Q, Zhou X, Chai CS, Cheng M. Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. Comput Educ Artif Intell. 2023;4:100118. https://doi.org/10.1016/j.caeai.2022.100118.
12. Choi EPH, Lee JJ, Ho M, Kwok JYY, Lok KYW. Chatting or cheating? The impacts of ChatGPT and other artificial intelligence language models on nurse education. Nurse Educ Today. 2023;125:105796. https://doi.org/10.1016/j.nedt.2023.105796.
13. Cotton D, Cotton PA, Shipway JR. Chatting and cheating: ensuring academic integrity in the era of ChatGPT. Innov Educ Teach Int. 2023. https://doi.org/10.1080/14703297.2023.2190148.
14. Crawford J, Cowling M, Allen K. Leadership is needed for ethical ChatGPT: Character, assessment, and learning using artificial intelligence (AI). J Univ Teach Learn Pract. 2023. https://doi.org/10.53761/1.20.3.02.
15. Creswell JW. Educational research: planning, conducting, and evaluating quantitative and qualitative research [Ebook]. 4th ed. London: Pearson Education; 2015.
16. Curry D. ChatGPT Revenue and Usage Statistics (2023)—Business of Apps. 2023. https://www.businessofapps.com/data/chatgpt-statistics/
17. Day T. A preliminary investigation of fake peer-reviewed citations and references generated by ChatGPT. Prof Geogr. 2023. https://doi.org/10.1080/00330124.2023.2190373.
18. De Castro CA. A Discussion about the Impact of ChatGPT in education: benefits and concerns. J Bus Theor Pract. 2023;11(2):p28. https://doi.org/10.22158/jbtp.v11n2p28.
19. Deng X, Yu Z. A meta-analysis and systematic review of the effect of Chatbot technology use in sustainable education. Sustainability. 2023;15(4):2940. https://doi.org/10.3390/su15042940.
20. Eke DO. ChatGPT and the rise of generative AI: threat to academic integrity? J Responsib Technol. 2023;13:100060. https://doi.org/10.1016/j.jrt.2023.100060.
21. Elmoazen R, Saqr M, Tedre M, Hirsto L. A systematic literature review of empirical research on epistemic network analysis in education. IEEE Access. 2022;10:17330–48. https://doi.org/10.1109/access.2022.3149812.
22. Farrokhnia M, Banihashem SK, Noroozi O, Wals AEJ. A SWOT analysis of ChatGPT: implications for educational practice and research. Innov Educ Teach Int. 2023. https://doi.org/10.1080/14703297.2023.2195846.
23. Fergus S, Botha M, Ostovar M. Evaluating academic answers generated using ChatGPT. J Chem Educ. 2023;100(4):1672–5. https://doi.org/10.1021/acs.jchemed.3c00087.
24. Fink A. Conducting research literature reviews: from the Internet to Paper. Incorporated: SAGE Publications; 2010.
25. Firaina R, Sulisworo D. Exploring the usage of ChatGPT in higher education: frequency and impact on productivity. Buletin Edukasi Indonesia (BEI). 2023;2(01):39–46. https://doi.org/10.56741/bei.v2i01.310.
26. Firat, M. (2023). How chat GPT can transform autodidactic experiences and open education. *Department of Distance Education, Open Education Faculty, Anadolu Unive.* https://orcid.org/0000-0001-8707-5918
27. Firat M. What ChatGPT means for universities: perceptions of scholars and students. J Appl Learn Teach. 2023. https://doi.org/10.37074/jalt.2023.6.1.22.
28. Fuchs K. Exploring the opportunities and challenges of NLP models in higher education: is Chat GPT a blessing or a curse? Front Educ. 2023. https://doi.org/10.3389/feduc.2023.1166682.

29. García-Peñalvo FJ. La percepción de la inteligencia artificial en contextos educativos tras el lanzamiento de ChatGPT: disrupción o pánico. Educ Knowl Soc. 2023;24: e31279. https://doi.org/10.14201/eks.31279.

30. Gilson A, Safranek CW, Huang T, Socrates V, Chi L, Taylor A, Chartash D. How does ChatGPT perform on the United States medical Licensing examination? The implications of large language models for medical education and knowledge assessment. JMIR Med Educ. 2023;9: e45312. https://doi.org/10.2196/45312.

31. Hashana AJ, Brundha P, Ayoobkhan MUA, Fazila S. Deep Learning in ChatGPT—A Survey. *In 2023 7th international conference on trends in electronics and informatics (ICOEI)*. 2023. (pp. 1001–1005). IEEE. https://doi.org/10.1109/icoei56765.2023.10125852

32. Hirsto L, Saqr M, López-Pernas S, Valtonen T. (2022). A systematic narrative review of learning analytics research in K-12 and schools. *Proceedings*. https://ceur-ws.org/Vol-3383/FLAIEC22_paper_9536.pdf

33. Hisan UK, Amri MM. ChatGPT and medical education: a double-edged sword. J Pedag Educ Sci. 2023;2(01):71–89. https://doi.org/10.13140/RG.2.2.31280.23043/1.

34. Hopkins AM, Logan JM, Kichenadasse G, Sorich MJ. Artificial intelligence chatbots will revolutionize how cancer patients access information: ChatGPT represents a paradigm-shift. JNCI Cancer Spectr. 2023. https://doi.org/10.1093/jncics/pkad010.

35. Househ M, AlSaad R, Alhuwail D, Ahmed A, Healy MG, Latifi S, Sheikh J. Large Language models in medical education: opportunities, challenges, and future directions. JMIR Med Educ. 2023;9: e48291. https://doi.org/10.2196/48291.

36. Ilkka T. The impact of artificial intelligence on learning, teaching, and education. Minist de Educ. 2018. https://doi.org/10.2760/12297.

37. Iqbal N, Ahmed H, Azhar KA. Exploring teachers' attitudes towards using CHATGPT. Globa J Manag Adm Sci. 2022;3(4):97–111. https://doi.org/10.46568/gjmas.v3i4.163.

38. Irfan M, Murray L, Ali S. Integration of Artificial intelligence in academia: a case study of critical teaching and learning in Higher education. Globa Soc Sci Rev. 2023;8(1):352–64. https://doi.org/10.31703/gssr.2023(viii-i).32.

39. Jeon JH, Lee S. Large language models in education: a focus on the complementary relationship between human teachers and ChatGPT. Educ Inf Technol. 2023. https://doi.org/10.1007/s10639-023-11834-1.

40. Khan RA, Jawaid M, Khan AR, Sajjad M. ChatGPT—Reshaping medical education and clinical management. Pak J Med Sci. 2023. https://doi.org/10.12669/pjms.39.2.7653.

41. King MR. A conversation on artificial intelligence, Chatbots, and plagiarism in higher education. Cell Mol Bioeng. 2023;16(1):1–2. https://doi.org/10.1007/s12195-022-00754-8.

42. Kooli C. Chatbots in education and research: a critical examination of ethical implications and solutions. Sustainability. 2023;15(7):5614. https://doi.org/10.3390/su15075614.

43. Kuhail MA, Alturki N, Alramlawi S, Alhejori K. Interacting with educational chatbots: a systematic review. Educ Inf Technol. 2022;28(1):973–1018. https://doi.org/10.1007/s10639-022-11177-3.

44. Lee H. The rise of ChatGPT: exploring its potential in medical education. Anat Sci Educ. 2023. https://doi.org/10.1002/ase.2270.

45. Li L, Subbareddy R, Raghavendra CG. AI intelligence Chatbot to improve students learning in the higher education platform. J Interconnect Netw. 2022. https://doi.org/10.1142/s0219265921430325.

46. Limna P. A Review of Artificial Intelligence (AI) in Education during the Digital Era. 2022. https://ssrn.com/abstract=4160798

47. Lo CK. What is the impact of ChatGPT on education? A rapid review of the literature. Educ Sci. 2023;13(4):410. https://doi.org/10.3390/educsci13040410.

48. Luo W, He H, Liu J, Berson IR, Berson MJ, Zhou Y, Li H. Aladdin's genie or pandora's box For early childhood education? Experts chat on the roles, challenges, and developments of ChatGPT. Early Educ Dev. 2023. https://doi.org/10.1080/10409289.2023.2214181.

49. Meyer JG, Urbanowicz RJ, Martin P, O'Connor K, Li R, Peng P, Moore JH. ChatGPT and large language models in academia: opportunities and challenges. Biodata Min. 2023. https://doi.org/10.1186/s13040-023-00339-9.

50. Mhlanga D. Open AI in education, the responsible and ethical use of ChatGPT towards lifelong learning. Soc Sci Res Netw. 2023. https://doi.org/10.2139/ssrn.4354422.

51. Neumann, M., Rauschenberger, M., & Schön, E. M. (2023). "We Need To Talk About ChatGPT": The Future of AI and Higher Education. https://doi.org/10.1109/seeng59157.2023.00010

52. Nolan B. Here are the schools and colleges that have banned the use of ChatGPT over plagiarism and misinformation fears. *Business Insider*. 2023. https://www.businessinsider.com

53. O'Leary DE. An analysis of three chatbots: BlenderBot, ChatGPT and LaMDA. Int J Intell Syst Account, Financ Manag. 2023;30(1):41–54. https://doi.org/10.1002/isaf.1531.

54. Okoli C. A guide to conducting a standalone systematic literature review. Commun Assoc Inf Syst. 2015. https://doi.org/10.17705/1cais.03743.

55. OpenAI. (2023). https://openai.com/blog/chatgpt

56. Perkins M. Academic integrity considerations of AI large language models in the post-pandemic era: ChatGPT and beyond. J Univ Teach Learn Pract. 2023. https://doi.org/10.53761/1.20.02.07.

57. Plevris V, Papazafeiropoulos G, Rios AJ. Chatbots put to the test in math and logic problems: A preliminary comparison and assessment of ChatGPT-3.5, ChatGPT-4, and Google Bard. *arXiv (Cornell University)*. 2023. https://doi.org/10.48550/arxiv.2305.18618

58. Rahman MM, Watanobe Y (2023) ChatGPT for education and research: opportunities, threats, and strategies. Appl Sci 13(9):5783. https://doi.org/10.3390/app13095783

59. Ram B, Verma P. Artificial intelligence AI-based Chatbot study of ChatGPT, google AI bard and baidu AI. World J Adv Eng Technol Sci. 2023;8(1):258–61. https://doi.org/10.30574/wjaets.2023.8.1.0045.

60. Rasul T, Nair S, Kalendra D, Robin M, de Oliveira Santini F, Ladeira WJ, Heathcote L. The role of ChatGPT in higher education: benefits, challenges, and future research directions. J Appl Learn Teach. 2023. https://doi.org/10.37074/jalt.2023.6.1.29.

61. Ratnam M, Sharm B, Tomer A. ChatGPT: educational artificial intelligence. Int J Adv Trends Comput Sci Eng. 2023;12(2):84–91. https://doi.org/10.30534/ijatcse/2023/091222023.

62. Ray PP. ChatGPT: a comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. Internet Things Cyber-Phys Syst. 2023;3:121–54. https://doi.org/10.1016/j.iotcps.2023.04.003.

Discover

63. Roumeliotis KI, Tselikas ND. ChatGPT and Open-AI models: a preliminary review. Future Internet. 2023;15(6):192. https://doi.org/10.3390/fi15060192.

64. Rudolph J, Tan S, Tan S. War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education. J Appl Learn Teach. 2023. https://doi.org/10.37074/jalt.2023.6.1.23.

65. Ruiz LMS, Moll-López S, Nuñez-Pérez A, Moraño J, Vega-Fleitas E. ChatGPT challenges blended learning methodologies in engineering education: a case study in mathematics. Appl Sci. 2023;13(10):6039. https://doi.org/10.3390/app13106039.

66. Sallam M, Salim NA, Barakat M, Al-Tammemi AB. ChatGPT applications in medical, dental, pharmacy, and public health education: a descriptive study highlighting the advantages and limitations. Narra J. 2023;3(1): e103. https://doi.org/10.52225/narra.v3i1.103.

67. Salvagno M, Taccone FS, Gerli AG. Can artificial intelligence help for scientific writing? Crit Care. 2023. https://doi.org/10.1186/s13054-023-04380-2.

68. Saqr M, López-Pernas S, Helske S, Hrastinski S. The longitudinal association between engagement and achievement varies by time, students' profiles, and achievement state: a full program study. Comput Educ. 2023;199:104787. https://doi.org/10.1016/j.compedu.2023.104787.

69. Saqr M, Matcha W, Uzir N, Jovanović J, Gašević D, López-Pernas S. Transferring effective learning strategies across learning contexts matters: a study in problem-based learning. Australas J Educ Technol. 2023;39(3):9.

70. Schöbel S, Schmitt A, Benner D, Saqr M, Janson A, Leimeister JM. Charting the evolution and future of conversational agents: a research agenda along five waves and new frontiers. Inf Syst Front. 2023. https://doi.org/10.1007/s10796-023-10375-9.

71. Shoufan A. Exploring students' perceptions of CHATGPT: thematic analysis and follow-up survey. IEEE Access. 2023. https://doi.org/10.1109/access.2023.3268224.

72. Sonderegger S, Seufert S. Chatbot-mediated learning: conceptual framework for the design of Chatbot use cases in education. Gallen: Institute for Educational Management and Technologies, University of St; 2022. https://doi.org/10.5220/0010999200003182.

73. Strzelecki A. To use or not to use ChatGPT in higher education? A study of students' acceptance and use of technology. Interact Learn Environ. 2023. https://doi.org/10.1080/10494820.2023.2209881.

74. Su J, Yang W. Unlocking the power of ChatGPT: a framework for applying generative AI in education. ECNU Rev Educ. 2023. https://doi.org/10.1177/20965311231168423.

75. Sullivan M, Kelly A, McLaughlan P. ChatGPT in higher education: Considerations for academic integrity and student learning. J ApplLearn Teach. 2023;6(1):1–10. https://doi.org/10.37074/jalt.2023.6.1.17.

76. Szabo A. ChatGPT is a breakthrough in science and education but fails a test in sports and exercise psychology. Balt J Sport Health Sci. 2023;1(128):25–40. https://doi.org/10.33607/bjshs.v127i4.1233.

77. Taecharungroj V. "What can ChatGPT do?" analyzing early reactions to the innovative AI chatbot on Twitter. Big Data Cognit Comput. 2023;7(1):35. https://doi.org/10.3390/bdcc7010035.

78. Tam S, Said RB. User preferences for ChatGPT-powered conversational interfaces versus traditional methods. Biomed Eng Soc. 2023. https://doi.org/10.58496/mjcsc/2023/004.

79. Tedre M, Kahila J, Vartiainen H. (2023). Exploration on how co-designing with AI facilitates critical evaluation of ethics of AI in craft education. In: Langran E, Christensen P, Sanson J (Eds). *Proceedings of Society for Information Technology and Teacher Education International Conference*. 2023. pp. 2289–2296.

80. Tlili A, Shehata B, Adarkwah MA, Bozkurt A, Hickey DT, Huang R, Agyemang B. What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. Smart Learn Environ. 2023. https://doi.org/10.1186/s40561-023-00237-x.

81. Uddin SMJ, Albert A, Ovid A, Alsharef A. Leveraging CHATGPT to aid construction hazard recognition and support safety education and training. Sustainability. 2023;15(9):7121. https://doi.org/10.3390/su15097121.

82. Valtonen T, López-Pernas S, Saqr M, Vartiainen H, Sointu E, Tedre M. The nature and building blocks of educational technology research. Comput Hum Behav. 2022;128:107123. https://doi.org/10.1016/j.chb.2021.107123.

83. Vartiainen H, Tedre M. Using artificial intelligence in craft education: crafting with text-to-image generative models. Digit Creat. 2023;34(1):1–21. https://doi.org/10.1080/14626268.2023.2174557.

84. Ventayen RJM. OpenAI ChatGPT generated results: similarity index of artificial intelligence-based contents. Soc Sci Res Netw. 2023. https://doi.org/10.2139/ssrn.4332664.

85. Wagner MW, Ertl-Wagner BB. Accuracy of information and references using ChatGPT-3 for retrieval of clinical radiological information. Can Assoc Radiol J. 2023. https://doi.org/10.1177/08465371231171125.

86. Wardat Y, Tashtoush MA, AlAli R, Jarrah AM. ChatGPT: a revolutionary tool for teaching and learning mathematics. Eurasia J Math, Sci Technol Educ. 2023;19(7):em2286. https://doi.org/10.29333/ejmste/13272.

87. Webster J, Watson RT. Analyzing the past to prepare for the future: writing a literature review. Manag Inf Syst Quart. 2002;26(2):3.

88. Xiao Y, Watson ME. Guidance on conducting a systematic literature review. J Plan Educ Res. 2017;39(1):93–112. https://doi.org/10.1177/0739456x17723971.

89. Yan D. Impact of ChatGPT on learners in a L2 writing practicum: an exploratory investigation. Educ Inf Technol. 2023. https://doi.org/10.1007/s10639-023-11742-4.

90. Yu H. Reflection on whether Chat GPT should be banned by academia from the perspective of education and teaching. Front Psychol. 2023;14:1181712. https://doi.org/10.3389/fpsyg.2023.1181712.

91. Zhu C, Sun M, Luo J, Li T, Wang M. How to harness the potential of ChatGPT in education? Knowl Manag ELearn. 2023;15(2):133–52. https://doi.org/10.34105/j.kmel.2023.15.008.