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Implications of Artificial Intelligence for Teaching and Learning

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ABSTRACT: Artificial Intelligence (AI) has significantly transformed teaching and learning, facilitating a shift from teacher-centered to student-centered education. This review outlines the broad implications of AI for education and synthesizes both the opportunities and challenges associated with its implementation. Examining over 55 papers related to the impacts of AI on education, the review encompasses various educational contexts, avoiding a singular focus on specific types of education or the teaching of AI alone. According to the review, AI introduces new opportunities for creating intelligent content that enhances learning experiences, fostering interactivity and a student-centered approach. Smart content enables instructors to integrate multimedia, interactive tools, AI-related wearables, and information technologies, diversifying learning modes and engaging students more effectively. The creation of smart content aligns with smart education frameworks to ensure efficient content development. AI also contributes to the development of intelligent tutoring systems, which simulate human tutors to deliver personalized and adaptive educational experiences. These systems can host smart content, enabling independent learning. Additionally, AI improves virtual learning environments by analyzing student data to tailor content and delivery methods based on individual needs. It automates tasks such as grading and feedback, allowing teachers to concentrate on other essential responsibilities. While AI brings significant benefits, it is not without limitations. Challenges include infrastructure requirements, considerations of inclusion and equity, teacher readiness and preparation, data quality and inclusivity, profit orientation, data privacy and ethical concerns, and the potential for unequal access. Addressing these limitations is crucial for maximizing the positive impacts of AI in the realm of education.

KEYWORDS: Artificial intelligence; feedback; smart content; teaching and learning; virtual learning environments

1. Introduction

Artificial intelligence (AI) is the buzzword in the world that increasingly relies on information technology and machines to carry out diverse tasks. AI has permeated many industries, including the education industry. The education industry is quick to respond to the new technological trend by rolling out a myriad of courses on or related to AI. Meanwhile, it also benefits from the rise and popularization of AI, particularly in teaching and learning [1]. The term ‘artificial intelligence’ has frequently popped up on different occasions, but what exactly is AI? It is the ability of a computer or robot to perform tasks that typically require human

intelligence, such as learning, reasoning, problem-solving, and using language. AI can be applied to various domains, such as speech recognition, self-driving cars, and web search. It is a rapidly evolving field of computer science that aims to create systems that can perform tasks beyond the capabilities of humans [2].

AI has come a long way since it was first coined by John McCarthy in 1956 at a workshop held at Dartmouth College, where he invited a group of researchers to discuss the possibility and challenges of creating machines that can think [3]. The research on AI eventually stalled in 1974 when funding from the United States and the British governments became highly selective, but it was revived seven years later through the initiative of the Japanese government to fund AI projects [3]. However, the funding was restricted again in the late 1980s as investors were unsure where the research was heading. The breakthrough in machine learning in the 2020s spurred interest and investment in AI [3]. AI has since undergone tremendous development in line with the availability of powerful computer hardware and new data management systems.

The education sector has seen an increasing emphasis on adopting student-centered learning and shifting away from teacher-centered learning [4]. From the conventional instructional strategies where teachers are the main source of knowledge and authority in the classroom, there has been an unprecedented interest in actively involving students in the learning process and letting them take responsibility for their own learning [5]. In teacher-centered learning, teachers control the pace, activities, and evaluation of the learning process. It offers the advantages of maintaining order and ensuring coverage of key topics but limits student engagement, collaboration, and creativity [6]. Teachers become facilitators or guides rather than the sole source of knowledge in student-centered learning. This form of learning can enhance the accessibility of education and the development of essential skills and competencies [7, 8]. The rise of AI could facilitate student-centered learning by providing personalized and adaptive learning experiences, feedback, and student support. It also helps teachers to develop activities and materials that better suit the needs of students and more effectively engage them [9].

AI also provides opportunities for higher education institutions to introduce new courses. This prepares students to take on new challenges in the era of AI and trains the experts much needed in AI-related fields [10]. By riding on the tide of AI, the courses offered by higher education institutions become relevant and appealing, and this helps to position the institutions in the education market better [10]. Higher education institutions either offer AI directly as a course or program where students are introduced to the basic concepts and techniques of AI, such as heuristic search, game playing, knowledge representation and reasoning, uncertainty, machine learning, and neural networks, or the spin-offs and specialized areas of AI, such as natural language processing, computer vision, cybersecurity, and data analytics [11]. Concurrently, AI reshapes teaching and learning in higher education institutions, making it more interactive and student-centered. AI tools can enable online and blended learning and reduce language and cultural barriers, thus offering educational opportunities to underserved and marginalized communities [12]. It provides an instrumental channel to diversify learning modalities while improving access to education in general [13]. Therefore, AI not only has implications for tertiary education, but it also impacts education of all types at all levels.

Currently, few reviews have been dedicated to systematically presenting the implications of AI for teaching and learning. The extant review focuses on the teaching and learning of AI as a subset of computer science education. Ng et al. reviewed the pedagogical models and

teaching tools to raise AI literacy and highlighted a lack of scaffolding of students' AI understandings [14]. AI educators often employ collaborative project-based learning, such as developing software, experimenting with robots, and building game elements, which are technology-oriented and do not impart the interdisciplinary design aspect of AI [14]. Another review is mainly about the integration of AI in teacher education, and it probes the behavioral and perceptual aspects of pre- and in-service teachers on adopting AI in teaching [15]. Chen et al. pointed out the gaps in the educational application of AI, particularly the lack of work in employing deep learning technologies in education and the lack of progress beyond natural language processing [1]. The review does not discuss the impacts of AI on teaching and learning in a broader sense, particularly the opportunities and challenges associated with the use of AI in designing educational content, developing assessments, engaging students, and providing feedback. Similarly, the review by Akgun and Greenhow addresses the application of AI in K-12 education and the associated ethical dilemmas [16]. With an apparent deficiency in the review of the overarching influences of AI on teaching and learning, this review aims to present the implications of AI on teaching and learning generally and synthesizes the opportunities and challenges. It hopes to contribute to advancing the integration of AI in teaching and learning to optimize students' learning experiences and facilitate the implementation of student-centered learning.

2. Methods

A literature search was conducted with scholarly databases comprising Scopus, Web of Science, ProQuest, and ScienceDirect, with keywords such as artificial intelligence, education, analytics, machine learning, teaching, and learning. Combinations of keywords, such as artificial intelligence in education, machine learning in teaching, analytics in teaching and learning, and artificial intelligence in teaching and learning, were used to refine the search [17]. The keywords were combined using Boolean operators (AND, OR), for instance, artificial intelligence OR machine learning AND education, analytics AND grading, artificial intelligence AND feedback AND education, etc. A total of 149 articles were retrieved from the databases. The titles of the articles were screened for their relevance. Articles with titles indicating the design and implementation of courses on or related to AI were excluded. Those in a language other than English were also excluded. There were only 3 articles not written in English, and they were mainly related to teaching AI-related courses.

Articles passing the initial screening were subjected to examination of their abstracts. The articles are excluded if 1) They have been published more than ten years ago; 2) They are mainly about the policies and ethics of AI in education; 3) They do not explicitly explain how AI can be incorporated into teaching and learning; 4) They do not explicitly explain the effects of AI on teaching and learning; 5) They are mainly about the perceptions of AI in teaching and learning. The same criteria were applied in the final text screening of the articles. Only 52 papers were ultimately included in this review.

3. Results and Discussion

Artificial intelligence has been employed in teaching and learning for different purposes. Smart content utilizes AI to create digitized guides of textbooks and customizable learning digital interfaces, which are being introduced at all levels, from elementary and post-secondary to corporate environments. Intelligent tutoring systems are AI systems that can adapt to each

student's learning needs and target instruction based on their strengths and weaknesses. They can also provide customized support and instruction [18]. Virtual Learning Environments (VLEs) employ AI to create virtual facilitators and learning environments. AI can help grade exams using an answer key and even compile student performance data. It can also grade more abstract assessments such as essays [19]. Additionally, AI has the ability to personalize learning, as it can figure out how to meet the needs of every student in a classroom and adapt to their learning needs [2].

3.1. Smart content.

Smart content is a transformative application of AI in the field of education. It is implemented in numerous ways. AI-based voice assistants are typical examples of smart content generators (Figure 1). Examples of popular AI-based voice assistants are Amazon Alexa, Apple Siri, and Microsoft Cortana. These voice assistants can answer students' questions, help with homework, and even teach lessons [20]. For instance, teachers can design activities that require AI-based voice assistants to provide the relevant content, keywords, or information to create an active and interactive classroom dynamic that is not limited to conventional discussion or web search [21]. Furthermore, teachers may ask students to reflect on the learning experience with AI-based voice assistants and compare it against conventional web search. Misinformation or bias in AI content can then be used to foster students' critical thinking and analytical skills [21]. In view of the increasing popularity of AI in education, frameworks have been introduced to allow teachers to more effectively design content that incorporates AI technologies. Smart education framework is a novel education framework that arises with AI to generate smart content. It recognizes the opportunities presented by advances in information technologies for novel approaches, methods, and tools for new or improved education and training practices [22]. The framework systematically incorporates information technologies in smart education design. The technologies could be categorized into essential, enriching, and supportive technologies. The framework assists in developing a specific course or lecture design that harnesses the power of AI and information technologies [22]. A variant of the framework is the Technological pedagogical content knowledge (TPACK), which involves using information tools to improve students' performance in subjects like chemistry [23]. It is a framework that describes the knowledge required by teachers for successful integration of technology in teaching. It provides the basis for creating smart content by considering three types of knowledge: technological, pedagogical, and content [23]. Technological knowledge refers to the understanding of various technologies, including hardware, software, and their related practices, that can be used to facilitate teaching and learning. Pedagogical knowledge revolves around the understanding of how teaching and learning processes occur. It involves instruction strategies, assessment methods, and classroom management techniques. Content knowledge is the teacher's knowledge about the subject matter to be learned or taught. It provides a valuable guide for teachers to employ smart content by considering the relationships between technology, pedagogy, and content, which are not mutually exclusive [23].

Smart content can also be generated through wrist-worn wearables such as smartwatches and fitness tracking bands that track the fitness and health of students (Figure 1). Their ability to track heart rates, steps taken, distance traveled, and sleep patterns could make learning body functions and measurements interesting [24]. Students can analyze their body's response to exercise as they learn about the body and measure the distance traveled in relation to the steps taken. Furthermore, certain features of smartwatches like speech-to-text, text-to-speech, voice

recognition, and personal organizer can be helpful in learning, particularly the learning of languages. Speech-to-text can convert long texts to speeches, thus enabling learning by hearing instead of reading alone [25]. Virtual reality headsets can provide immersive learning experiences, making abstract concepts tangible and facilitating experiential learning. For example, students can take a virtual solar system tour in a physics class or explore ancient civilizations in a history class [26]. The combination of AI and virtual reality can also help bridge the skills gap and prepare students for the future workforce. Concerning this, AI and virtual reality can be used to create virtual apprenticeships and internships, giving students the opportunity to gain real-world experience and develop valuable skills in a simulated environment [27].

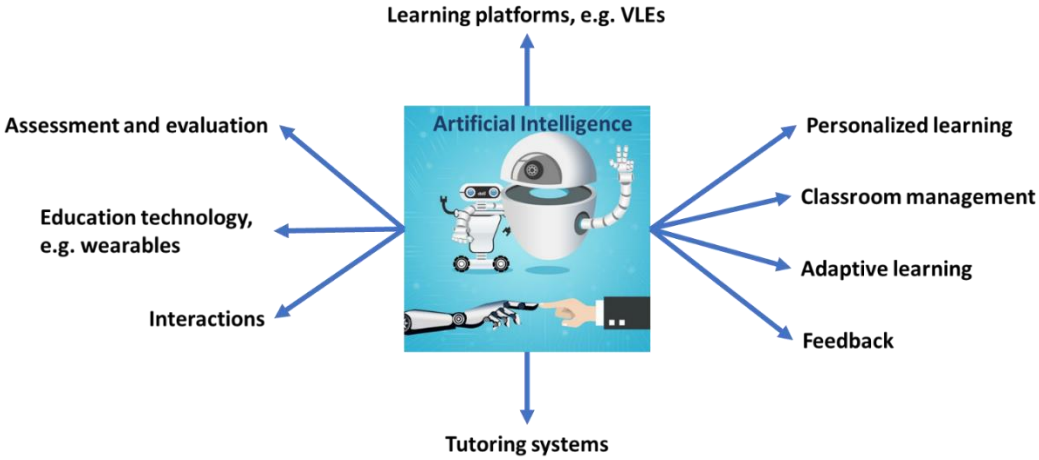

Figure 1. The applications of artificial intelligence in teaching and learning.

Smart glasses are wearable devices that help generate smart content and make learning interactive. Smart glasses can overlay digital information onto the real world, enabling learning through augmented reality [28]. Teachers can use smart glasses to record their lectures, which students can access at any time for review. Students can use smart glasses to record their observations during field trips or practical sessions, which can then be used to prepare reports [29]. Additionally, smart glasses are capable of providing insights into a student's learning process, helping educators tailor their teaching methods to individual needs [30]. Interactive tools for measurement are another feature of smart content, especially for online courses. Progress and comprehension are typically measured through completion percentages, internal quizzes, and final assessments in online courses [31]. The interactive tools permit gamification of the measurement process with puzzles and challenges that can be inserted into the course material to maintain interest and gauge understanding [32]. Interactive tools can be in the form of interactive videos that provide a broad understanding of a particular concept, such as videos provided by the Khan Academy. IXL is another example of an interactive tool for K-12 education. It offers skill-specific practice and provides reteaching and corrections when a student answers incorrectly [33].

Smart content allows educators to expand the depth and breadth of content in their subject areas. Teachers can identify the most relevant and updated information related to the content and include it in their instruction, thus enabling them to implement student-centered learning better by selecting content and instruction that fit students' needs [22]. Smart content incorporates multimedia, which helps teachers make their teaching engaging and student-

friendly [31]. This permits better understanding and retention of knowledge. Smart content also integrates tools such as wrist-worn wearables that permit experiential learning by monitoring body functions and traveling [25]. Smart content often includes interactive measurement of progress via gamification tools that make learning varied and interesting in face-to-face or online environments. The interactive tools are usually equipped with analytics, which highlights the mistakes of students and reteaches certain concepts [33]. Smart content enables teachers to quickly collect students' learning data, analyze students' learning status, and adjust the teaching process based on intelligent terminals and learning platforms (Figure 1) [34]. Nonetheless, it is noteworthy that smart content relies on the input of teachers. Teachers often have to determine how AI, multimedia, interactive tools, and information technologies are integrated with teaching and learning for the best interest of students. Smart content implementation and generation, therefore, rest on good smart education frameworks serving as a guide for teachers to effectively adopt smart content in enhancing student-centered learning [6].

3.2. Intelligent tutoring systems.

An intelligent tutoring system is a computer-based learning system that uses AI to provide immediate and customized instruction or feedback to learners, usually without requiring intervention from a human teacher [35]. Unlike smart content, whose designs rely on the input of teachers, an intelligent tutoring system is autonomous. It aims to replicate the demonstrated benefits of one-to-one, personalized tutoring [35]. It consists of four basic components (Figure 2): 1) The domain model, which is the knowledge base of the subject matter that the system will teach; 2) The student model, which represents the system's understanding of the student's knowledge and skills in the domain; 3) The tutoring model, which is the instructional or teaching strategy that the system uses to teach the student; and 4) The user interface model, which is how the system interacts with the student [36].

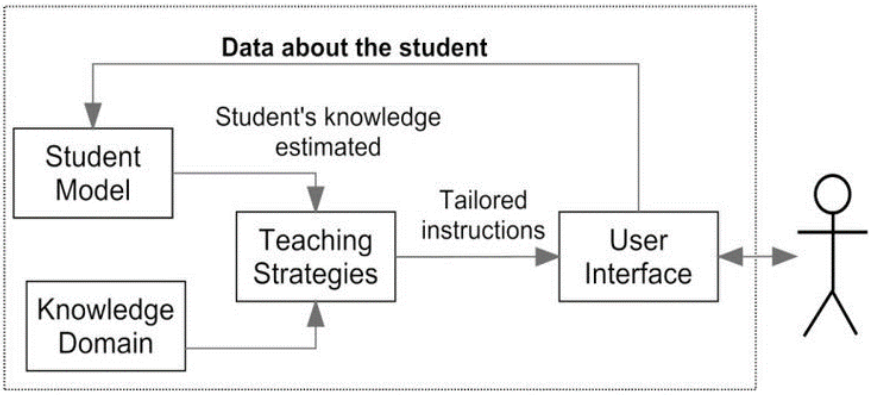

Figure 2. The basic components of an intelligent tutoring system [37].

Intelligent tutoring systems are designed to provide a human-like learning experience (Figure 1). They promote interaction as they utilize AI tutors that can collaborate with learners, engage in turn-by-turn conversations, and adapt to discussions [35]. They can give relevant feedback to motivate learners individually, monitor the relationship between students' emotions and learning, and encourage students when needed. This helps students learn as they will be given feedback based on their learning style, speed and needs [38]. Intelligent tutoring systems can host multimedia learning. While most online learning systems offer text and video, intelligent tutoring systems offer text, multimedia, simulations, and games. By delivering

information, assignments, and scenarios in this way, intelligent tutoring systems provide learning experiences that best suit the learners [38].

Numerous intelligent tutoring systems have been introduced. AutoTutor has been developed by the University of Memphis and it can engage in naturalistic dialogue with students. Atlas and Why2 are examples of intelligent tutoring projects based on conversational dialogue [39]. The University of Memphis also rolled out an upgraded ElectronixTutor, which incorporated multiple intelligent learning platforms comprising AutoTutor, Dragoon, LearnForm, ASSISTments, and BEETLE-II, in addition to multimedia. It aims to provide students with an integrated STEM (science, technology, engineering and mathematics) learning environment [40]. The ability of intelligent tutoring systems to combine various teaching and learning tools means that they can also offer smart content to students. In this instance, the smart content is delivered without a human teacher. Therefore, AI modalities in teaching and learning can be used separately or in combination, depending on the purpose. Intelligent tutoring systems have been shown to be effective in helping to teach certain subjects, such as algebra or grammar.

The emergence of these systems raises the question of whether human teachers could be replaced in the future. This is unlikely because human teachers are the ones who create the curriculum in the first place. Without human teachers, the tutoring systems will not be programmed with the relevant syllabus to teach students [41]. For instance, a hypermedia-based intelligent tutoring system called MetaTutor has been used to teach STEM content designed by a team of educators from five different universities in the North America [42]. The content has been progressively enriched with input from experts in multiple STEM fields [42]. This shows the critical roles of human teachers and experts in the development of such systems. The roles of human teachers in the design of intelligent tutoring systems have been further accentuated through the incorporation of strategies in the systems, such as prompts, allocation of resources, and feedback to address different learning needs [35]. Human teachers are still the best for skill-based courses such as arts, writing, and photo- or video-editing. Their creativity and artistic ability are hard to replace [43]. In addition, computers do not understand emotions and context as well as human teachers. While AI tutoring systems are more sophisticated and can remember chat history and understand context, human teachers can quickly and accurately interpret students' queries and provide the best possible answers [43]. As such, intelligent tutoring systems are more frequently used to complement human tutors by providing personalized learning and practice modules. This complementation can be optimized through flipped classrooms where intelligent tutoring systems can be employed to guide students more effectively in self-learning prior to face-to-face classes during which they are engaged in concept reinforcement, activities, and problem-solving [44]. Intelligent tutoring systems have the advantage of providing more systematic and regulated guidance to students in comparison to the conventional at-home tasks assigned. Teachers can then use the class time to monitor students' understanding, reinforce their learning and impart other crucial skills [44].

3.3. Virtual learning environment.

A VLE is a web-based platform for the digital aspects of courses of study, usually within educational institutions [45]. It refers to an environment where students study a digital-based curriculum taught by instructors (Figure 1). The lectures can be conducted online via video audio, or face-to-face in classrooms with materials provided through VLEs [45]. VLEs present resources, activities, and interactions within a structure and provide for the different stages of

assessment. They are often used as authoring and design environments by teachers and instructors [46]., A virtual environment enables synchronous, asynchronous, and hybrid learning. In synchronous learning, students attend online live-streamed lectures. Instructors stream their presentation or lectures, allowing students to ask questions in real-time via webcam, microphone, or live chat [47]. Asynchronous learning uses pre-recorded lectures that students can watch on their own time. Instructors post either a video or audio file along with lecture notes. Hybrid learning makes use of both virtual and in-person learning. This is most common for classes that also require a lab component [47].

AI has enhanced VLEs by enabling VLEs to analyze student data, such as grades, learning patterns, and preferences, to adapt content and delivery methods to individual needs and learning styles, thus conferring personalized learning experiences. This helps students learn at their own pace and receive tailored support, making education more accessible and inclusive [48]. AI also automates time-consuming tasks in VLEs, such as grading and feedback, freeing teachers to focus on more critical tasks like mentorship with their students [49]. Moodle LMS, for instance, is a popular open-source VLE that provides educators, administrators, and learners with a robust, secure, and integrated system to create personalized learning environments [46]. Virtual Science Laboratories permit students to conduct experiments or observe phenomena virtually. Firefly goes beyond being a virtual repository for learning resources. It offers diverse pathways for connection, content, and learning from which teachers, school leaders, students, and parents all benefit [50].

While multiple forms of AI technologies have been developed or employed for teaching and learning, they are not mutually exclusive and can often be combined. Smart content can be integrated into VLEs for interactive learning via games, multimedia, virtual reality, and augmented reality. VLEs can also be used as platforms for intelligent tutoring systems to manage learning resources and assessments [51]. They can complement intelligent tutoring systems in providing personalized student feedback on assessments. It is possible to include Chatbots in VLEs to simulate conversation and idea exchange for low-stakes skills practice. Learners can practice language-based soft skills like leading a class discussion or diagnosing English proficiency levels [52]. Chatbots can support students in finding course details quickly by connecting them to key information. As chatbots can serve as the first line of communication regarding due dates, assignment details, homework resources, etc., they reduce the administrative burden of instructors. In VLEs, learners can also prompt chatbots to generate explanations and analogies for concepts or ask open-ended questions that encourage further thinking [52].

3.4. Providing feedback.

AI significantly enhances the feedback process in education (Figure 1). AI systems can evaluate responses and provide detailed feedback quickly and objectively. This helps students identify areas for improvement and promptly correct mistakes, expediting their learning process [53]. Furthermore, AI can be used to automatically grade student assignments and projects, allowing teachers to spend more time providing feedback and helping students. These systems can assess written assignments, multiple-choice tests, and other types of assessments, and provide immediate feedback to students [1]. AI can analyze student data to provide personalized feedback. A recent study explored the impact of the large language model GPT-3 on educators giving feedback to struggling students. The AI could use supportive language to appreciate projects, recognize the work put into these projects, and value student strategies

used in makerspace [54]. Instructors can also use AI to improve their performance as facilitators. For example, AI can provide a concise and accurate overview of student progress, which can be added directly to emails providing student feedback. AI also enables feedback in different ways, such as audio or voice-note feedback, video or screencast feedback, and graphic feedback in the form of mind maps and sketch notes. These feedback features are frequently incorporated into VLEs. In addition, Chatbots can help give students frequent, immediate, and adaptive feedback [48]. For instance, students can be guided in using chatbots to get feedback on the structure of an essay or to find errors in programming code. A summary of the different AI technologies and their contributions to teaching and learning is shown in Table 1.

Table 1. AI technologies and their educational contributions.

AI technologies/ frameworks	Educational Contributions
AI-based voice assistants	Answer students' questions; help with homework; teach lessons; search for information.
Smart education framework	Guide educators in developing a specific course or lecture design that harnesses the power of AI and information technologies.
Wrist-worn wearables	Engage students through activities, facilitate interactive learning.
Smart glasses	Overlay digital information onto the real world, enabling learning through augmented reality; record lectures and field observations; provide insights into a student's learning process, helping educators tailor their teaching methods to individual needs.
Virtual reality headsets	Provide immersive learning experiences, making abstract concepts tangible and facilitating experiential learning.
Interactive tools	Incorporate multimedia that provides a broad understanding of a particular concept; track students' learning progress through analytics; allow gamification.
Intelligent tutoring systems	Utilize AI tutors that can collaborate with learners, engage in turn-by-turn conversations, and adapt to discussions; give relevant feedback to motivate learners individually; monitor the relationship between students' emotions and learning, and encourage students when needed.
Virtual learning environment	Present resources, activities, and interactions within a structure and provide for the different stages of assessment.
Natural language AI chatbots	Aid in language-related tasks; provide feedback to students; facilitate information search.

3.5. Challenges in the use of AI.

While AI offers new opportunities to enhance teaching and learning by enabling adaptive and personalized learning, intelligent tutoring systems, automated assessment, efficient feedback loops, generation of smart content for diverse and interactive learning experiences, holistic and inclusive learning, as well as improved teaching practices, some challenges need to be addressed. AI requires advanced infrastructures and an ecosystem of innovative educators. This can be a challenge, especially for developing nations [55]. Ideally, AI should promote inclusiveness in education. However, inclusion and equity are constrained by access to AI technologies and infrastructures [55]. The least developed countries are at risk of suffering new technological, economic, and social divides with the development of AI. Basic technological infrastructure must be established to implement new strategies that take advantage of AI to improve learning [55].

Furthermore, teachers might not be adequately trained or prepared to employ AI in teaching. Teachers must learn new digital skills to use AI in a pedagogical and meaningful way [56]. AI developers must also understand how teachers work and create sustainable solutions in real-life environments [56]. Even though AI has analytical functions and can generate data on learning promptly, the quality of data should be the main concern. AI creates large amounts of data and not all the data are useful. It is essential to develop state capabilities to improve

data collection and systematization [10]. A significant challenge in the effective integration of AI into teaching and learning is the profit orientation of most current AI applications in education. This further widens inequality and inequity in the access to AI-facilitated education, where AI may not be equally accessible to all students due to differences in AI-related infrastructural and technological development and differences in socioeconomic status, making profit-oriented AI unaffordable to marginalized groups [57]. AI developers often lack the pedagogical knowledge needed for the effective implementation of AI in teaching, thus limiting the potential of AI for educational purposes [55].

Integrating technology into the classroom presents challenges such as data privacy and ethics. AI systems often require access to a large amount of data, which can include sensitive information about students [58]. This raises concerns about how this data is stored, who has access to it, and how it is used. There are questions about whether students and parents have given informed consent for their data to be used in certain ways by AI systems [16]. It is important that users understand what data is collected, why it is collected, and how it will be used [58]. There is often a lack of transparency about how AI systems make decisions. This can make it difficult for users to understand why a particular recommendation was made. If an AI system makes a mistake, it can be difficult to hold anyone accountable. The reason is it may be difficult to trace whether the fault lies with the algorithm, the data, or the people who created or implemented the system [58]. AI systems can be vulnerable to attacks that manipulate input data to produce desired outputs. This could potentially be used to change grades or alter student records [59].

AI algorithms can be complex and difficult to understand. The lack of transparency can make AI applications in grading and assessment challenging, particularly in explaining why a grade is given [60]. AI systems are trained on data, and if the data is biased, the AI system can also become biased. This can lead to unfair outcomes in grading and assessment. AI systems may not fully understand or take into account the cultural context of a student's work. This can lead to misinterpretations and inaccuracies in grading and assessment [60]. AI systems may struggle to evaluate certain qualitative aspects of learning, such as creativity, which can limit its effectiveness in grading. The reduction of biases in AI grading and assessment relies on the representativeness of data used to train AI. If an AI is trained primarily on science assignments, the system might not grade history or literature assignments as accurately [61]. If certain assignments or grading styles are underrepresented or overrepresented in data training, the AI system would also have difficulty generalizing its grading. This currently limits AI to the grading of simple assignments, such as those with multiple-choice questions, true-false questions, fill-in-the-blanks, matching, or short answers [61].

4. Conclusions

The rise of AI has significantly changed teaching and learning as it facilitates the transition to student-centered learning, making learning more inclusive, interactive, diverse, and less dependent on teachers as the source of knowledge. AI allows teachers to design smart content, which enhances the learning experience of students and enables them to build on the foundational information provided by teachers, and even synthesize knowledge. The creation of smart content relies on sound frameworks that guide teachers in effectively adding AI elements, such as wearables, interactive tools with analytic capability, and multimedia, into teaching and learning. The development of AI gives rise to intelligent tutoring systems

characterized by autonomous platforms that aim to provide personalized human-like learning experiences to learners. However, the systems function to complement human tutors rather than replace them since they are designed by humans and may lack the pedagogical knowledge of human teachers. AI has the potential to enhance VLEs by collecting and analyzing student learning data, personalizing learning, providing adaptive feedback, engaging students, and generating explanations. AI enhances the feedback process by increasing the quality and quantity of feedback provided to students and teachers. The future of AI focuses on continuous improvement of the current functions of AI to provide personalized and immersive learning experiences, as well as continuous learning analytics. Advancements in virtual or augmented reality experiences could make learning more vivid, engaging, and exciting, while better learning analytics enables AI to provide more accurate grading and feedback to students. There is also interest in developing more powerful AI-enabled online learning platforms and intelligent tutoring systems that address different learning needs and patterns of students. However, the use of AI could be limited by infrastructure requirements, inclusion and equity, teacher readiness and preparation, data quality and inclusivity, profit orientation, data privacy and ethics, and the potential for unequal access. To optimize the functions of AI in teaching and learning, it is recommended to prepare teachers to use technologies in teaching and learning, consult educators in the design of AI systems for education, create open-source, not-for-profit AI platforms to address inequity in accessing AI-facilitated learning, address ethical and data issues related to the use of AI in teaching and learning, as well as invest in infrastructural development to enable AI-facilitated education. Al algorithms can be trained with diverse and representative data sets to improve accuracy in grading and feedback. Regular testing and evaluation of AI algorithms help to identify and correct any biases that may have been inadvertently introduced. Privacy protections are necessary, and these include using secure data storage and transmission methods, and being transparent about how student data is used. Furthermore, educational institutions can develop students' ethical literacy while enacting prudent safeguards in AI tool selection and management. This can help the institutions to tap into AI's potential while upholding values and inclusivity in learning.

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Competing Interest

No competing interest has been identified.

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