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PAPER

Chatbots: The Future of Education?

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ABSTRACT

Chatbots are emerging technologies with the potential to improve teaching and learning processes. This paper conducts a systematic review of research on chatbots in education, focusing on articles published in Online-Journals.org from 2011 to 2024. The aim is to examine the various aspects addressed by the authors, such as design principles, pedagogical roles, interaction styles, and evaluation methods for chatbots in educational contexts. The tools were classified according to the type of user they targeted, revealing that 42% were aimed at students, 11% at teachers, 29% at both types of users, and 18% at external users. The characteristics of the tools along the above dimensions were analyzed, highlighting trends, good practices, and observed limitations. The key findings, challenges, and implications of using chatbots to improve learning outcomes, and experiences were discussed. It was concluded that chatbots are an emerging technology that offers benefits such as teaching personalization, self-learning, and real-time feedback but also poses challenges, such as evaluation and research into their effectiveness for education.

KEYWORDS

chatbot, education, natural language processing (NLP), self-learning

1 INTRODUCTION

The rise of artificial intelligence (AI)-based tools is a reality. In fact, they are already being used in everyday life, for example, in cell phones. Many of these tools began to gain popularity with ChatGPT. However, there were already several developments based on chatbots or natural language processing (NLP) used as educational tools before ChatGPT. These tools enhance the capabilities of students, teachers, administrators, and parents.

Literature reviews on chatbots in education reveal valuable insights. For example, the study by [1] (2015–2021) provides structured, up-to-date information on the benefits while identifying areas requiring further research. The study by [2] also revealed that more than half of the articles reviewed focused on teaching agents, with peer agents accounting for the remaining third. Systematic literature reviews between 2011 and 2021 explored various aspects of chatbots in education, including design, interaction, evidence for their use, and their limitations. The review by [3]

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(2018–2023) similarly explores the benefits, opportunities, and limitations of AI chatbots in education for both students and educators.

Literature reviews also reveal a lack of information about the target audience, including students and teachers. In addition, the main methods and strategies used to develop chatbots are not sufficiently considered, and their advantages over traditional teaching are not highlighted. To advance the use of chatbots in education, we propose seven key aspects.

Given the service provided by Online-Journals.org, its journals—namely, *Journal of Emerging Technologies in Learning (iJET)*, *International Journal of Interactive Mobile Technologies (iJIM)*, *International Journal of Online and Biomedical Engineering (iJOE)*, and *International Journal of Engineering Pedagogy (iJEP)*—have published numerous articles dealing with the use of AI-based tools and the benefits derived from them. Importantly, these articles also address the challenges and drawbacks of using these tools. The content of these articles covers the period from 2011 to 2024 and specifically concerns chatbots or NLP, as indicated by their titles, summaries, or keywords. In fact, this paper compiles, and analyzes strategies related to the use of AI in education, covering aspects such as definition, methods, benefits, and challenges.

The remainder of this paper is organized as follows: Section 2 describes the methodological aspects of this systematic review. Section 3 presents the main conclusions.

2 METHODOLOGY

This literature review is divided into three parts: *definition of the research questions*, followed by *bibliographic search*, and finally the analysis of the *information collected*, as proposed in [4] and [5]. The databases consulted come from Online-Journals.org. Articles published before 2011 were directly excluded from the aforementioned database. Initially, 53 articles were retained, but 15 were excluded because they were not relevant to this work. In the end, this literature review includes 38 research articles published between 2011 and March 2024, all in English.

For the development of the paper, certain questions were established in order to obtain information on the definition, strategies, differences, progress, research recipients, and challenges of chatbots in education; the research questions (RQs) being as follows:

RQ1. How do different authors define chatbots?
RQ2. What are the different strategies for using chatbots in education?
RQ3. What are the differences between chatbots and other educational technologies?
RQ4. What is the latest on chatbots in education?
RQ5. Who can benefit from research into chatbots in education?
RQ6. What are the challenges of using chatbots in education?

2.1 Chatbots

Given that several works were developed before the emergence of ChatGPT and other current AI tools, and according to the authors consulted, the aim is to establish the meaning of chatbot. For some authors, a chatbot is defined as a system that answers a user's question with a sentence [6], and it has been correlated with computer programs that can parse or understand language, as presented by [7]–[16]. Chatbots can interact with users using natural language, images, or voice recognition, particularly online, as suggested by [17]–[21]. Chatbots can be classified into three subtypes according to their goals: personal or impersonal, domain-specific or non-domain-specific, and task-, information-, or conversation-based, as references [22]–[25] show. In addition, other authors introduce the concept of AI programs; as shown in references [26]–[28], users can develop human-computer interaction technologies capable of handling natural language understanding (NLU).

According to [29]–[31], a chatbot can provide automated customer service, answer FAQs, and even engage in natural language conversations. It uses dialog management modules, stimulus tags, knowledge bases, and patterns to respond to user input, as shown in [32], and it can provide personalized guidance, as suggested in [33]–[37]. Chatbots use NLP, which allows for efficient multilayered linguistic annotation and indexing. This is made query-able through a user-friendly web interface that minimizes the expertise required for data-driven learning activities, as in [38], and provides help and answers to queries, as suggested in [39] and [40]. In fact, according to [41], NLP translates natural language into data used by computers to learn how to understand the language.

2.2 Main methods or approaches used in chatbots

In the method developed by [6], the rapid prototyping approach was used to present a lab based on AI speakers and the ADDIE model, which focuses on formative assessment. On the other hand, in [26], a conversational chatbot uses the Moodle platform. The use of methods such as NLP and deep learning (DL) makes it possible to integrate strategies such as remediation into massive open online courses (MOOCs). This contributes to identification and direct intervention to prevent dropout, as shown in [21]. [29] suggests using an algorithm for keyword extraction and text reprocessing methods. Similarly, the authors of [17] used summarization, word selection, and question formation methods for text analysis.

In [19], the development of the gramabot chatbot used tree-based chatbot structures, AI, and a hybrid approach, as well as basic programming models, NLP, and digital signal processing technologies. In [9], input strings, WordNet-based semantic similarity, and string metrics were utilized in a computer algebra system, such as MAXIMA. The authors in [41] used NLP through tokenization, case folding, and stop word removal to find the verb to assign the question to the cognitive process dimension. In [39], the Seq2Seq model was used, in addition to the configuration of special features such as encoding with a gated recurrent unit (GRU) network, word embedding, and dropout rates.

Different AI techniques and cognitive approaches are used in various studies. For example, in [40] analyzed the use of stop words, spelling correction, slang replacement, stemming, lemmatization, bag-of-word, word2vec, and doc2vec. The authors in [7] utilized pre-classification, clustering based on cosine similarity, and educational knowledge mining for processing the Finnish language. In [14], we discussed the use of NLP and probability statistics. In [33] and [13], addressed the use of algorithms such as naïve bayes and PR, besides different AI techniques, model-tracing, and constraint-based modeling (CBM).

The method proposed by [38] has the main characteristics of teacher-led instruction in the classroom and self-learning. The authors in [11] used two methods, the morphology analyzer (MA) and the HMM trigram, for the objective and subjective measurement of the level of precision. In [34], the authors used self-reports and tools, such as Skype and Cisco, during the COVID-19 pandemic. In contrast, [32] used unsupervised learning, NLP, keyword mapping, and datasets. In [22], we used single page application (SPA) development, information, and conversation-based bots.

The latent semantic indexing approach, corpus-based approach, NLP, and social network analysis are also used, as shown in [10] and [8]. The study in [10] employed discourse content analysis, social network analysis, multilevel modeling, NLP, mining techniques, object-oriented programming, agent programming, distributed programming, and ontology indicators. The authors in [8] utilized HMM for response extraction and frequency list and file generation. In [12], the authors analyzed text using AI, manual validation, categorization, and extraction. In [18], the authors used tokenization, stop word removal, tagging, verb extraction, and sentimental analysis. In [42], multiple linear regression, NLP, information retrieval, and a hold-out method were employed.

2.3 Technological tools for better stakeholder training

Several authors have developed tools to improve student learning in different areas. For example, ChatGPT is a learning tool for undergraduate students, according to [23], [35], and [36]. For assessment, researchers in [26] and [25] have developed a tool that allows students to be placed at the appropriate level, while researchers in [13] have developed an evaluation tool for high school students. Additionally, the authors in [40] have shown a tool that allows for the evaluation of student cognitive presence. In a job search, the authors [29] and [28] have developed a tool focused on university students seeking employment opportunities. Meanwhile, researchers in [33] concentrate on the need to practice speaking English for job interviews. [37] focuses on K-12 students, specifically fifth graders, who participated in a randomized controlled trial. In language practice, [19] has developed a tool focused on beginner students of the German language, and several authors, such as [8], [11], [14], and [42], have developed tools aimed at language students.

Other tools mentioned include the development of [39], which seeks to be a complement for educators and is focused on students. The development of [21], which is designed for online courses and provides support to students; and the works of [32] and [22], which address the solution to student questions and searches. Additionally, [10] has created a tool with the purpose of observing contributions between peer groups. Some tools are focused on both teachers and students. For instance, [6] has developed a tool focused on university students who are practicing chemistry teachers and attend practical science laboratory classes. In [38], the focus is on improving English language knowledge for teachers and students at all levels. Authors in [9] and [30] offer tools for students and teachers in mathematics, while [34] has developed a tool focused on higher education teachers and students. The benefits extend to individuals with dyslexia and instructors, among others, as demonstrated in [15].

For teachers, the research in [17] focuses on creating and evaluating quizzes more efficiently. Another study, presented in [41], concentrates on evaluating quality and effectiveness. In [12], it is possible to obtain relevant information from courses, while [18] focuses on categorizing questions according to the level of learning.

Some articles have the particularity of being used by external parties while contributing to the improvement of learning. For [29], the tool can also be used by companies wishing to hire university students. Healthcare personnel are the subject of [7] and [16]. For biomedical and neuroscience researchers and clinicians, the authors of [31] present an essential tool for exploring and extracting relevant information. Tourists in the city of Jeddah can find recommendations and information, as shown in [27]. In [24] and [43], the use of chatbots to involve various stakeholders and help with employee training and managerial decision-making is well explained. Figure 1 shows the percentage of different research approaches presented in the articles consulted.

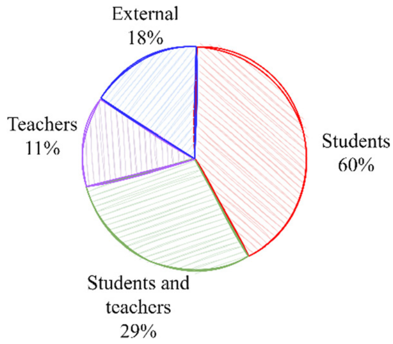

Fig. 1. Percentage of people for whom tools are intended

Some of these developments use NLP techniques to analyze text, extract keywords, and generate answers. They also focus on providing personalized learning experiences for each student based on his or her needs and abilities. Some developments use large datasets to train their models, which can help improve model accuracy and reliability. Others create new ontologies to make sense of isolated data events. Web forums are used to collect collaborative indicators using NLP techniques. This can help identify highly semantic indicators to describe various primitive acts of collaboration. One development uses images as part of the question description to improve the accuracy of question classification.

Another development identifies the need for a deeper understanding of collaboration between participants in working groups to develop effective AI-powered educational technologies. Challenges posed by the Arabic language are also mentioned, such as the absence of capital letters and the use of different shapes for letters depending on their position in the word. Many of these developments have the potential to improve learning outcomes by offering learners more engaging and effective learning experiences. However, research and development are still in its infancy. In addition, Figure 2 outlines ten key characteristics of AI-powered education developments.

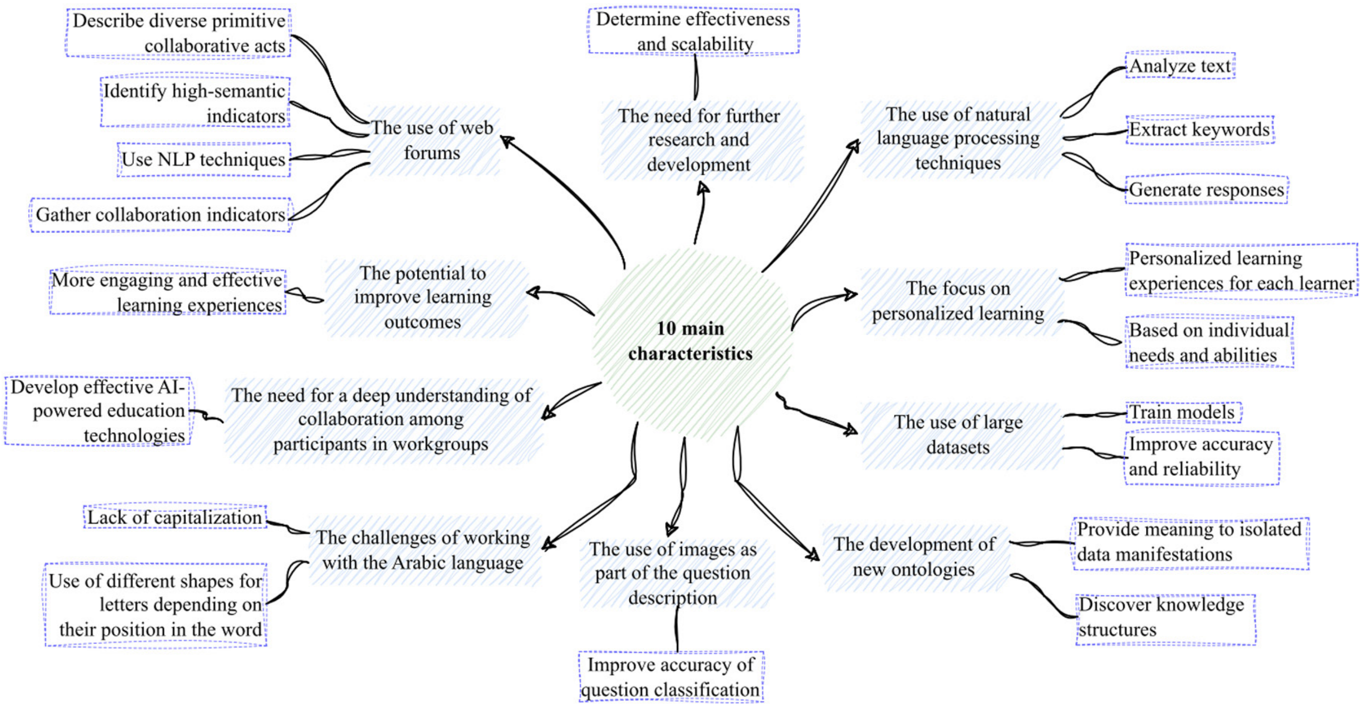

Fig. 2. Ten key features of educational developments and consultations using chatbots

2.4 Advantages over traditional teaching

This section has been organized according to the years in which the articles were published, from the most recent to the oldest, in order to examine the advantages, put forward by the authors over traditional education. ChatGPT illustrates the potential of educational technologies in promoting personalized learning, critical thinking, problem-based learning, and interactive practice [35]. In addition, AI can enhance learning by making it more enjoyable and personalized, increasing student engagement and motivation [16], [24], [36], and [37].

Chatbots offer personalized advice and dynamic support, adapting to educational trends and job market requirements. They learn from feedback and continuously improve. By improving accessibility, chatbots democratize career guidance, ensuring that all students can make informed decisions. In addition, chatbots reduce teacher workload, improve learning outcomes, and integrate gamification elements, such as points and badges, to make learning more engaging. They facilitate individualized learning and promote collaborative communication between students and experts [25], [28].

Several studies have shown the benefits of using AI tools in education. According to [6], the use of a high-speaker system with AI allowed students to feel more confident in the laboratory and acquire scientific knowledge. Research in [26] highlights the ability of these tools to perform self-assessments and provide personalized guides for each student. In [17], it highlights the effectiveness of generating quality quizzes and evaluations. In addition, [29] emphasizes that real-time feedback and data analysis are the main benefits of remote experimentation.

The work in [41] highlights its ability to assist in the evaluation of learning processes and outcomes. In [19], it emphasizes flexibility and personalization in learning the German language. In [38] notes overcoming temporal and geospatial obstacles for more efficient research. Researchers in [9] mention more efficient and effective evaluation compared to the traditional laboratory. In [21], the highlights are personalized assistance with tutors and intelligent agents. For [30], chatbots can handle large numbers of students without compromising teaching quality.

In [20], it shows a reduction in ambiguity and an increase in productivity in distance education. In [34], the highlight is the increase in learning performance in classrooms. For [23], a chatbot can reduce the workload and cost of teachers and educators by automating some of the tasks and feedback. A frequently mentioned aspect is personalization. In [32], present its importance and the possibility of simulating a conversation with a virtual teacher or tourism recommendations, as shown in [27]. Chatbots can generate interest and publicity, helping companies reach new or younger audiences and improve specific parts of their websites, such as the FAQs [43].

In [39], the highlights scalability and cost-effectiveness for more detailed experiences. [31], [40] note time management for activity development and improved learning. In [7], it shows the ability to automatically analyze responses and improve the organization of training courses. As well as greater satisfaction with the results obtained and immersion by the user are the benefits presented by [22], compared to traditional laboratories.

In addition, [14] presents the ability to improve teaching focus and tutoring through quantitative results. Likewise, [33] features the benefit of online conversations in English and the ability to provide specific interviews for a job. [15] helps to improve the reading skills and confidence of dyslexic children. Furthermore, [13] notes that accelerated learning and a variety of assistance can be better than the traditional way. In the case of [11], the acquisition of different characteristics almost simultaneously with a friendly interface is highlighted.

In terms of time savings, [42] highlights the increased ability to improve specific features, such as punctuation and semantics. In [12], it emphasizes the ability to handle educational information and competencies. Researchers in [18] mention the automatic performance of exams according to learning levels and their extension to other fields of knowledge. In [10], the highlights are monitoring, personalization, and collection in web-based learning. Finally, [8] notes the simultaneous acquisition of unique characteristics and the filtering of responses to identify the most appropriate candidates. Table 1 presents a summary of the main benefits of using chatbots in education.

Table 1. Main benefits highlighted by the authors

Benefits	References
Improved safety, scientific knowledge and student self-assessment.	[6], [14], [26], [30], [42]
Efficient generation of questionnaires and quality evaluations.	[9], [12], [17], [23], [25], [41], [43]
Real-time feedback and data analysis to improve learning.	[7], [11], [16], [29], [31]
Flexibility and personalization in the educational process.	[10], [19], [28], [32], [36], [37], [39], [40]
Overcoming temporal and geospatial obstacles for more efficient studies.	[18], [24], [38]
Reducing ambiguity and increasing productivity in distance education.	[13], [20], [27]
Personalized assistance with tutors and intelligent agents.	[8], [21], [33], [35]
Increased learning performance in classrooms and greater user satisfaction and immersion.	[15], [22], [34]

2.5 Seven key aspects for advancing the development and application of chatbots

1. **Research and evaluation.** The merits of the AI speaker system should be investigated based on the responses of experts and university students. Then, review the current state, limitations, and future directions for the system in science laboratory classes [6]. The evaluation of QuizCbot in [26] should be based on participants' perceptions of the usefulness of personalized feedback and the recommendations previously given to them. In the case of [9], more testing and refinement of the algorithms used to evaluate open-ended math questions is required. In addition, [39] proposes conducting more experiments to obtain definitive conclusions about the generative power of Seq2Seq models. In [16], [36], user satisfaction is evaluated in terms of content, functionality, and usability. At the University of Jordan, [35] covers research, evaluation, and analysis aspects related to ChatGPT and its application in the educational context. Finally, formative and summative evaluations should be conducted to determine the quality of service (QoS) and quality of experience (QoE) as expressed by [11].
2. **Data collection and management.** All information and data should be recorded in the MongoDB database, and students should be allowed to use the chatbot on any device of their choice [26]. For [20], it is necessary to collect feedback from students and teachers. In [34], the goal is to identify the important technological tools used in teaching in higher education in India during COVID-19. A national registry of toxic exposures should be established, providing medical care and

financial help to those affected. In addition, a storage structure should improve the efficiency of retrieval of the dialogue management module, as expressed by [32]. The quantitative data collected in the tables should construct the frequency list according to [10] and [8].

3. **Analysis and modeling.** According to [29], it is necessary to compare the probability of occurrence of skills learned by university students in a job position. LDA should be applied in a discussion forum to discover students' interest in topics and recommend semantic elements [32]. A separate classifier such as the Watson classifier should be evaluated to improve intent matching and entity extraction [22]. For [40], pre-processing using NLP, feature extraction, and concatenation of the values got should be performed. An algorithm such as Naïve Bayes can classify the results of [33]. Responses should be modeled based on specific constraints, according to [13]. According to [34], the hybrid force model applicable in education is proposed. This model is based on the simultaneous interaction between humans, content, and technological tools.
4. **Implementation and experimentation.** The application should be reviewed and adapted for use in the classroom; working with chatbots for other levels and topics of German grammar or other applications, according to [19], should also be considered. For [38], it can be deployed in a blended learning environment and its effectiveness evaluated. Instructions by the teacher and student-centered autonomous learning should be integrated into a combined English for specific purposes (ESP) pedagogy model, which is data-based. [15] helps children with dyslexia to improve their reading and spelling skills in learning the Arabic alphabet. The tool Mathbot is used for mathematical tasks, however, suggests some improvements for the app, such as adding more trainers and questions [30]. In [23], [43] compare the chatbot with the traditional website and evaluate the differences in speed, user satisfaction, and user experience. For [25], the users are 150 postgraduate students at King Faisal University. In [31], the BioNLP platform requires evaluating and validating the performance and accuracy in systems biology modeling and translational medicine.
5. **Improvement and optimization.** Several works agree on improving their accuracy by defining clear evaluation criteria. Pilot tests with specialists are required to validate the instructions [17]. Its application should be expanded to other cognitive frameworks [41], and the model optimized considering dropout rates [39]. In addition, a dedicated API for data retrieval should be provided as proposed by [22] and evidence-based knowledge used to further improve the organization of training courses [7]. Several processes can be improved, as shown by [12]. Among them, the linguistic cleaning process in the parser step stands out to more effectively deal with multi-word terms. New techniques that use collective knowledge to find possible equivalences in cases of acronyms, technical names, and different languages should be applied. Functionalities should be added to previous processes to extract learning outcomes and analyze alignment with terms extracted from learning resources. In [18], the verb extraction process needs to be improved to achieve higher levels of accuracy of the WordNet algorithm. With a variety of translations, it should be established whether particular features can be produced [42]. The feedback can help improve the quality of the guidance provided over time, as shown in [28].
6. **Technology development and implementation.** The range of input types that can be evaluated by the STACK system should be expanded according to [9]. Chatbots should be implemented in several courses to determine their effectiveness [20], and this model was used to develop a question-answering system in educational environments [39]. The tool should be integrated into e-learning

platforms to provide students with real-time feedback on their cognitive level [41]. A chatbot capable of satisfying student requests in natural language should be developed by [32], and the experimental voice recognition function activated. More data APIs should be provided to increase the user experience and significance of the bot, as expressed by [22]. Sentence reinforcement algorithms should make a summary at the end of the interview session and generate ordered graphs of all conversations, as proposed by [33]. An editor should be implemented to facilitate the manual refinement process of terms [12]. It should be connected to an e-learning environment such as Moodle, and weights generated and assigned to exam questions according to Bloom's Taxonomy [18]. Another unified MOOC search platform that leverages semantics for personalized and effective online learning opportunities [44]. Aspects such as data quality, scalability, and user satisfaction in [27], [37] incorporate QuizVentor, a tool that adds game elements to Moodle quizzes, and show that the gamified assessment can obtain better results.

7. **Qualitative analysis.** Clustering can be used to automatically group reflections from healthcare supervisors, and word clouds and qualitative analysis can be used to summarize different profiles [7]. The graph can also be used to make qualitative interpretations of participant behavior and a specific ontology defined to provide high-level meaning to the results extracted from the model, as suggested by [10].

2.6 Disadvantages or challenges

It is essential to take into account a range of challenges when using or evaluating distance education tools. These challenges include long response times, reduced authenticity of information, difficulties in processing data, limitations in platform availability, operational complexity, lack of research into potential negative effects, and constraints on integrating technology into teaching and learning processes. In addition, specialized functionalities, the complexity of question entry and evaluation, scoring limitations, feedback constraints, lack of human interaction, or risks of misuse also need to be carefully considered. Furthermore, the various challenges and difficulties presented in [45] due to the post-COVID-19 era underline the need to acquire, master, and stay up-to-date with new tools, such as chatbots, in order to improve the skills and capabilities of future students and professionals.

3 CONCLUSIONS

Chatbots are computer programs capable of understanding and responding to human language. They can be used for a variety of purposes, including providing customer service, answering questions, and engaging in conversation. NLP and DL can be used to improve the effectiveness of MOOCs. These technologies can be used to provide personalized teaching, identify and support learners in difficulty, and track student progress.

A number of tools have been developed to enhance student learning in different areas. These tools focus on assessment, job search, language practice, student support, peer collaboration, and teacher support. AI-powered education development uses a variety of techniques to improve learning outcomes. These techniques include NLP, large datasets, ontologies, and images.

Some of these developments are specifically designed to foster collaboration between learners. This is important for real-world learning, where people often have to work together to solve problems.

The use of AI tools in education has been shown to deliver a number of benefits, such as greater confidence, personalized learning, improved assessment, and increased productivity. AI tools can also be used to provide real-time feedback, aid research, and improve the organization of training courses. The use of AI tools in education is likely to continue to grow in the future. However, further research and evaluation is needed to determine the effectiveness of AI-powered educational tools.

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