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PAPER

AI Chatbots in Higher Education: Opportunities and Challenges for Personalized and Mobile Learning

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ABSTRACT

The landscape of higher education is increasingly shaped by the integration of innovative tools such as chatbots, which offer promising solutions to enhance e-learning experiences. As conversational agents, chatbots are being adopted to address challenges in e-learning environments, including low student engagement and lack of personalized support. This literature review explores the current state of e-learning chatbots in higher education, with a particular focus on mobile learning environment. It aims to investigate how these tools contribute to personalize learning, the opportunities they present, and the key limitations and challenges they face. We conducted a comprehensive review of 815 publications from 2018 to 2024 across three major digital databases: *Scopus*, *IEEE Xplore*, and *Science direct*. From these, 39 studies were selected for in-depth analysis. Findings reveal that chatbots enhance personalized learning by adapting content and feedback based on various learner-specific features. In addition, chatbots are particularly effective when integrated into mobile applications and powered by AI technologies. Results show further that e-learning chatbots in higher education support a wide range of educational tasks from language learning to personalized guidance. Despite these advancements, significant challenges need to be addressed, including the technical limitations of both rule-based and AI-based chatbots. These challenges highlight the need for continued research aimed at improving chatbot capabilities. This review aims to inspire and support the effective integration of chatbots in higher education by offering concrete insights for instructors, developers, and researchers.

KEYWORDS

e-learning, mobile learning, higher education, university, personalized learning, AI chatbots, mentoring

1 BACKGROUND AND INTRODUCTION

In recent years, e-learning has been adopted by most international universities worldwide, resulting in significant shifts in teaching and learning approaches [1].

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Through e-learning, students can choose their own learning courses, proceed at their own pace [2], and participate actively in their education [1], [3], and [4].

The Covid-19 emergency has abruptly pushed billions of students out of their classes and has significantly changed the way students are learning. Given the increased attention e-learning received in the emergency period, it has grown in popularity [5], [6], [2], [4], [7], and its use in higher education has increased [8]. E-learning is becoming the new standard mode of education for many universities around the world. Consequently, stockholders and decision making are more interested in improving e-learning systems than before [9]. Moreover, the growing use of smartphones and mobile technologies has transformed the landscape of e-learning. These tools offer innovative ways to engage with learning by facilitating communication and interactions [10], [11]. As a branch of e-learning, mobile learning, or mLearning, enables the knowledge acquisition and skills development using mobile technologies anytime and anywhere [12], [10]. Consequently, traditional teaching methods are becoming less effective for today's students, who are more engaged and prefer to communicate through mobile applications [13]. Mobile learning is emerging as a new standard for learning [14].

Despite the benefits of mobile learning, students in higher education still face challenges such as low interaction and participation and poor communication with teachers in e-learning environments [15]. Teachers' workload can act as a barrier to provide immediate and interactive support to students [16], [17], and [5]. They may struggle to offer real-time support for self-regulation techniques [18]. The inability to answer questions from large groups of students [19] and the fear of negative feedback can also discourage student participation [16], [20]. Disengagement, a common issue in e-learning systems, is defined as students not participating or withdrawing from activities and remains an important challenge in higher education [9], [5], and [21]. Studies on disengagement in online courses highlight self-regulation as a key factor in student performance. Students often struggle with self-regulation, which hinders their ability to engage in autonomous learning and leads to disengagement. Additionally, limited interactions in online environments can contribute to reduce social presence. This happens when students do not receive timely responses to their questions or requests for help [9], [18]. These challenges can negatively impact the learning process, leading to low performance [21]. Also, the problem of high dropout rates in online higher education courses remains a crucial issue [9], [19], and [21], in part due to students' difficulties in moving from high school to university and in acquiring self-directed skills [19]. In addition, the lack of support is contributing to low completion rates in online learning environments [22]. Addressing these challenges requires more personalized approaches, and learning materials should be adapted to students' needs and interests [2], [7]. [21] confirmed the relationship between personalized support and lower dropout rates in higher education. Hence, it is important to explore techniques and methods to address student disengagement in online learning [9].

The rapid adoption of smartphones among university students and the widespread popularity of mobile applications have greatly impacted education [23]. Thus, higher education has shifted toward adopting new approaches and tools to enhance and personalize e-learning systems [2]. [16] and [2] reported that the application of AI and recent technologies to improve learning quality has made significant progress in e-learning, leading to more intelligent learning experiences. [24] highlighted that the majority of recent e-learning advancements are linked to AI and confirmed that the learning process could be greatly simplified by the use of chatbots. [8], [25], and [20] noted that chatbots may be a promising and effective teaching and learning tool in online education. According to [26], chatbots and AI are rapidly being used in higher education institutions to enhance student engagement

and support. Consequently, chatbots are becoming an important component of university education, as they are integrated into e-learning platforms to address many challenges [21], [27]. They also provide an innovative approach to enhance student learning experiences through the use of mobile devices [21].

While numerous studies have explored the use of chatbots in educational settings, to our knowledge there is no recent comprehensive literature review that specifically examines the application of these conversational agents within e-learning environments in higher education. Existing research primarily focuses on general education, often neglecting the unique challenges and opportunities presented by e-learning systems in higher education institutions. Additionally, the type of chatbot, whether rule-based or AI-based, and the platform on which it operates, whether mobile or web, play a crucial role in its effectiveness and influence the personalization of learning. However, these aspects remain largely underexplored in current research. To address this gap, a literature review is needed to explore the following research questions:

RQ1: How do e-learning chatbots enhance personalized learning experiences in higher education?
RQ2: What opportunities do e-learning chatbots offer in higher education?
RQ3: What are the key limitations and challenges faced by e-learning chatbots in higher education?

To answer these research questions, the remainder of this paper is presented as follows: First, in Section 2, we outline the method used to select relevant papers. Then, in Section 3, we present the results of our findings. In Section 4, we discuss our findings, and present some future directions to explore in Section 5. Finally, we summarize our findings and present the conclusion in Section 6.

2 METHOD

This paper aims to present the state-of-the-art of e-learning chatbots in higher education by conducting a review of recent literature. To identify relevant studies, we searched journal and conference papers and book chapters published between 2018 and 2024 across three major academic databases: *Scopus*, *IEEE Xplore*, and *science direct*. The literature review focused on four key concepts: chatbots, e-learning, mobile learning, and higher education. To capture these concepts comprehensively, we constructed a search string using Boolean operators as follows:

("Chatbot" OR "Conversational Agent" OR "Pedagogical Agent") AND ("e-learning" OR "mobile learning") AND ("higher education" OR "university")

This query was applied across the selected databases, resulting in an initial total of 815 papers. To refine the selection, we applied the inclusion and exclusion criteria presented in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
1. Papers written in English	**1.** Duplicate and unavailable papers
2. Journals and conferences papers, book chapters	**2.** Papers that implement ChatGPT as chatbot
3. Papers that present an e-learning chatbot or a mobile learning chatbot	**3.** Papers that do not specify higher education or university as a context of the study/paper
4. Papers that present chatbots designed for higher education or university students	**4.** Papers that present chatbots designed for primary or secondary education

After applying the first two inclusion and exclusion criteria (language, type of publication, duplicates, and availability), 213 papers were retained for further review. Next, we conducted a screening phase by analyzing the title, abstract, keywords, and conclusion of each article, applying the remaining inclusion and exclusion criteria (3 and 4). A full-text review was then performed on eligible papers. As a result, 39 studies were selected for in-depth analysis to address our research questions.

3 RESULTS

3.1 Personalization through e-learning chatbots

Chatbots are interactive agents that communicate with users through text or voice, using natural language [18], [28], and [29]. According to [9] and [24], they are software applications designed to engage with users in conversational interactions. Chatbots are commonly used in various industries, including online banking and retail customer support [9]. In education, they are considered among the most successful e-learning technologies [2], [28]. They answer students' questions, offload teachers, and reduce time spent on repetitive tasks [11], [21], improving the learning process and reducing dropout rates [19]. Chatbots can also change how students access information and improve interactivity in the learning process [17], [18], [24], and [27]. Moreover, they support self-directed learning by offering students opportunities for reflection and self-assessment. They align with micro-learning and facilitate activities that can motivate students and boost their interests [30].

In higher education, chatbots are increasingly being used to help students complete learning tasks and activities, provide personalized support, and boost engagement [5], [19], [21], and [27]. They facilitate communication and collaboration between students and teachers [17], [21], and [27], and help improve student confidence and motivation [21]. By tracking students' progress and offering feedback, chatbots enhance learning outcomes, adapting to students' needs and preferences [26], [27]. In addition, chatbots that implement personalization can further improve motivation, and self-regulation skills and provide relevant content to engage students [17].

In this context, mobile learning combined with chatbot-driven personalization plays a pivotal role in adapting educational content to the students' needs. [31] and [30] reported that chatbot-based mobile applications enhance peer communication while providing personalized learning experiences. This ubiquitous technology operates across multiple devices, allowing learners to engage in self-paced learning anytime and anywhere. These systems offer continuous practice and real-time feedback that foster self-regulation skills. [32] further reported that integrating AI with mobile technologies is transforming career guidance, offering real-time and personalized support that helps students navigate their career paths with more confidence. The authors of [11] highlighted that mobile learning groups, facilitated by instant communication, enhance collaborative learning and communication. In a study on nursing education using smartphones, [33] demonstrated that personalized learning experiences offered by chatbots promote active and self-directed learning, which are key factors in ensuring students' success. To understand how chatbots provide personalized learning experiences, it is important to examine the key features that enable personalization.

Key features of personalization. Personalization is a fundamental component of modern e-learning systems. It assists students in the learning process by providing relevant learning resources and materials. Personalized content can further

enhance the quality of e-learning [3]. According to [7], a personalized e-learning system can adapt to a specific student based on a variety of features, including personality traits, interests, learning styles, and other parameters of the student's identity. [3] reported that personalization is related to adaptability; it refers to the process used to meet the needs of a specific user and cited that learning methods can be adapted to learners' profiles. Personalized learning is one of the most effective approaches to improve the learning outcomes [24].

As a feature for implementing personalization, the Myers-Briggs type indicator (MBTI) was used by [7] to determine the personality traits of students (sensing (S), intuitive (N), feeling (F), and thinking (T)). The proposed chatbot use four learning paths, one for each personality based on dominant personality preferences. Each learning path consists of a selection of courses, exercises, and assessments, tailored to the student's personality. In a similar approach [28], the chatbot recommends the learning objects to students according to their learning style. They used the index of learning styles questionnaire developed by Felder and Silverman to determine the preferred learning styles of students and classify them to the appropriate style (visual, verbal, active, reflective). To meet the learning styles, the learning materials are given in several media and format options, including text documents, presentations, videos, etc. For example, a visual learner will prefer to watch a video rather than read a PDF document, while a verbal learner will choose the opposite. [3] implemented personalized learning by recommending learning objects based on two approaches: knowledge level (KL) and learning style (LS). First, students take pre-tests to assess their KL and identify areas for improvement; after the chatbot provides personalized learning objects. Next, students complete the Felder & Silverman Index of Learning Styles Questionnaire to determine their LS, and learning materials are provided in formats tailored to their preferences. Similarly, [2] classified students based on their learning styles to introverts and extraverts learners using VARK questionnaires. Many researchers use Neil Fleming's VARK questionnaires to categorize students according to their preferred methods of learning. Also, [33] personalized the educational content based on parameters like knowledge levels, learning anxiety, and self-efficacy. The chatbot ensures that support and feedback are suited to each student's unique needs. [24] proposed a framework that adapts course examples to learners' professional backgrounds and psychological profiles, offering customized tasks to align with students' attitudes and preferences. For instance, students in need of stability were given tasks aimed at managing stress, while those facing communication challenges received tasks to strengthen their communication skills. The authors of [34] designed personalized learning paths based on learners' needs and preferences, enabling adaptive navigation through concepts and guiding content recommendations. This supports that learning materials, including videos, texts, and examples, align with each learner's profile, providing a fully personalized learning experience.

Personalization is also powered by data analytics; the chatbot tracks metrics such as message frequency, suggested Open Educational Resources (OERs), likes, and comments. These insights allow the chatbot to provide adaptive feedback, personalized recommendations, and even participation-based grading [11]. [12] implemented personalization by detecting the user's role and identifying the conversation type, such as exam question generation, self-assessment, or free dialogue. Additionally, it identifies the specific area and topic of discussion, maintaining a contextual history of up to six previous utterances. [4] advanced personalization by analyzing student profiles and employing a course relevance analysis agent that interprets learners' questions. Based on the most appropriate keywords, the chatbot identifies and recommends the most relevant learning materials from the multimedia

teaching material database. An authentication system was used to enable personalized learning, the system allows students to log in with institutional credentials to access schedules, grades, course materials, and academic performance. Student profile data, including IDs, groups, and scores, play a key role in the personalization process [20]. In [32], questionnaires were used to collect students' information to personalize interactions, and career orientation were continuously refined based on students' engagement. Feedback from professional orientation experts enriches the chatbot's knowledge base, enabling the chatbot to deliver context-aware and adaptive advice. Assessment scores were also used to tailor learning recommendations based on students' performance, further personalizing the learning process [35]. After outlining the main features of personalization, the following section explores how these features are implemented across different types of chatbots.

Personalization across different chatbot types. Chatbots can be classified into two main categories based on their programming approach: rule-based and AI-based [9]. Rule-based chatbots are designed to follow predefined rules [9], while AI-based chatbots respond to students' queries using artificial intelligence technologies [16], [36]. [37] added that chatbot models have progressed from traditional rule-based models to retrieval-based models, and then, to generative models.

Several studies have explored rule-based chatbots in higher education, highlighting different levels of personalization. [7] introduced a chatbot that, despite using a rule-based approach, offers personalization by structuring learning paths based on predefined concepts. Similarly, [9] designed a chatbot that ensures accuracy through predefined intents and entities. However, its adaptability is limited, as the approach of personalization depends on manual updates rather than the chatbot learning autonomously from user interactions.

For programming education, [38] designed a closed-domain chatbot that prioritizes accuracy within a specific subject area but lacks personalized interactions. In addition, [39] proposed a chatbot that sequences questions using algorithms and assesses responses through similarity computations. The chatbot enhances engagement with graphical elements but without dynamically adjusting to individual learners' progress.

Instead of rule-based chatbots, AI chatbots are designed to engage in interactive conversations, offering more adaptable and engaging learning platforms than rule-based systems [27]. By leveraging Natural Language Processing (NLP) and deep learning, these chatbots can dynamically personalize learning experiences to meet diverse students' needs [25]. Recently, many researchers have explored AI-driven personalization. [26] developed a chatbot that personalizes responses based on student preferences. Furthermore, [20] designed a chatbot that understands different phrasings of the same question and updates its knowledge base to provide context-aware personalized guidance. The chatbots in [18] and [28] interpret students' queries using NLP, personalizing responses based on intents and contexts. In addition, the proposed chatbot for pre-service teachers (PSTs) in [18] employs advanced AI techniques to adapt to open-ended teaching scenarios. [40] highlighted the advantages of retrieval-based and generative AI models, allowing chatbots to select predefined responses while generating contextually relevant answers. In career guidance, generative AI with Large Language Models (LLMs) enhanced students' support by providing personalized orientations based on academic performance, interests, and career goals. As the AI learns from interactions, the chatbot refines recommendations to align with evolving job market trends [32].

This highlights that while rule-based chatbots can incorporate structured guidance, their personalization capabilities remain limited compared to AI-based models

that can adapt to user input. AI chatbots enhance personalized learning by dynamically adapting to students' inputs and progress. The following section explores how personalization is supported and enhanced through mobile platforms.

Personalization through mobile platforms. The rise of smartphones has opened a new era in online education, transforming how students access and engage with learning. [10] highlighted that mobile devices can effectively support mobile learning by offering students the flexibility to learn anytime and anywhere while facilitating communication and interactions. Mobile phones have the advantage of push notifications, which deliver timely reminders and prompts, keeping students engaged and creating a more responsive learning experience [14]. This flexibility enhances students' learning experiences by complementing traditional methods and enabling personalized learning through the integration of AI chatbots [11].

According to [29], chatbots, whether implemented as mobile or web applications, enhance the learning experience. In addition, AI-based chatbots can be developed for mobile applications [27]. In fact, the integration of AI-based chatbots into mobile learning platforms ensures accessibility and engagement across devices while also personalizing the learning experience for each student [30], [12], and [32]. [41] highlighted that mobile AI chatbots improve interactions and self-regulated learning. By integrating positive design principles, mobile technology can support well-being. Moreover, mobile AI chatbots enhance academic performance through automated feedback and learning analytics in order to increase engagement and motivation. Furthermore, mobile chatbots promote self-reflection, alleviate symptoms of depression, and strengthen emotional resilience, fostering a holistic learning experience [30], [41]. They facilitate instant communication and the creation of mobile learning groups, enabling students to collaborate and receive personalized resource recommendations tailored to their needs [16]. Drawing from these benefits, mobile chatbots offer interactive, flexible, and personalized learning experiences based on individual needs [42]. The access from mobile devices allows the chatbot to act as an intelligent and supportive companion, providing a more personalized learning experience [33].

In conclusion, the integration of mobile AI chatbots in higher education e-learning systems creates a dynamic and personalized learning environment. This empowers students to take control of their learning process and improves engagement. These chatbots contribute to both cognitive development and learning success. The following section explores the opportunities presented by e-learning chatbots in higher education, considering their role in fostering personalized and engaging learning.

3.2 Opportunities of e-learning chatbots in higher education

Chatbots can support students in various learning activities by offering personalized resources and feedback. We grouped the chatbots identified in our literature into five categories based on the opportunities they provide: opportunities for learning languages, opportunities for learning computer sciences, opportunities for interdisciplinary learning, opportunities for academic assistance, and opportunities for personalized guidance.

Learning languages. In higher education, e-learning chatbots are widely used to support language learning. According to [30], language learning chatbots have been implemented for second language acquisition, with a particular emphasis on English. [9] proposed the learning buddy chatbot to assist English as a foreign language (EFL) students in an online English course at an Asian public university.

By providing real-time feedback and fostering interactive communication, the chatbot enhances social presence and helps reduce self-blame by informing students about common errors and challenges faced by their peers.

A study in a Malaysian higher institution examined students' experiences with mobile and web chatbots for English learning. It highlighted the importance of promoting independent learning, which helps reduce anxiety and encourages active engagement. Findings confirmed that chatbots enhance language practice, communication, and the development of ubiquitous and autonomous learning skills [50]. Similarly, [42] deployed a mobile-based chatbot for first-year students in an EAP course. Drawing from an analysis of the needs of previous EAP students, the chatbot supports L2 learners by guiding them to relevant resources, including external tools such as MOOCs, SPOCs, and language-learning apps. The authors of [31] proposed a mobile-based chatbot to enhance English communication skills. The learning process involved four steps: active reading, vocabulary listening, and interactive writing and speaking. Interactive activities helped improve writing and reading while also enhancing listening and speaking skills. To support Spanish language learning, [30] developed a chatbot for teaching punctuation as part of an access course at the National University of Distance Education (UNED). The chatbot guides students through a series of tasks such as scoring exercises and writing assignments. It also adapts to each student's progress by offering personalized difficulty levels and learning paths.

In maritime education, English plays a crucial role in communication across sectors such as maritime law and port management, a mobile-based chatbot was introduced to facilitate the learning of maritime English. The chatbot offers access to essential learning features and high-quality documentation. It ensures an engaging and effective learning experience for maritime students [43].

Computer sciences education. Chatbots are also used in computer sciences education, [20] presented Infobot, a chatbot designed for an introductory networking course at Hong Kong University. The chatbot provides real-time answers regarding course materials and logistics, such as class schedules and locations. For the cybersecurity course at Mapua University Makati IT College, a chatbot named Cybele is proposed as a virtual teacher to personalize the learning path based on each student's personality. The chatbot engages students by providing definitions and terminology for every lesson [7]. [38] developed a chatbot named PROBSOL-BOT for a beginner programming course for students at Buraimi University. The purpose is to help beginner programmers in their learning process using fundamental programming concepts, frequent programming errors, and course information. The chatbot covers the most of the beginner programming course, including topics such as basics, selection, repetition, functions, and arrays. In the same way, [17] introduced a chatbot for the university course "Methods of teaching computer science". The chatbot answers questions regarding the structure and content of the basic course material in an interactive way. The findings confirmed that the use of chatbots as virtual teaching assistants improves students' learning experiences.

For learning Java, [40] integrated a chatbot into a first-year computer engineering course at Galileo University to enhance Java programming. It provides self-paced practice, allowing students to review concepts and refine coding skills. Students debugged Java programs with support from the chatbot and Codeboard. For the introduction to programming course, [44] introduced a chatbot as an academic assistant for first-semester students at the University of Zagreb, aiming to help them acquire key concepts and enhance students' problem-solving skills. The chatbot supports learning fundamental programming concepts like data structures

and file handling. Additionally, it reinforces software engineering principles such as algorithm design and the software development lifecycle.

Interdisciplinary learning. Across various educational domains, chatbots have been demonstrated as effective tools for enhancing learning experiences and supporting students' academic progress. In the social sciences, [51] developed a chatbot for the "Statistics for Social Sciences" course, enabling students to engage with formative exercises and explore a wide range of resources. Similarly, [41] proposed a chatbot for postgraduate students at King Faisal University's College of Education, helping them accurately generate references in APA 7th Edition style. The positive design of the chatbot not only made the process enjoyable but also boosted students' academic performance and engagement.

The use of chatbots extends beyond social sciences into fields such as healthcare and mathematics. In a nursing school in Taiwan, [33] introduced a chatbot to assist students in training for physical examination and anatomy, offering interactive quizzes and detailed anatomical information. In the dental education, a chatbot supported clinical simulations and educational assessments for pre-doctoral students at the University of Illinois Chicago, providing an alternative to traditional platforms like Blackboard [49]. Mathematics education also benefits from the emergence of chatbots; the work by [35] presented an intelligent chatbot to deliver structured pedagogical support and generate performance reports, offering valuable insights to educators. In the same way, [39] introduced QuizBot, a dialogue-based agent that helps university students learn science, safety, and English vocabulary. Finally, [12] proposed a mobile chatbot that generates questions and answers in multiple disciplines, from history to engineering, showcasing the adaptability of chatbots across diverse academic fields.

Academic assistance. In higher education, chatbots can provide assistance, and support students in managing their learning process while alleviating the workload of teachers. [21] introduced the mobile application, Differ, at London University to help students make connections through group chats. This approach addresses feelings of isolation common when moving from high school to university and fostering a dynamic learning community. Similarly, [26] presented the Digital Professor chatbot at Kyiv National University, which grants students easy access to learning materials, such as textbooks and readings. The chatbot offers effective support to students while reducing repetitive queries. In addition, [45] proposed Edubot, a smart classroom management system, which provides learning materials and tracks academic performance. By connecting students with professors and offering various support tools, Edubot contributes to an effective learning environment. [27] introduced a chatbot framework at a Bulgarian university, which supports both students and teachers at different course levels by providing access to materials before class and automating administrative tasks afterward. In addition, [46] introduced BoilerTAI, a chatbot that helps teaching assistants in educational forums by generating first-draft responses to student queries, significantly reducing their workload.

For administrative support, the University of Jordan proposed a bilingual chatbot within a mobile application, offering administrative assistance in both Arabic and English. The chatbot includes features, such as a campus map and notifications, to help students navigate their academic environment [23]. Finally, [47] presented a mobile chatbot created for students at the University of Guayaquil that provides timely answers to queries regarding enrollment and tuition payments.

Personalized guidance. Chatbots have also been used to support mentoring activities such as course recommendations, active learning, and self-regulated learning. According to [48], chatbots offer a scalable solution for mentoring students

in higher education. [28] proposed LearningPartnerBot, a chatbot designed for C programming course at the Engineering School of Mohammedia. It recommends learning materials and provides personalized suggestions by using a pre-test to assess students' knowledge and identify areas for improvement.

Emphasizing self-regulated learning, [9] presented a chatbot that supports students in setting personal learning goals using a SMART framework on Moodle. This goal-setting activity promotes active and personalized learning. [22] and [18] further highlighted the importance of self-regulation in online learning by proposing chatbots that act as a metacognitive virtual assistant. These chatbots help students regulate their learning process and enhance the quality of learning within e-learning environments.

In a different use case for chatbots, [25] designed a coach chatbot to assist PSTs in a U.S. university. The chatbot guides PSTs in asking relevant questions, promoting authentic and open-ended interactions that improve mathematical reasoning and teaching attitudes. [34] developed an e-mentor chatbot within a student-centric model to provide personalized content recommendations, helping students navigate their academic goals effectively. For career-oriented support, [32] introduced a chatbot at the Ben M'sik Faculty of Sciences in Casablanca, helping students match their job preferences with career paths. This mobile e-orientation application offers personalized guidance to assist students in their job search. Moreover, [11] proposed the Virtual Intelligent Teaching Assistant (VITA), a mobile chatbot designed to support collaborative learning, was proposed to assist students in forming study groups and managing academic tasks. The chatbot promotes engaging and adaptive learning experiences. Although e-learning chatbots in higher education hold considerable promise, it is important to address the challenges involved in their integration.

3.3 Challenges of e-learning chatbots in higher education

Chatbots have been implemented in courses such as cybersecurity, programming, and language learning [38], [17]. While they provide quick assistance, their limitations can negatively impact students' learning. In programming courses, chatbots can suggest solutions to coding problems but often fail to explain the reasoning behind them. They may provide correct syntax or debugging tips without clarifying fundamental concepts such as algorithmic efficiency, data structures, or logical problem-solving. Over time, reliance on chatbots for immediate answers can impede students' ability to think critically, adapt to new challenges, and develop problem-solving skills. Despite chatbots' benefits, they cannot replace human instructors, who play a crucial role in guiding students through complex reasoning processes and fostering learning.

Beyond these pedagogical issues, chatbots also face significant technical challenges that impact their effectiveness in e-learning environments. The reviewed literature indicates that most implementations rely on AI-based models, followed by rule-based and then generative models. Rule-based chatbots are based on predefined rules, making them limited when handling novel or unexpected queries [49]. Their accuracy is limited by the developers' ability to anticipate user inputs, which restricts chatbots' capacity to address complex, text-based questions [38]. Additionally, rule-based chatbots designed for closed-domain applications struggle when queries fall outside their predefined knowledge base. This limitation reduces the natural flow of interactions, making conversations less dynamic and engaging. Maintaining these models is also time-consuming, as manually curating the knowledge base requires

continuous effort. These chatbots may provide outdated and inaccurate responses if not regularly updated, reducing their reliability [49]. Furthermore, as students interact with these chatbots for a long time, the lack of variety in responses may lead to disengagement [9]. The lack of personalization and adaptability in rule-based chatbots can frustrate students, especially when responses fail to address their specific needs. A more intelligent rule-based chatbot will be produced if user data is added in the chatbot's knowledge base. Rule-based chatbots remain valuable tools when rigorously programmed and regularly updated [49].

On the other hand, AI-based chatbots, despite their flexibility, also have notable limitations. Chatbots rely on NLP techniques to generate responses but struggle with complex interactions [50]. Students often express their queries in diverse ways, making it difficult for the chatbots to accurately interpret intents. Misinterpretations can result in irrelevant or misleading answers [20]. In addition, open-ended educational discussions complicate response generation, as they involve nuanced intents that are difficult to categorize. This complexity reduces the chatbot's effectiveness in providing meaningful support [25]. Maintaining conversational context is another important challenge for AI chatbots. As user interactions progress, chatbots may lose context from previous exchanges, resulting in irrelevant responses. This heightens the risk of misinformation, especially when chatbots generate responses based on incomplete or ambiguous input. Delivering context-aware and accurate interactions with AI-driven chatbots requires robust data handling and continuous algorithm improvements. Another limitation in chatbots' implementation is the reliance on small training datasets, such as those based on only 60 student queries and FAQs [47]. Limited data reduces the chatbot's ability to generalize across diverse queries, increasing the risk of generating inaccurate responses. Expanding the dataset with more varied inputs is essential to improve the adaptability and reliability of chatbots [47].

4 DISCUSSION

In this paper, we explored the state-of-the-art of e-learning chatbots in higher education according to our research questions.

RQ1: AI applications are playing a crucial role in higher education, significantly reshaping learning environments. Notably, chatbots have enhanced students' engagement through personalized learning and adaptive feedback [52]. By tracking students' progress and delivering personalized feedback, chatbots improve self-regulation and increase motivation. In fact, personalization is driven by learner-specific features such as personality traits, learning styles, and prior knowledge. To this end, several model, including the MBTI and Felder-Silverman questionnaires, are used to classify students and inform the recommendation of suitable content in diverse formats (e.g., videos, texts, interactive exercises). However, the effectiveness of personalization largely depends on the underlying design and technological capabilities of chatbots.

Regarding the impact of chatbot types on personalization, while rule-based chatbots offer reliability, their reliance on predefined rules limits their adaptability, making chatbots less responsive to dynamic students' needs. In the other hand, AI-driven chatbots, powered by deep learning and NLP, enable more responsive and context-aware interactions. Recent studies have shown that retrieval-based and

generative models enhance personalization by continuously adapting recommendations and refining responses based on learner behaviors and preferences. This shift towards AI-driven personalization allows for more learning experiences aligned with students' cognitive and emotional states.

Mobile applications can enhance the learning experience for students by providing flexible and accessible tools that support various educational activities [53]. This flexibility has also facilitated the growing integration of chatbot-driven personalization, enabling learning to occur anytime and anywhere. Mobile-based chatbots increase learner engagement through real-time assessments, interactive feedback, and personalized learning paths. Beyond academic support, these chatbots contribute to emotional well-being by promoting self-regulated learning and fostering peer collaboration. In areas such as career orientation, mobile-based chatbots facilitate personalized orientation, reinforcing their value in higher education. However, the effectiveness of chatbots depends on the ongoing enhancement of their algorithms and models.

RQ2: Chatbots are emerging as powerful e-learning tools in higher education, offering support and opportunities across multiple learning domains. Their role extends beyond basic tasks, enhancing student engagement, academic success, and self-regulated learning. The opportunities presented by chatbots in this literature are categorized into language learning, with the majority focused on English language learning. Additional opportunities include computer science education, interdisciplinary learning, academic support, and personalized guidance.

In the context of learning languages, chatbots enhance dynamic learning that promotes communication skills and independent learning. They offer real-time feedback and structured exercises, making them valuable tools for students in various contexts, from academic writing to specialized fields like maritime English. Similarly, in computer science education, they are used as virtual assistants, helping students practice programming, cybersecurity, and networking concepts by reinforcing key principles and identifying coding errors.

Beyond discipline-specific applications, chatbots support interdisciplinary education by personalizing content in fields like healthcare, social sciences, and mathematics. Their use in medical training illustrates their ability to bridge theoretical knowledge with practical application. Furthermore, their contribution extends to academic support, where chatbots enhance administrative processes, reduce cognitive load, and improve communication between students and institutions. More than just information providers, chatbots can be used as mentors, offering personalized guidance through course recommendations and self-regulation strategies. Their ability to enhance autonomy and motivation makes them important tools in adaptive and personalized learning. As research progresses, improving chatbots' ability to personalize interactions and respond to individual needs remains a key focus. This highlights the need for studies to enhance their effectiveness.

RQ3: In higher education, chatbots are increasingly recognized for their ability to handle various functions across learning and administrative tasks. However, their limitations may restrict a more profound comprehension. In programming, chatbots may suggest syntax fixes but fail to explain underlying concepts. This lack of deeper explanation affects students' ability to think critically and solve problems independently. While chatbots assist students'

learning, they cannot replace the guidance provided by human instructors, who can foster critical thinking and deeper understanding. Researchers highlight that the successful integration of AI into educational settings requires a cohesive framework of principles to guide its implementation in pedagogical contexts [52].

Technically, both rule-based and AI-based chatbots face challenges. Rule-based chatbots are limited and rely on predefined inputs, making them ineffective with unexpected queries. AI-based chatbots struggle with interpreting diverse student inputs and maintaining conversation context. In many cases, both types suffer from limited training data, which reduces their ability to generalize and respond accurately. However, emerging solutions like LLMs can enhance chatbot interactions by enabling more dynamic conversations. Their ability to process and generate human-like text allows chatbots to provide personalized responses and adapt to user inputs [32]. Furthermore, retrieval augmented generation (RAG) and human-in-the-loop approaches show promise by improving the accuracy and relevance of chatbot responses. RAG allows chatbots to access external knowledge databases for updates [44], while human oversight ensures the alignment of AI-generated responses with educational standards [46]. Future research should focus on enhancing AI capabilities, expanding training datasets, and improving context awareness to make chatbots more effective while maintaining the role of human instructors in the learning process.

5 FUTURE DIRECTIONS

Findings reveal that AI chatbots are transforming e-learning in higher education by offering more intelligent, adaptive, and personalized learning experiences. AI chatbots can dynamically refine their responses, alleviating the limitations of predefined interactions. This shift will allow instructors to dedicate more time to strategic tasks, such as course development, while chatbots efficiently manage repetitive queries. However, despite their advantages, AI chatbots lack the emotional intelligence, empathy, and ethical reasoning of human instructors. In some cases, they may generate responses that do not consider students' emotional states, potentially affecting their learning experience. Future research should explore the integration of sentiment analysis and academic emotion recognition into AI chatbots to detect frustration, confusion, or curiosity. This would enable chatbots to adapt their responses in real-time, providing students with an emotionally supportive and effective learning experience.

Advancements in AI-powered personalization highlight the growing importance of student-centered learning, where content and interactions are tailored to individual needs. Current research emphasizes the crucial role of personality types and learning styles in adaptive learning. Future studies should explore additional personalization factors, such as learning duration, intensity, prior knowledge, and students' interests. The integration of trace analysis and course prerequisites could further refine chatbots' abilities to recommend personalized learning paths or resources. AI techniques, particularly deep learning models, can analyze student performance data to dynamically adapt educational content. This ensures that learners receive support personalized to their evolving needs. Generative AI models present promising opportunities for chatbot-based personalized learning. Compared to traditional rule-based and retrieval-based approaches, these models perform at

retaining context across long conversations. This capability allows chatbots to provide more coherent and responsive interactions. Future research should investigate how generative models can enhance knowledge retention and support complex problem-solving in domains such as computer science education and mathematics.

Also, AI-based mobile chatbots are redefining education by enabling anytime and anywhere learning through intelligent push notifications and personalized support. Future research should focus on optimizing context-aware notifications to deliver timely and personalized prompts that enhance engagement. Additionally, integrating adaptive micro-learning will allow students to interact with bite-sized lessons and quizzes dynamically tailored to their progress. Advancing these areas will ensure that AI chatbots become crucial tools for personalized, on-the-go learning experiences.

6 CONCLUSION

Artificial intelligence is increasingly recognized as a valuable support tool for enhancing student success in higher education [52], particularly by enhancing students' problem-solving and critical thinking skills. E-learning platforms facilitate access to course materials, lectures, and assignments anytime and anywhere. However, challenges such as low engagement and interactions persist, negatively impacting students' performance and retention.

The reviewed literature highlights the role of e-learning chatbots in higher education, with a particular focus on how mobile chatbots enhance personalized learning. Our study sheds light on opportunities they offer and showcases their effectiveness in boosting engagement, metacognitive skills, and self-regulated learning. In particular, AI-based chatbots offer more conversational and adaptive interactions compared to rule-based models, making them better suited for dynamic learning environments. Results indicate that AI-based chatbots have significant potential to implement personalized and adaptive learning, addressing many e-learning challenges by tailoring content to students' needs. The integration of mobile learning technologies enhances this potential, enabling students to learn from anywhere and anytime through micro-learning strategies. As generative AI continues to evolve, mobile chatbots will play a crucial role in delivering ubiquitous and personalized learning experiences, making education more accessible and responsive to each student.

While chatbots are valuable tools for learning and guidance, they will never replace teachers. Instead, teachers will remain important in guiding students on how to effectively use AI-based technologies. University decision-making must embrace digital transformation by investing in AI-based mobile learning solutions. Additionally, enhancing digital competencies among both teachers and students is crucial to ensure that technology aligns with pedagogical goals. In this context, further empirical studies are needed to validate and expand upon these findings. One promising direction is to pilot mobile AI chatbots within university courses. These systems can support self-regulated learning, boost student engagement, and contribute to a more ubiquitous learning environment. To fully understand the impact of chatbots, quantitative data such as engagement metrics, completion rates, and academic performance should be analyzed. These findings should be complemented by qualitative methods, including student surveys, focus groups, and interviews, to assess levels of satisfaction, perceived usefulness, and areas for improvement. Finally, these studies should also take into account contextual factors that influence the adoption and effectiveness of these chatbots. These factors include academic

discipline, student motivation, and how well the chatbot's features align with course objectives and teaching strategies.

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9 DECLARATIONS: ETHICAL APPROVAL

This study did not involve human participants or personal data, and no ethics approval was required. All literature review procedures were conducted in accordance with institutional ethical guidelines.