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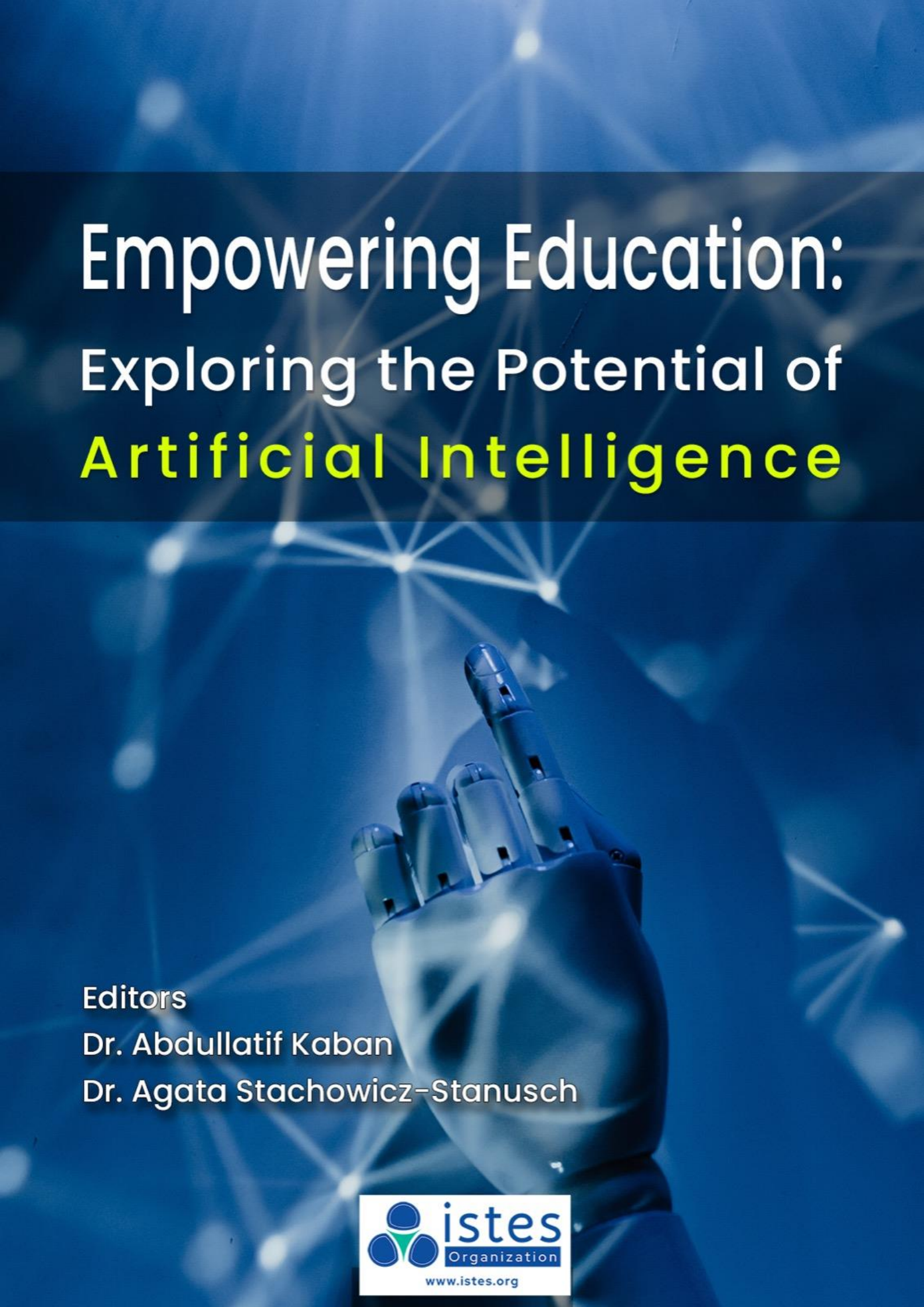
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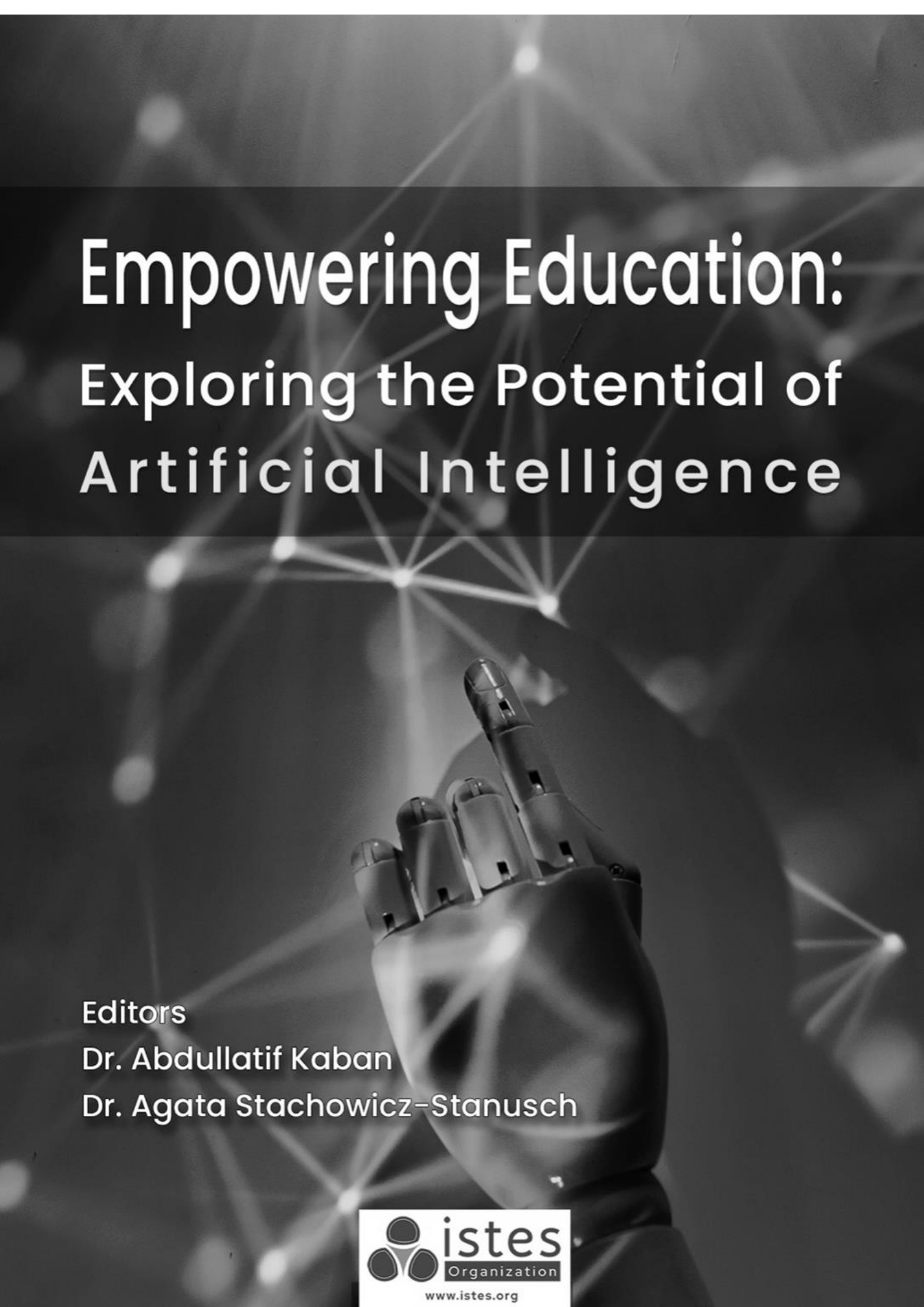

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ISBN: 978-1-952092-57-2

Date of Publication

September, 2023

Publisher

ISTES Organization
Monument, CO, USA

Contact

International Society for Technology, Education and Science (ISTES)
www.istes.org
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Citation

Kaban, A. & Stachowicz-Stanusch, A. (Eds.). (2023). Empowering Education: Exploring the Potential of Artificial Intelligence. ISTES Organization.

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Preface

Welcome to the enlightening journey of "Empowering Education: Exploring the Potential of Artificial Intelligence." Our purpose is to embark on a profound exploration of the profound impact of artificial intelligence on the field of education, revealing the boundless possibilities, invaluable insights, and exciting opportunities that await within these pages.

In our inaugural chapter, "Transforming Education with Artificial Intelligence: Shaping the Path Forward," we lay the cornerstone of our journey by emphasizing the paramount role of AI in education. Here, we prepare you for the exhilarating voyage that unfolds as we delve deeper into the transformative landscape of AI in education.

As we progress into chapter two, "Revolutionizing Education: Applications of Artificial Intelligence," we immerse ourselves in the myriad ways AI can revolutionize traditional educational methodologies. This chapter offers a comprehensive exploration of AI's applications within education, uncovering its potential to redefine how knowledge is imparted and acquired.

Chapter three, "Envisioning the Future of Education with AI," invites you to gaze into the horizon of education and imagine the profound shifts that AI may usher in. Here, we delve into the realm of visionary possibilities and innovative transformations that AI promises for the future of learning.

In chapter four, "Artificial Intelligence in Instructional Pedagogy: Potential Benefits and Future Implications," we embark on a deeper voyage, investigating the profound impact of AI on instructional pedagogy. We assess the tangible benefits AI offers and ponder the implications it carries for the future of teaching.

Chapter five introduces an innovative approach with "Design of Artificial Intelligence (AI) Education for Primary Schools: Arts-based Approach," tailored for primary education, where creativity meets AI-driven learning.

In chapter six, "A Model of Pedagogical AI-Enabled Smart Learning Environment," we embark on a visionary quest, exploring a pedagogical approach amplified by AI, envisioning smart learning environments that redefine the educational experience.

Chapter seven, "From Data to Insights: The Power of Learning Analytics," illuminates the transformative potential of learning analytics and data-driven insights, offering new dimensions to educational decision-making.

Chapter eight, “Application of Artificial Intelligence in Teachers’ Performance Management: A Mini-Review and Research Opportunities,” evaluates the realm of AI in enhancing teachers' performance and identifies exciting research avenues.

Finally, chapter nine, “Artificial Intelligence (AI) in Teaching and Learning: A Comprehensive Review,” provides an extensive overview of AI's multifaceted applications in education, spanning diverse aspects of both teaching and learning.

This book serves as a guiding beacon through the ever-evolving intersection of education and artificial intelligence. We cordially invite you to embark on this enlightening journey of discovery, encouraging you to explore your pivotal role in shaping the future of education within the boundless realms of knowledge offered within these pages.

We thank ISTES for the opportunity to bring together this valuable information.

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Citation

Kaban, A., & Stachowicz-Stanusch, A. (2023). Preface. In A. Kaban & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 1-2). ISTES Organization.

Chapter 1 - Transforming Education with Artificial Intelligence: Shaping the Path Forward

Hamza Polat

Chapter Highlights

- Artificial intelligence has a considerable positive impact on education, opening up possibilities like individualized learning experiences and improved teacher interaction, but it also brings ethical problems to the fore.
- Artificial intelligence tools are frequently used in educational settings and can be divided into three categories: learner-facing tools that enable personalized learning, teacher-facing tools that help teachers manage their workloads and gain new perspectives, and system-facing tools that assist administrative choices.
- Artificial intelligence applications tailored to student needs and intended to improve teaching and learning processes include profiling, intelligent tutoring systems, assessment, and adaptivity.
- Generative modeling in AI involves producing artificial creations by studying patterns and distributions of training data, enabling the generation of authentic content beyond initial programming, which has significant implications for education and various creative domains.
- The development of generative AI in education poses a paradoxical problem that needs to be balanced by its advantages and potential disadvantages.
- Chatbots, including conventional and AI-enabled types, play diverse roles in education, facilitating personalized learning and instructional support through various interaction modes, categorized as teaching, peer, teachable, and motivational agents, thereby enhancing the teaching and learning process in online environments.
- A balanced strategy by educators and policymakers is required to maximize the potential of AI in education by addressing ethical considerations.

Introduction

Artificial intelligence (AI), introduced in the 1950s, refers to systems capable of performing human-like tasks and continuously enhancing themselves by processing information. Initially, AI systems followed specific patterns to solve certain problems, but they now generate more creative and original solutions that emulate human intelligence. Advanced techniques like machine learning, artificial neural networks, deep learning, and advanced algorithms enable these systems to extract patterns and features from large datasets and learn from them.

Among several domains, education is one in which AI integration has significantly transformed. Incorporating AI into education has led to a paradigm change in its landscape, influencing key educational aspects like predictive analytics, intelligent tutoring systems, evaluation methods, and personalized learning experiences. These transformative changes have brought ethical considerations to the forefront, spurring conversations about pertinent issues.

This book chapter aims to comprehensively discuss the applications of AI in education, the integration of generative AI into educational contexts, and the ethical challenges surrounding these topics based on the existing literature. This chapter focuses on AI and education, the use of generative AI in education, the application of chatbot technology, and the ethical issues arising from using AI in education.

Artificial Intelligence and Education

The origins of AI can be traced back to the 1950s when initial depictions of the field emerged. The phrase “Artificial Intelligence (AI)” was coined by John McCarthy during an academic conference organized at Dartmouth College in the USA (Russell & Norvig, 2010). AI is a comprehensive term that encompasses a broad spectrum of technologies and methodologies, such as machine learning, natural language processing, data mining, neural networks, and algorithms (Zawacki-Richter et al., 2019). AI has been defined in various ways, with some definitions emphasizing its collection of skills or capabilities present in digital computers. According to Baker and Smith (2019), AI refers to the capacity of computers to perform cognitive tasks akin to human minds, especially in learning and problem-solving.

AI plays a pivotal role in providing solutions across diverse fields, including but not limited to health, education, and engineering. Regarding education, AI applications increasingly attracted interest and considerable attention in recent years (Taş, 2021; Zawacki-Richter et al., 2019). Although it presents numerous opportunities to enhance teaching and learning, the advancement of AI in higher education also introduces fresh ethical considerations and potential risks (Zawacki-Richter et al., 2019). Incorporating AI into education (AIEd) represents a two-sided phenomenon capable of yielding unintended outcomes and prompting a reevaluation of our perspectives on learning, knowledge, skills, performance, creativity, and innovation (Gibson et al., 2023). Indeed, integrating artificial intelligence opportunities in conjunction with pedagogical components can potentially drive a transformative paradigm shift in education. In this regard, the crucial emphasis lies not in attempting to exclude artificial intelligence from the teaching process by instructional designers and practitioners but rather in

reimagining learning activities by incorporating the advancements in artificial intelligence.

The Horizon report published in 2023 discusses AI advancements in detail, highlighting the potential for new predictive and personalized learning applications. AI-enabled applications promise to transition from "one size fits all" technology to scalable personalized learning experiences, allowing students to leverage these tools even when faculty and staff are unavailable (EDUCAUSE, 2023). The same report also stresses that AI applications offload time-consuming teaching tasks, giving faculty more time to engage directly with students on challenging pedagogical endeavors like synthesizing information and fostering new knowledge.

Categories of Artificial Intelligence Tools in Education

AIEd tools are extensively employed in schools and colleges, broadly categorized into three groups: learner-facing, teacher-facing, and system-facing, acknowledging that certain products may combine features from multiple categories (Baker & Smith, 2019). Table 1 presents examples of these tools. Additionally, Baker and Smith (2019) provide explanations for these concepts. Firstly, learner-facing tools, also called 'intelligent tutoring systems,' 'adaptive,' 'personalized,' or 'differentiated' learning platforms, are software applications that students use to receive and comprehend new information tailored to their needs.

Table 1. Categories of AIEd (Adapted from Baker and Smith (2019))

AIEd Type	**Examples**
Learner-facing	Customizing and organizing learning materials to match individual student needs. Identifying a student's strengths, weaknesses, or knowledge gaps. Offering automated feedback. Fostering collaboration among learners.
Teacher-facing	Automating tasks like assessment, plagiarism detection, administration, and feedback. Supplying valuable insights into the progress of individual students or entire classes. Assisting teachers in fostering innovation and experimentation in their teaching approaches.
System-facing	Organizing timetables efficiently. Predicting inspections and optimizing institutional planning.

Secondly, AIEd tools designed for teachers offer advantages like reducing their workload, gaining valuable student insights, and promoting classroom innovation. Lastly, system-facing AIEd plays a crucial role in supporting and influencing decisions made by school administrators and education system managers. In summary, the diverse range of AIEd tools shows AI's capacity to revolutionize and optimize the paradigm shift in education, covering student-directed applications for learners' benefits, teacher-oriented tools to enhance instructors' capabilities, and system-oriented solutions to aid administrators.

AI Applications in Education

Several systematic review studies provide insights into the various AI applications in education. These studies also present specific examples of these applications. According to Zawacki-Richter et al. (2019), for example, AIEd tools find applications in (i) profiling and prediction, (ii) intelligent tutoring systems (ITSs), (iii) assessment and evaluation, as well as (iv) adaptivity and personalization. Learner profiling and prediction involve the development of learner models or profiles, enabling the anticipation of individual learners' behaviors and needs. The tutoring system offers real-time feedback and hints at each step, with some systems providing immediate feedback as the student progresses, while others wait until the solution is submitted to mark individual steps or conduct a debriefing, commonly known as intelligent tutoring systems (VanLehn, 2011). Assessment and evaluation direct our attention toward the level of teaching and learning. Finally, adaptive and personalized systems are automated and utilize real-time data from an automated system to tailor learning content and activities to individual learners' characteristics and needs (Peng et al., 2019).

As seen in Table 2, Zawacki-Richter et al. (2019) suggest various sub-categories of AIEd applications based on the literature. Within the "profiling and prediction" category, there are three primary research areas. The first area examines the possibility of accurately predicting admission decisions, which could alleviate administrative staff workload and enable them to concentrate on more complex cases. The second area centers on developing early warning systems to identify at-risk students during their first year of study and forecast undergraduate student attrition. Lastly, certain studies within this category aim to profile students and model their learning behaviors, aiming to predict their academic achievements at the course level.

The research on Intelligent Tutoring Systems (ITSs) is classified into five groups by Zawacki-Richter et al. (2019). Firstly, ITSs provide teaching content to students while offering adaptive feedback and hints to help them solve related questions, and they also detect students' difficulties or errors when engaging with the content or exercises by monitoring their actions. Secondly, ITSs mainly involve one-way communication from computer to student, addressing gaps in students' knowledge and providing feedback. Thirdly, ITSs offer personalized assistance by observing students' behavior and generating individual profiles, tailoring recommendations and course material to meet each learner's needs. Fourthly, ITSs foster collaboration among learners through online discussions and collaborative writing activities. Lastly, ITSs support teachers in collaborative learning and alleviate their workload using AI applications.

AI applications in assessment and evaluation in education encompass four categories. Firstly, automated grading systems across disciplines offer potential benefits in streamlining large-scale assessments, reducing costs and time. Secondly, AI-supported feedback employs student-facing tools, including intelligent agents for guidance, software for pilot alerts, and machine learning for automatic feedback, enhancing student writing and reducing cognitive overload. Thirdly, AI assesses student understanding, evaluates engagement, and checks academic integrity, possibly minimizing the need for invigilators and addressing privacy concerns. Lastly, data mining algorithms evaluate lecturer performance through course evaluations, identifying irrelevant questions and providing insights into the impact of teaching methods on various tasks.

Table 2. AIEd Applications in Higher Education (Adapted from Zawacki-Richter et al. (2019))

Research domain	**AIEd Applications**
Profiling and prediction	Admission decisions and course scheduling
	Drop-out and retention
	Student models and academic achievement
Intelligent tutoring systems (ITSs)	Teaching course content
	Diagnosing strengths or gaps in student knowledge, and providing automated feedback
	Curating learning materials based on student needs
	Facilitating collaboration between learners
	The teachers' perspective
Assessment and evaluation	Automated grading
	Feedback
	Evaluation of student understanding, engagement, and academic integrity
	Evaluation of teaching
Adaptivity and personalization	Teaching course content
	Recommending/providing personalized content
	Supporting teachers in learning and teaching design
	Using academic data to monitor and guide students.
	Supporting representation of knowledge in concept maps

The final category of AI in Education is adaptivity and personalization, encompassing five research areas. The literature lacks a consensus on a standard term for adaptive systems, likely due to their diverse functions, reinforcing the classification of studies (Zawacki-Richter et al., 2019). However, these systems can be utilized to personalize teaching course content across various disciplines. They also assist teachers in defining teaching strategies, addressing detected problems, and freeing up more time for teachers to focus on creative work. Adaptive systems analyze students' academic information to perform diagnostic tasks and offer proactive personal guidance to tutors. Moreover, they support tasks such as accommodating peer ideas in concept or mental maps.

Consequently, the growing digitalization of society is being significantly influenced by the pivotal role of AI. As AI continues to automate tasks, process massive volumes of data, and offer predictive insights, its impact on various aspects of our daily lives is bound to revolutionize further and expand (Yang, 2022). As highlighted earlier, AI presents numerous opportunities and advantages from an educational standpoint. However, as noted by Celik (2023), the full potential of AI in the educational context still needs to be explored and fully comprehended. There is much more to discover and understand about how AI can truly revolutionize and enhance the field of education. In this regard, the generative transformation of AI solutions stands as a notable advancement in AIEd that is poised to shape the direction of educational research and practical applications. The forthcoming section will focus on "Generative AI," delving into its principles, capabilities, and potential implications in various domains, particularly in education.

Generative AI (GAI) in Education

Generative modeling is an AI method that produces artificial creations by studying training instances, understanding their patterns and distribution, and subsequently crafting authentic replicas (Jovanovic & Campbell, 2022). This technology utilizes deep learning models to create human-like content, such as images or text, responding to diverse and intricate prompts, such as languages, instructions, or questions (Lim et al., 2023). While traditional AI applications follow a pre-determined flow designed by programmers, generative AI (GAI) surpasses these limitations by going beyond its initial programming, enabling it to produce more authentic and creative outcomes. In contrast to conventional AI machine learning approaches that identify patterns in training data to make predictions, classifications, personalized recommendations, or aid in decision-making, GAI stands out as it has the capability to generate fresh content rapidly and spontaneously in response to user prompts (Murugesan & Cherukuri, 2023). Thus, GAI has been identified by many higher education experts as one of the most disruptive technologies of our time, with the potential to create educational text, images, and sounds in ways that sometimes convincingly mimic human creation, impacting instructional materials, assessments, and more (EDUCAUSE, 2023).

GAIs can be differentiated based on their employed architecture, training techniques, and the types of data they are designed to generate. Generative adversarial networks (GANs), for example, are composed of two neural networks: the generator and the discriminator. The generator's role is to produce synthetic data, while the discriminator's task is to differentiate between the generated synthetic data and actual data (Goodfellow et al., 2020). This interplay between the two networks leads to the generation of high-quality content, particularly in the case of images. Another example of GAI, Generative Pre-trained Transformer (GPT), is a large transformer-based language model that underwent pre-training on extensive datasets, enabling it to generate human-like words, sentences, and paragraphs with a natural and coherent structure (OpenAI, 2023). The key distinguishing feature of GPT from other language models is its ability to perform effectively in multiple tasks without the need for retraining (Radford et al., 2019).

A paradoxical viewpoint

The advancements in GAI technologies have opened up new opportunities for developing diverse AI solutions in education and have also introduced numerous challenges that must be carefully addressed. Lim et al. (2023) outlined a paradoxical approach addressing this dilemma concerning the potential adverse influence of GAI on education or its role in facilitating the teaching process. To begin with, the dual nature of GAI is highlighted, characterized as both a 'friend' and a 'foe.' Initial considerations of GAI lean towards its role as a 'friend,' as it demonstrates the potential to provide a personalized learning experience (Kuhail et al., 2023), support collaborative learning, and possess the ability to provide valuable feedback (Hsu & Ching, 2023). However, concerning knowledge production, educators express apprehension that GAI might transform into a 'foe' that hampers students' creativity and impedes the learning process. For instance, there are concerns about GAI being used to present AI-generated knowledge as if it were a student's original work. Consequently, maintaining a balance between these two aspects is crucial for realizing a promising future for GAI.

GAI demonstrates remarkable proficiency in retrieving, organizing, and presenting information. For example, GAI systems have advanced to the point where they can effortlessly generate many scenarios on a wide range of topics, and the cost for users is virtually negligible (Spaniol & Rowland, 2023). However, the outputs of GAI are contingent upon the inputs it receives. The resulting response may also be inadequate when insufficient instructions are provided in the input. This circumstance has given rise to the paradox of GAI being 'capable' yet 'dependent,' illustrating its capability while highlighting its dependence on the clarity and comprehensiveness of the input instructions (Lim et al., 2023). Thus, learners and educators must develop an essential skill: the capacity to produce and deliver proficient prompts that direct GAI systems to generate valuable and relevant answers (Lo, 2023).

The developers of GAI have underscored that this technology is primarily intended for the improvement and benefit of humanity (OpenAI, 2023). GAI systems, including ChatGPT and Bard, have gained widespread popularity in society. Furthermore, there has been a rapid influx of new GAI systems designed for various purposes, swiftly finding their place in the market. Unfortunately, the complete utilization of some GAI systems with all their features is not always accessible for free. As a matter of fact, certain new initiatives have emerged, offering access to these systems through intermediary applications and monetizing the information generated by these tools. This commercialization and restriction on access can hinder some individuals or organizations from fully benefiting from these GAI technologies initially designed for society's greater good. Lim et al. (2023) call this situation the paradox of GAI being 'accessible' but 'restrictive,' indicating that GAI systems lie in their potential to democratize access to knowledge, making valuable information more widely available; however, the ability to access and utilize these tools may be constrained by resource availability, leading to potential equity and accessibility challenges.

The latest editions of the Horizon Report (EDUCAUSE, 2019, 2023), which highlight emerging technologies and practical applications, forecast widespread adoption of GAI across various industries in the future. However, some researchers caution that these systems may negatively impact specific sectors. From an educational perspective, educators express serious concerns about students accessing information effortlessly through GAI and using it without proper effort, passing it off as their work. To act against this problem, several countries have raised discussions about potentially banning GAI systems. However, such prohibitive actions, often seen as buffer solutions, might not effectively curb the proliferation of GAI. Paradoxically, attempts to restrict the use of a system or product can lead to an opposite reaction, accelerating its popularity. This phenomenon was pointed out by Lim et al. (2023), suggesting that GAI could become even more 'popular' when 'banned.' Educators, researchers, and policymakers face a significant challenge to avoid this paradox. Addressing this issue requires comprehensively reconsidering educational practices at different levels, from micro to meso and macro scales (Gibson et al., 2023). The traditional focus on integrating technology, including artificial intelligence, into education processes must be reviewed. Finding a balance between leveraging GAI's potential benefits and addressing its potential drawbacks will be crucial for the future of education.

It is beneficial to approach the matter paradoxically to gain a deeper understanding of GAI in education. Such an approach helps us comprehend GAI's potential risks and hazards in education. Engaging in new discussions on this topic will aid in defining the limits and boundaries of the field.

Chatbots

Chatbot Technology in Education

A chatbot, also referred to as a conversational agent, is a computer program that utilizes a combination of language models and algorithms to engage in conversations with users in either written or spoken form (Ashfaque et al., 2020). There are two types of chatbots: conventional and AI-enabled chatbots. Conventional or rule-based chatbots are limited to specific functions as they can solely generate predefined responses for particular tasks (Luo et al., 2022). These chatbots have a couple of drawbacks, such as the absence of personalized guidance and an incapability to understand user intentions (Hwang et al., 2022).

On the other hand, AI chatbots, or conversational agents, are computer programs designed to engage in human-like conversations using various artificial intelligence techniques, such as natural language process, information retrieval, machine, and deep learning techniques (Fidan & Gencel, 2022; Mageira et al., 2022; Zhang et al., 2020). In educational settings, these chatbots can provide valuable instructional assistance (Huang et al., 2022), personalized learning experience (Mageira et al., 2022; Smutny & Schreiberova, 2020), feedback to students (Fidan & Gencel, 2022; Lee et al., 2020), scaffolding for learners' understanding (Winkler et al., 2020), and a chance to improve learners' outcomes (Wu & Yu, 2023).

The interaction between learners and chatbots can be in different ways, including text-based, voice-based, and embodied (Kuhail et al., 2023). The nature of this interaction depends on both the input system employed and the attributes of the media being engaged with. During text-based interaction, the user employs the keyboard as the input method. Voice-based interaction involves engaging through sound using the microphone as the input medium, such as Alexa, Siri, and Google Assistant (Følstad et al., 2019). Finally, embodied chatbots possess a human or pedagogical avatar-like appearance. These chatbots can utilize facial and eye movements, gestures, and verbal expressions. They can be used to provide cognitive, affective, and social learning support in context (Schouten et al., 2018). Chatbots can potentially promote emotional, transparent, and consistent interactions between students, thereby boosting their sense of social presence (Zhang et al., 2023). As these chatbots create the sensation of interacting with a real person (Wu et al., 2020), they have a positive impact on the social presence experienced by users. Progress in AI technologies will play a significant role in increasing both the quantity and the quality of such chatbots. As a case in point, these advancements enable educational videos, which typically offer a relatively linear interaction with learners, to be rendered more interactive by incorporating embodied chatbots. Having been trained on the subject matter outlined in the video in advance, these tools can equip learners with suitable feedback, guidance, and instruction.

The dialogue with the chatbots can take place in either a user-driven or chatbot-driven manner (Følstad et al., 2019). According to Følstad et al. (2019), in user-driven dialogue, the chatbot must be capable of discerning the

user's intention, both within individual messages and throughout the entire interaction or its segments, and also possess the ability to respond appropriately to this intent. Technically, providing such a dialogue might be more challenging. Nonetheless, the GAI systems' capacity to generate more genuine and innovative responses could potentially lead to increased adaptability concerning the diverse inputs users might provide. Conversely, specific chatbots generate responses following a predefined flowchart, making it exceedingly challenging for them to deviate from this pre-determined path. The distinction between these two dialogue forms can also be accounted for by the presence or absence of a generative capability in AI. From an educational perspective, both types of dialogue can be used to enhance the interactivity of the teaching process, particularly in online learning environments, where providing individual support from educators to students is challenging. For instance, the chatbot-driven dialogue can be employed to offer instructions or feedback based on input from students, providing an opportunity to assess their current progress. On the other hand, the user-driven dialogue can guide the student through the learning process using the chatbot system, facilitating a more personalized and authentic learning experience that aligns with the principles of student-centered learning approaches.

Various roles can be attributed to chatbots in education, and Kuhail et al. (2023) have classified these roles into four groups: teaching agents, peer agents, teachable agents, and motivational agents. First, teaching agents engage in conversations with students to propose a range of tutorials and instructional materials (Kuhail et al., 2023). For instance, Winkler et al. (2020) examined the impact of incorporating scaffolding and a voice-based chatbot onto online video lectures to enhance information retention and transfer capabilities. The research showed that using a voice- and text-based chatbot, which supports learners' understanding during video instruction, enhances both information retention and transfer abilities. Second, peer agents refer to chatbot systems that assist students on demand (Kuhail et al., 2023)—as an example of peer agent, Verleger and Pembridge (2018) developed an AI chatbot called EduBot, as a plugin to the Canvas Learning Management System. This tool allows students to ask questions anytime they need assistance. If the question is already in the database, the student receives support accordingly. Otherwise, the relevant faculty member is informed about the request. The findings indicated that chatbots like EduBot hold the potential to stimulate student questions, particularly from those who might feel hesitant or apprehensive about participating actively in a regular class session. The third agent, teachable agents, prompts students with questions to teach specific topics (Kuhail et al., 2023). Law et al. (2020) introduced a learning-by-teaching platform called Curiosity Notebook to respond to the need for teachable agents. This platform enables students to collaborate either individually or in groups to teach a conversational agent how to perform a classification task across different subject areas. The study offers valuable insights into the design factors for creating conversational, group-based learning-by-teaching scenarios. The last role of the chatbots is that of motivational agent. These agents act as coaches, seeking to inspire and motivate learners to take action (Schouten et al., 2018).

In summary, chatbots can be designed to facilitate personalized learning, experiential learning, social dialoguing, collaborative learning, affective learning, learning by teaching, and scaffolding in educational contexts (Kuhail et al., 2023). Indeed, the interaction and dialogue with these systems can vary based on their design and intended educational roles. However, research into using chatbots for facilitating learning is still in its initial phases, underscoring the need for further contributions to advance this field (Hwang & Chang, 2021; Zhang et al., 2023).

AI-Enabled Chatbots

AI chatbots are sophisticated systems or applications that possess intelligence, enabling them to engage in natural language interactions with humans across diverse aspects of daily life (Mageira et al., 2022). In order to enhance the quality of user interactions, these chatbots acquire knowledge from past user inputs through learning mechanisms (Nguyen et al., 2022). These chatbots possessing interactive, adaptable, and personalized traits can efficiently handle user inquiries and promptly respond in real-time through text, voice, or a combination of both mediums (Wu et al., 2020).

AI chatbots can be divided into three types for general classification: machine learning-based chatbots, natural language processing-based chatbots, and hybrid chatbots (Wu & Yu, 2023). This classification is based on the text understanding module, which facilitates direct interaction with the user and extracts meaning from the user's input before generating a specific response (Safi et al., 2020). By implementing machine learning algorithms, conventional machine learning-based chatbots can understand user intent, filter irrelevant information, and offer valuable guidance (Wu & Yu, 2023). There has been a noticeable and recent trend toward adopting machine learning-based approaches in developing chatbot systems (Safi et al., 2020). Natural language processing-based chatbots with advanced machine learning algorithms can learn from users' past inputs and recognize, infer, and effectively utilize human languages (Wu & Yu, 2023). Natural language processing help to teach computers to talk to humans naturally, like humans, by understanding user texts, voices, audio, or video notes and converting them into a structured data format for effective interaction (Christopherjames et al., 2021). Finally, hybrid chatbots are composed of a blend of AI algorithms and rule-based logic (Wu & Yu, 2023).

Due to advancements in GAI and large language models, numerous institutions are now creating diverse AI-enabled chatbots. Examples of publicly available chatbots include ChatGPT, Bard, Language Model for Dialogue Applications (LaMDA), Sparrow, and YouChat 2.0, along with their various extensions and application programming interfaces (APIs).

ChatGPT

ChatGPT (GPT-3.5), developed by OpenAI, a research organization supported by Microsoft, has gained considerable attention and popularity since its introduction in November 2022 (Mondal et al., 2023). In March 2023, the corporation launched GPT 4.0, with enhancements encompassing creativity, visual aids, dependability, precision, and contextual understanding. ChatGPT can collect information from the internet and deliver responses comparable to those found on the Google search engine. The distinction lies in their approach: Google presents multiple options from various sources, while ChatGPT rapidly provides a single answer through educated guesses. Trained on extensive textual data, such as books, news, articles, websites, and Wikipedia, ChatGPT constructs sentences step-by-step and selects the most probable phrase to follow each word. Due to its reliance on internet-sourced information, ChatGPT may occasionally provide incorrect responses (Murugesan & Cherukuri, 2023).

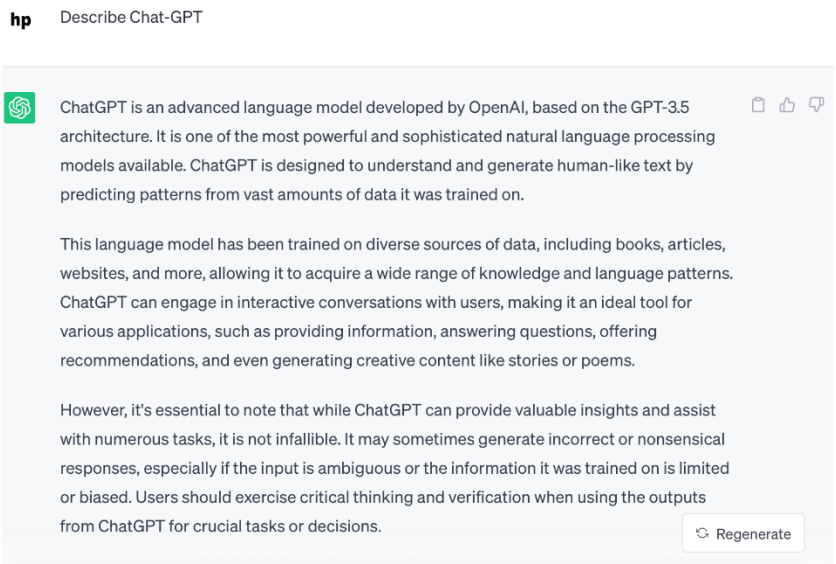

Figure 1. How ChatGPT is Described by ChatGPT

Figure 1 presents the outcome where ChatGPT defines itself in response to the question “Describe ChatGPT.” The response centers on three key aspects. Firstly, it highlights ChatGPT as a robust natural language processing model capable of generating text that resembles human language. Secondly, it provides insights into the training process and the types of results it can produce. Lastly, the response acknowledges that the generated information may occasionally be flawed, emphasizing the importance of cautiously approaching the results.

Microsoft has introduced a new iteration of ChatGPT, powered by Bing, which aims to deliver users with search outcomes that are both more precise and punctual (Mondal et al., 2023). Likewise, utilizing APIs enables the creation of various applications using ChatGPT. For educational settings, ChatGPT-supported applications can potentially find extensive use in online learning procedures and language learning, particularly in learning activities related to providing feedback, offering guidance, and assessing progress.

Google Bard

Launched in May 2022, Google Bard is a conversational AI service driven by a language model called LaMDA, which has been trained on an extensive dataset of over 1.56 trillion words from conversational exchanges and online content (Murugesan & Cherukuri, 2023). This training used the transformer architecture, making it a powerful tool for dialogue applications. Bard resembles ChatGPT’s functionality but distinguishes itself by sourcing information directly from the internet. Much like ChatGPT, Bard is capable of coding, solving mathematical queries, and aiding in writing tasks.

Both ChatGPT and Bard provide a user-friendly interface with a designated space for entering prompts and receiving responses. The AI engine produces answers that specifically address or prompt consumers’ queries. As a result, the engagement is more effective because the user’s needs are addressed with pertinent and coherent information. Users of ChatGPT have the helpful option to regenerate the same job or inquiry, allowing them to customize the answer they get. Users can comment on the generated responses through this iterative process,

which helps the system comprehend and advance over time. The effectiveness and precision of subsequent AI interactions are improved because of this interactive feedback loop. Like ChatGPT, Bard shares an iterative feedback mechanism that enables users to improve their responses and offer insightful feedback to the AI system.

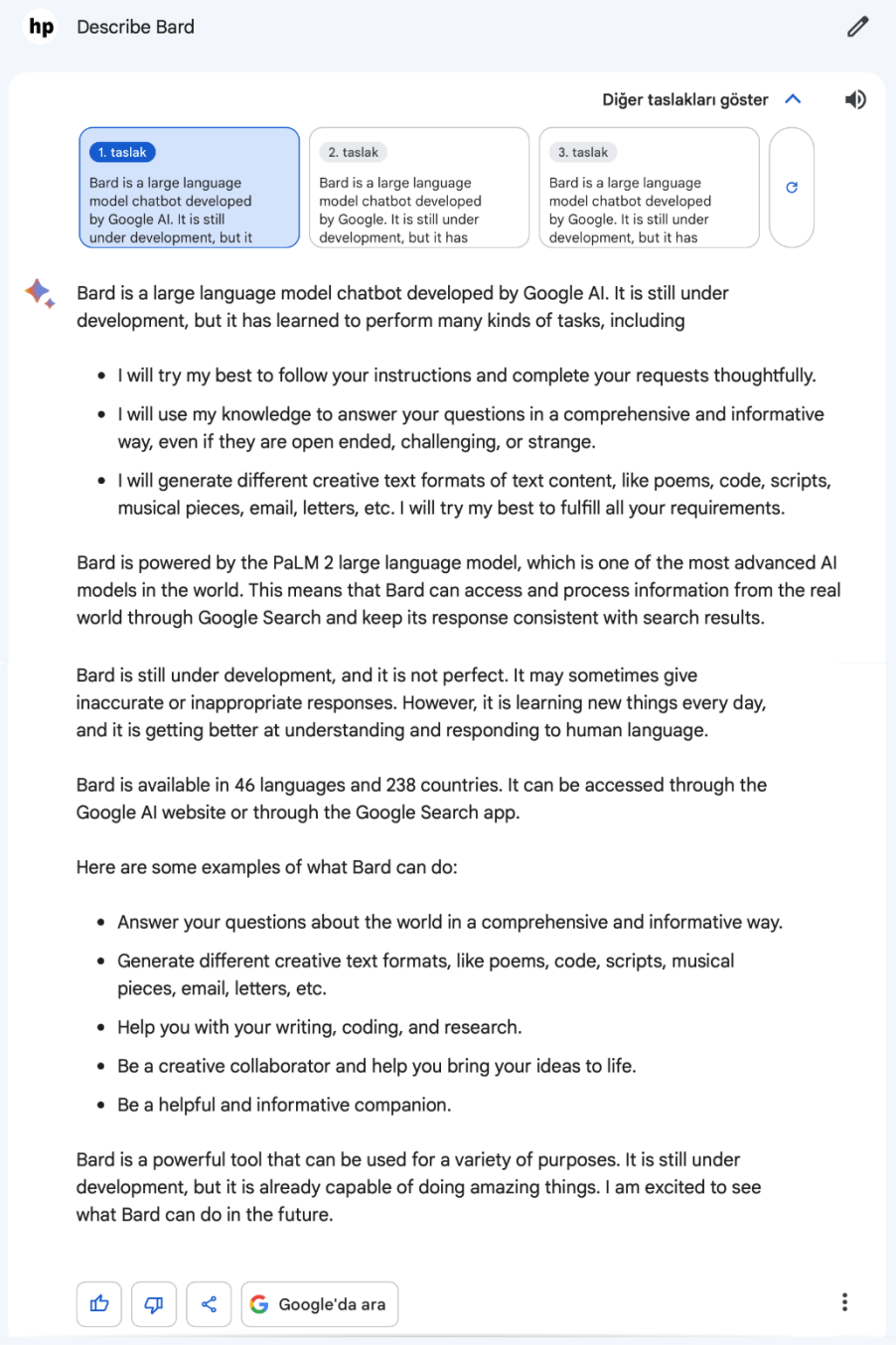

Figure 2. How Bard is Described by Bard

On the other hand, Bard allows customers to see alternate solutions within the same window, which is a noticeable difference. This feature increases transparency and provides a more thorough user experience by giving users a more comprehensive picture of the AI's capabilities and variances in its comprehension of the question. Additionally, Bard offers a unique function that lets users select to vocalize the generated responses. The voice-

based interaction gives the user experience a new dimension, making it more engaging and appropriate for situations where spoken communication is preferred or required.

As depicted in Figure 2, Bard introduces itself by highlighting its capabilities, methods to generate information, the range of tasks it can perform, its inherent strengths, and its potential applications. Consequently, it adheres to user directives and endeavors to provide precise responses. Bard can create diverse outputs, encompassing poems, code, and letters. It is important to note that Bard's evolution is an ongoing process; over time, it continues to enhance its capabilities by incorporating various features.

Both ChatGPT, Bard, and other newly released AI-enabled chatbots are in a continuous state of evolution driven by competitive forces. This progress is anticipated to yield a more profound comprehension of user prompts, leading to more accurate responses. As technical capabilities advance, these conversational agents will begin generating solutions with profound implications across various industries. From an educational perspective, it is essential to note that these tools are intended to supplement instructors. Instead, they will accelerate the development of diverse online solutions, alleviating some of the instructor's workload and fostering students' cognitive abilities. This acceleration is particularly significant in personalized learning, where we can expect a surge in applications designed to support students in their individual learning journeys, providing constructive feedback as needed.

However, these advancements in both General Artificial Intelligence (GAI) and chatbots raise significant ethical concerns, particularly in their use within education. The following section will delve into an ethical evaluation of the utilization of AI in educational settings.

Ethical Issues for AIEd

Artificial intelligence applications in education vary across different disciplines. These applications can be categorized into several groups: creating student profiles and making educational predictions, developing and implementing intelligent tutoring systems, monitoring and executing measurement and evaluation processes, and producing adaptable-personalized solutions (Zawacki-Richter et al., 2019). However, using AIEd tools also raises several ethical concerns (Selwyn, 2022). For instance, there are questions about the possibility of obtaining academic degrees or grants using AIEd tools. Additionally, the extent to which it is acceptable and appropriate for certain students to rely heavily on these systems in distance education processes is a matter of debate. Using AIEd tools for homework raises concerns about achieving fairness and justice in the classroom. Another ethical dilemma involves presenting other people's ideas as one's own when using AI-generated content. Furthermore, there is a need to identify who is responsible for educational outcomes derived from artificial intelligence tools. These ethical considerations have led to discussions in the literature about the appropriate use of AIEd and have raised question marks regarding its implications (Selwyn, 2022).

Dieterle et al. (2022) discuss ethical concerns about five distinct and interconnected divides in the AIEd contexts: algorithms, access, representation, interpretations, and citizenship. Initially, AI-driven algorithms have been

instrumental in developing digital tools and learning platforms to enhance students' learning experiences. However, researchers are concerned about the appropriate reliance on these systems, as they may not always provide precise information about students' current learning status. Algorithmic bias is linked to the accuracy of digital data, and both access and representation divides are considered upstream divides that significantly influence the data used in algorithm development, validation, and improvement (Dieterle et al., 2022).

Some students using educational digital tools or platforms may benefit from cognitive and affective gains. Nevertheless, the unequal access to these tools among students and educators raises ethical issues. The third ethical concern pertains to data representativeness, as not all stakeholders in the education process have access to digital learning tools or platforms. Consequently, the data derived from these environments might only partially reflect some population segments. This situation gives rise to the problem that the inferences drawn from the available data may not be applicable to real-world situations.

Dieterle et al. (2022) also suggest downstream divides (i.e., interpretation and citizenship divides) that emerge from algorithms using data disproportionately drawn from learners with access and representation. The data produced when students and educators interact with digital tools and learning platforms serves as a source of information for decision-making by researchers, educators, and policymakers. In this regard, Dieterle et al. (2022) ask whether educators can appropriately utilize this data and the algorithmic outputs to make decisions without proper training on interpreting and applying them. Finally, the digital divide affects learners and educators beyond technology access, impacting their success and opportunities. Algorithmic bias is prevalent in various domains, necessitating fairness and transparency. We must ensure that data-driven decisions lead to an equitable future.

Given the ethical considerations and the pedagogical affordances of AIEd, it can be concluded that AI in education is undoubtedly a two-sided tool that can bring about unintended outcomes and is likely to prompt a reconsideration of various assumptions concerning learning, knowledge, skills, performance, creativity, and innovation (Gibson et al., 2023). Undoubtedly, there are bound to be new opportunities and advancements in the utilization of AI in education soon. However, with these developments, there will also arise new ethical and practical challenges. While some (e.g., Gibson et al., 2023) will embrace AI as an intelligent partner in the educational journey, others (e.g., Selwyn, 2022) will approach it cautiously, viewing it as a tool that requires careful consideration. The matter at hand is likely to remain a topic of extended discussion, exerting a remarkable role in shaping future education policies. Educators, researchers, instructional designers, and policymakers should actively consider integrating these technologies into instructional processes rather than overlooking AIEd. This involves thoroughly considering theoretical frameworks, learning activities, and educational assessment and evaluation procedures. In essence, the primary goal is to support well-qualified human resources who can effectively cater to the needs of the contemporary educational landscape by leveraging AI.

Conclusion

Consequently, advancements in AI are prompting us to reconsider traditional educational practices and routines. This perspective anticipates the proliferation of online systems capable of making accurate forecasts regarding

student progress and instructional methods. Furthermore, incorporating artificial intelligence to support in-class activities and learning materials, along with adapting evaluation processes to align with the capabilities of AI applications, is recommended. Enhancing the functionality of AI-powered chatbot systems also holds the potential to deliver personalized learning experiences. Educators are enthusiastic about the potential to foster a more immersive learning environment and attach AI to education to lessen undesirable learning outcomes. However, numerous researchers have raised concerns that the benefits derived from generative AI-supported applications could restrain students' creativity and hinder their original output.

Hence, the involvement of AI in education carries a dual nature, akin to a double-edged sword. Rather than shying away from this technology, educational practices should be reevaluated through the lens of instructional design, carefully considering its advantages and limitations. Lastly, even though generative AI and AI-enabled Chatbot applications have introduced numerous innovations in education, the research in this field still needs to be expanded. Thus, it is advisable to transcend conceptual discussions about the topic and focus on empirical studies that delve into the practical integration of AI. In the present circumstances, AI emerges as a pioneering technology, with researchers predominantly concentrating on its affirmative aspects. However, the long-term impact of this technology on various cognitive, affective, and social learning outcomes remains uncertain and needs further investigation.

References

Ashfaque, M. W., Tharewal, S., Iqhbal, S., & Kayte, C. N. (2020). A review on techniques, characteristics and approaches of an intelligent tutoring Chatbot system. *2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC)*, 258–262. https://doi.org/10.1109/ICSIDEMPC49020.2020.9299583

Baker, T., & Smith, L. (2019). *Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges*. https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf

Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, *138*. https://doi.org/10.1016/j.chb.2022.107468

Christopherjames, J. E., Saravanan, M., Thiyam, D. B., S, P. A. S., Sahib, M. Y. B., Ganapathi, M. V, & Milton, A. (2021). Natural language processing based human assistive health conversational agent for multi-users. *2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC)*, 1414–1420. https://doi.org/10.1109/ICESC51422.2021.9532913

Dieterle, E., Dede, C., & Walker, M. (2022). The cyclical ethical effects of using artificial intelligence in education. *AI and Society*. https://doi.org/10.1007/s00146-022-01497-w

EDUCAUSE. (2019). *Educause Horizon report: 2019 Higher Education edition.* https://library.educause.edu/-/media/files/library/2019/4/2019horizonreport.pdf

EDUCAUSE. (2023). *2023 Educause horizon report. Teaching and learning edition*. https://www.educause.edu/horizon-report-teaching-and-learning-2021

Fidan, M., & Gencel, N. (2022). Supporting the instructional videos with chatbot and peer feedback mechanisms

in online learning: The effects on learning performance and intrinsic motivation. *Journal of Educational Computing Research*, *60*(7), 1716–1741. https://doi.org/10.1177/07356331221077901

Følstad, A., Skjuve, M., & Brandtzaeg, P. B. (2019). Different chatbots for different purposes: Towards a typology of chatbots to understand interaction design. In S. S. Bodrunova, O. Koltsova, A. Følstad, H. Halpin, P. Kolozaridi, L. Yuldashev, A. Smoliarova, & H. Niedermayer (Eds.), *Internet Science* (pp. 145–156). Springer International Publishing.

Gibson, D., Kovanovic, V., Ifenthaler, D., Dexter, S., & Feng, S. (2023). Learning Theories for AI Promoting Learning Processes. *BJET*, 1–22. https://doi.org/10.1111/bjet.13341

Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., & Bengio, Y. (2020). Generative adversarial networks. *Communications of the ACM*, *63*(11), 139–144. https://doi.org/10.1145/3422622

Hsu, Y.-C., & Ching, Y.-H. (2023). Generative Artificial Intelligence in Education, Part One: the Dynamic Frontier. *TechTrends*. https://doi.org/10.1007/s11528-023-00863-9

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

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

Hwang, W.-Y., Guo, B.-C., Hoang, A., Chang, C.-C., & Wu, N.-T. (2022). Facilitating authentic contextual EFL speaking and conversation with smart mechanisms and investigating its influence on learning achievements. *Computer Assisted Language Learning*, 1–27. https://doi.org/10.1080/09588221.2022.2095406

Jovanovic, M., & Campbell, M. (2022). Generative Artificial Intelligence: Trends and Prospects. *Computer*, *55*(10), 107–112. https://doi.org/10.1109/MC.2022.3192720

Kuhail, M. A., Alturki, N., Alramlawi, S., & Alhejori, K. (2023). Interacting with educational chatbots: A systematic review. In *Education and Information Technologies* (Vol. 28, Issue 1). Springer US. https://doi.org/10.1007/s10639-022-11177-3

Law, E., Baghaei Ravari, P., Chhibber, N., Kulic, D., Lin, S., Pantasdo, K. D., Ceha, J., Suh, S., & Dillen, N. (2020). Curiosity notebook: A platform for learning by teaching conversational agents. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–9. https://doi.org/10.1145/3334480.3382783

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

Lim, W. M., Gunasekara, A., Pallant, J. L., Pallant, J. I., & Pechenkina, E. (2023). Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators. *International Journal of Management Education*, *21*(2), 1–13. https://doi.org/10.1016/j.ijme.2023.100790

Lo, L. S. (2023). The CLEAR path: A framework for enhancing information literacy through prompt engineering. *The Journal of Academic Librarianship*, *49*(4), 102720. https://doi.org/10.1016/j.acalib.2023.102720

Luo, B., Lau, R. Y. K., Li, C., & Si, Y.-W. (2022). A critical review of state-of-the-art chatbot designs and applications. *WIREs Data Mining and Knowledge Discovery*, *12*(1), e1434.

https://doi.org/10.1002/widm.1434

Mageira, K., Pittou, D., Papasalouros, A., Kotis, K., Zangogianni, P., & Daradoumis, A. (2022). Educational AI Chatbots for Content and Language Integrated Learning. *Applied Sciences*, *12*(7). https://doi.org/10.3390/app12073239

Mondal, S., Das, S., & Vrana, V. G. (2023). How to bell the cat? A theoretical review of generative artificial intelligence towards digital disruption in all walks of life. In *Technologies* (Vol. 11, Issue 2). https://doi.org/10.3390/technologies11020044

Murugesan, S., & Cherukuri, A. K. (2023). The rise of generative artificial intelligence and its impact on education: The promises and perils. *Computer*, *56*(5), 116–121. https://doi.org/10.1109/MC.2023.3253292

Nguyen, Q. N., Sidorova, A., & Torres, R. (2022). User interactions with chatbot interfaces vs. Menu-based interfaces: An empirical study. *Computers in Human Behavior*, *128*, 107093. https://doi.org/10.1016/j.chb.2021.107093

OpenAI. (2023). *Better language models and their implications*. https://openai.com/research/better-language-models

Peng, H., Ma, S., & Spector, J. M. (2019). Personalized adaptive learning: An emerging pedagogical approach enabled by a smart learning environment. *Lecture Notes in Educational Technology*, *6*(9), 171–176. https://doi.org/10.1007/978-981-13-6908-7_24

Radford, A., Wu, J., Child, R., Luan, D., Amodei, D., & Sutskever, I. (2019). Language models are unsupervised multitask learners. *OpenAI Blog*, *1*(8), 9.

Russell, S., & Norvig, P. (2010). *Artificial intelligence a modern approach* (3rd ed.). Pearson Education, Inc.

Safi, Z., Abd-Alrazaq, A., Khalifa, M., & Househ, M. (2020). Technical aspects of developing chatbots for medical applications: Scoping review. *J Med Internet Res*, *22*(12), e19127. https://doi.org/10.2196/19127

Schouten, D. G. M., Venneker, F., Bosse, T., Neerincx, M. A., & Cremers, A. H. M. (2018). A digital coach that provides affective and social learning support to low-literate learners. *IEEE Transactions on Learning Technologies*, *11*(1), 67–80. https://doi.org/10.1109/TLT.2017.2698471

Selwyn, N. (2022). The future of AI and education: Some cautionary notes. *European Journal of Education*, *57*(4), 620–631. https://doi.org/10.1111/ejed.12532

Smutny, P., & Schreiberova, P. (2020). Chatbots for learning: A review of educational chatbots for the Facebook Messenger. *Computers & Education*, *151*. https://doi.org/10.1016/j.compedu.2020.103862

Spaniol, M. J., & Rowland, N. J. (2023). AI-assisted scenario generation for strategic planning. *Futures & Foresight Science*, *5*(2), e148. https://doi.org/10.1002/ffo2.148

Taş, N. (2021). Artificial Intelligence in Education: Literature Review. *International Conference on Studies in Education and Social Sciences (ICSES).* Antalya: ISTES .

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, *46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

Verleger, M., & Pembridge, J. (2018). A pilot study integrating an AI-driven chatbot in an introductory programming course. *2018 IEEE Frontiers in Education Conference (FIE)*, 1–4. https://doi.org/10.1109/FIE.2018.8659282

Winkler, R., Hobert, S., Salovaara, A., Söllner, M., & Leimeister, J. M. (2020). Sara, the lecturer: Improving learning in online education with a scaffolding-based conversational agent. *Proceedings of the 2020 CHI*

Conference on Human Factors in Computing Systems, 1–14. https://doi.org/10.1145/3313831.3376781

Wu, E. H.-K., Lin, C.-H., Ou, Y.-Y., Liu, C.-Z., Wang, W.-K., & Chao, C.-Y. (2020). Advantages and constraints of a hybrid model k-12 e-learning assistant chatbot. *IEEE Access*, *8*, 77788–77801. https://doi.org/10.1109/ACCESS.2020.2988252

Wu, R., & Yu, Z. (2023). Do AI chatbots improve students learning outcomes? Evidence from a meta-analysis. *British Journal of Educational Technology*. https://doi.org/10.1111/bjet.13334

Yang, W. (2022). Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation. *Computers and Education: Artificial Intelligence*, *3*, 100061. https://doi.org/10.1016/j.caeai.2022.100061

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(39). https://doi.org/10.1186/s41239-019-0171-0

Zhang, J., Oh, Y. J., Lange, P., Yu, Z., & Fukuoka, Y. (2020). Artificial intelligence chatbot behavior change model for designing artificial intelligence chatbots to promote physical activity and a healthy diet: Viewpoint. *J Med Internet Res*, *22*(9). https://doi.org/10.2196/22845

Zhang, R., Zou, D., & Cheng, G. (2023). A review of chatbot-assisted learning: pedagogical approaches, implementations, factors leading to effectiveness, theories, and future directions. *Interactive Learning Environments*, 1–29. https://doi.org/10.1080/10494820.2023.2202704

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Citation

Polat, H. (2023). Transforming Education with Artificial Intelligence: Shaping the Path Forward. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 3-20). ISTES Organization.

Chapter 2 - Revolutionizing Education: Applications of Artificial Intelligence

Nurullah Taş

Chapter Highlights

- Artificial Intelligence is defined as a computer and software system used to solve problems that require human intelligence and to achieve human-like goals. In education, systems that perform human-like functions such as visual perception, speech recognition, decision-making, and translation are being developed.
- Artificial Intelligence plays an important role in education. It is used in areas such as smart teaching, language learning, and online education. In addition, institutions and projects focusing on AI education (for example, the Institute for Artificial Intelligence Systems of the Technical University Eindhoven) are being developed.
- AI is used to deliver personalized learning experiences, enhance practical training with virtual labs, and assess student performance. Virtual labs offer great advantages, especially for educational institutions with limited resources. AI-powered education can increase student engagement. It provides personalized feedback to students, can monitor attention levels, and adapt learning materials. This can help students to be more engaged and improve their learning outcomes.
- Artificial Intelligence can improve assessment processes in education. Facial and voice recognition technologies can be used to assess student engagement and understanding. Such tools can provide personalized feedback to students and optimize their learning experience.

Introduction to Artificial Intelligence

Computer and information science include artificial intelligence (AI). AI is used to construct hardware and software systems that solve problems and achieve goals that would normally require human intelligence (Moursund, 2006). AI is a conceptual framework for developing and using computer systems with human-like intelligence. These systems perform human-like functions, including visual perception, speech recognition, decision-making, and translation (Chen et al., 2020). AI research in computer science addresses cognitive difficulties related to human intelligence. These obstacles include learning, problem-solving, pattern identification, and adaptation. AI has historically been tied to computers, but embedded computers, sensors, and other technologies have enabled integration into buildings and robotics (Chen et al., 2020). AI has been used in education to solve problems and achieve goals. Examples include intelligent tutoring, computer-assisted language learning, and online education (Moursund, 2006). Language learning and teaching use AI to mimic teachers' and students' behavior. The content requires further details on AI's methodology and uses in this context. AI has unique characteristics and concepts and is closely linked to the future of higher education (Zawacki-Richter et al., 2019). Google and other non-profit public-private collaborations like the German Research Center for Artificial Intelligence have invested heavily in AI. Education AI application development and deployment are expected to rise. To promote artificial intelligence education and research, the Technical University of Eindhoven is developing an Artificial Intelligence Systems Institute (Zawacki-Richter et al., 2019). AI in education (AIEd) has a 30-year history. Zawacki-Richter et al. (2019) noted that educators must determine how to use AIEd to improve teaching on a larger scale. Ethical and pedagogical methods for employing AIEd in higher education need more investigation. Zawacki-Richter et al. (2019) also suggest a more critical review of AIEd's challenges and risks.

Advantages and Disadvantages of Using Artificial Intelligence in Education

Artificial intelligence (AI) in education is rising, potentially changing how students use educational materials. Wahyono et al. (2019) say artificial intelligence can assess a user's skill level and motivation to recommend models, media, and resources for personalized learning. This might improve learning by giving pupils personalized suggestions. AI-enabled virtual labs had a 90.8% accuracy rate in 2019. Virtual laboratories also benefit educational institutions with limited space and equipment, which hinders practical, hands-on learning. The benefits above suggest that AI-enabled virtual laboratories can adapt learning. However, virtual labs provide a one-way learning experience without user feedback (Wahyono et al., 2019). To address this constraint, tailor-made virtual laboratories using AI should be considered. This might improve learning results and make using educational materials easier for pupils.

How is Artificial Intelligence revolutionizing the field of education?

The practicality of using artificial intelligence (AI) technology in higher education has increased since its introduction (Malik et al., 2019). Uunona and Goosen (2023) say that using AI-powered online learning apps can potentially enhance student results. Furthermore, these applications can serve as a means to foster cooperation among different participants within the education system. The utilization of AI-based learning has the potential

to effectively tackle the obstacles encountered in the teaching and learning process. Furthermore, it may provide academic committees with enhanced decision-making capabilities, as highlighted by Malik et al. (2019). According to Malik et al. (2019), universities can efficiently utilize and modify technology to enhance learning outcomes and educational quality. According to Malik et al. (2019), using information and communication technologies (ICT) has significantly changed education. Moreover, integrating artificial intelligence (AI) can enhance the effectiveness and caliber of these technologies. Malik et al. (2019) suggested using a framework to make it easier to establish a thorough structure for implementing artificial intelligence (AI) in educational settings. This framework enables universities to effectively leverage their educational resources and enhance the quality of the learning experience provided to their students.

Most Popular AI-enabled Learning Solutions

The utilization of AI-enabled learning solutions is growing in several sectors, with a particular emphasis on accounting and finance. AI-enabled systems are built on the foundations of machine learning, expert systems, and perception. AI-enabled wargaming represents a notable instrument in the field, with deep reinforcement learning gaining increasing recognition and use. Numerous endeavors, exemplified by IBM Watson, are actively contributing to disseminating knowledge on technologies empowered by artificial intelligence. AI-enabled systems are also utilized in medical contexts, where supervised learning techniques are employed for categorization and diagnosis. Ethics and technological components play a significant role in developing AI-enabled systems (Aruleba et al., 2022). Moreover, the efficacy of AI-enabled services is heavily contingent upon the data with which they are provided (Rani & Suresh, 2021). For example, using artificial intelligence (AI) in in-store dialogues has enhanced the likelihood of attracting customers while reducing perceived intimidation (Saxena & Upadhyaya, 2023). Nevertheless, the consideration of safety has significant importance in the design of AI-enabled systems that are vital for safety. To guarantee these systems' security, many operational safety verification approaches have been developed (Lamrani, 2020). To deal with the problems of making soft AI-enabled systems, it is important to reevaluate common beliefs and thoroughly analyze the landscape of AI-enabled financial services (Ozkaya, 2020; Panday & Sergeeva, 2022). Furthermore, Elsayed and Erol-Kantarci (2019) have proposed a resource allocation strategy that enhances delay performance.

AI-Enabled Learning Solutions and Learning Outcomes

Artificial intelligence AI-enabled educational solutions represent a promising advancement in education, potentially significantly shaping the future of learning. According to the study conducted by Elsayed and Erol-Kantarci in 2019, the utilization of artificial intelligence (AI) in the context of wargames, as discussed by Schwartz et al. (2020), has the potential to enhance the design of military mission systems to optimize their results. According to Lin and Hazelbaker (2019) and Johnson (2022), using AI-enabled technologies, such as generating fabricated news, can potentially be employed for malicious intentions. Nevertheless, it has been suggested by Pandey and Sergeeva (2022) that they have the potential to improve the efficiency of financial services. Additionally, Rani and Suresh (2021) have highlighted their ability to boost the functionality of mobile phones. Furthermore, Saxena and Upadhyaya (2023) have indicated that they can also optimize operations inside physical

retail establishments. According to Hajishirzi and Costa (2021), using artificial intelligence (AI) can potentially enhance the overall consumer experience. Ali and Alhumaidi (2023) also assert that AI may improve medical diagnostics' precision, efficiency, and affordability, resulting in enhanced results. According to Aruleba et al. (2022), using AI-enabled gadgets and technology has promise for automating many daily tasks, including developing educational aids for children to enhance their learning achievements. Therefore, integrating artificial intelligence (AI) in educational tools can enhance learning outcomes by automating processes, optimizing performance, and improving the overall user experience.

Effectively Using AI-enabled Learning Solutions in Classroom

Ali et al. 2021 state that AI-enabled learning systems can provide pupils with a complete education. AI-enabled learning systems can teach students to recognize deep fakes. AI-enabled learning systems can help students identify and stop disinformation. Interactive games like "Created by AI or Not can help students understand AI-generated material. AI-enabled learning can teach students about generative models and deep fakes. Classrooms may develop synthetic media such as pictures, writing, music, colors, paintings, numbers, and movies. Classroom discussions could also cover AI-enabled learning systems' efficacy. Conversations can teach students about generative models and how realistic machine-generated media can be. Students may learn about AI technical applications like deepfakes using AI-enabled learning methods. AI-enabled learning solutions encourage media literacy in computer science curricula and technical literacy in K12 digital media sessions. AI-enabled learning solutions can also be employed in K–12 AI literacy curricula to tackle AI ethics. AI-enabled learning systems can address how changing technology affects knowledge distribution in media literacy programs. Digital literacy is complicated and requires sociology, politics, and technology. Social network bots, filter bubbles, and algorithmic bias may also be taught via AI. Whether or not it was AI-created, AI can aid student learning by provoking emotion and cognitive dissonance. AI-enabled learning solutions can challenge students' reality-based beliefs and inform them about generative AI's possible drawbacks. Teachers may employ AI-enabled learning solutions to educate students about complicated socio-technical systems and their ethical consequences. Students can also advise on AI-enabled technology regulations using AI-enabled learning methods. AI-enabled learning solutions may explain how distorted media affects social media information intake and diffusion. AI-enabled learning systems may also teach students about disinformation and its propagation. Students can comprehend difficult technological systems like GANs with accessible methods. Students can learn about technological systems' potential damage and critically analyze them.

AI-Powered Assessment Tools

AI-powered assessment technologies provide several benefits in the field of education. For example, using AI-powered educational dashboards has been shown to facilitate the development and evaluation of teaching augmentation strategies (Kulkarni, 2021). Furthermore, artificial intelligence (AI) based facial and vocal recognition technologies can potentially evaluate educational standards (Bhise et al., 2023). Yan (2023) has also suggested that chatbots powered by artificial intelligence can provide students with various educational services. The utilization of artificial intelligence (AI) in Massive Open Online Courses (MOOCs) has been significant in

facilitating the delivery of high-quality education to students (Chukwuedo et al., 2019). Moreover, implementing AI-driven autonomy in many fields has the potential to develop AI-driven scenarios that may assist nations in enhancing their educational systems (Brobbey et al., 2021). Furthermore, using AI-driven analytics enables nations to conduct comparative analyses and evaluate their benchmark advantages over other countries (Alkhalifah, 2023). AI-powered evaluation systems, such as AlphaCE Coaching & Education, which is based in Uppsala, have the potential to offer students personalized experiences with AI-driven autonomy (Eklund & Isaksson, 2019). Using AI-powered solutions can offer significant advantages to students, facilitating their access to high-quality education.

AI-powered Assessment Tools and Student Learning

According to Bhise et al. (2023), using AI-powered assessment tools enables the evaluation of student involvement and receptiveness. For instance, Bhise et al. (2023) demonstrated that facial and vocal recognition technologies could discern the level of concentration and comprehension exhibited by students about the topic being taught. Yan (2023) has also suggested that chatbots with artificial intelligence can assess students' language proficiency in real time. According to Chukwuedo et al. (2019), empirical studies have demonstrated that massive open online courses (MOOCs) enhanced by artificial intelligence (AI) have the potential to greatly facilitate the development of cooperation, communication, and critical thinking abilities. The use of AI-driven evaluation instruments has been demonstrated to be effective in assessing the implications of incorporating mobile learning (Brobbey et al., 2021). Additionally, these tools have been employed to forecast the identification of COVID-19 patients by analyzing chest X-ray pictures and coughing sounds (Shakira Fathima & Dilshad Begum, 2021). In addition, AI-driven technologies can investigate user-centric design and develop and evaluate solutions (Eklund & Isaksson, 2019). According to Akramov and Anvarjonova (2022), using AI-driven arbitrations and awards can enhance the efficiency and timeliness of dispute resolution by enabling decisions based on user preferences. In summary, using AI-powered assessment tools can significantly transform the landscape of student learning by providing customized, adaptive, and real-time feedback, enhancing the optimization of learning experiences.

Limitations of AI-powered Assessment Tools?

AI-driven evaluation technologies provide several benefits and constraints compared to conventional pen-and-paper tests. The utilization of artificial intelligence (AI) in facial and vocal recognition, as well as in massive open online courses (MOOCs), has played a significant role in offering suggestions that are tailored to students' academic achievements (Bhise et al., 2023). According to Kulkarni (2021), it is important to comprehend the technological challenges that might emerge throughout the evaluation procedure (Kulkarni, 2021). The study conducted by Chukwuedo et al. (2019) examines the impact of artificial intelligence (AI)-enabled Massive Open Online Courses (MOOCs) on the provision of high-quality education. Furthermore, it is worth noting that some businesses are now developing artificial intelligence (AI) systems or acquiring AI-powered software. However, it is important to acknowledge that these endeavors may expose these organizations to potential issues arising from data sensitivity or erroneous data (Silverman, 2020). In their study, Eklund and Isaksson (2019) thoroughly analyze and evaluate an autonomous system that uses artificial intelligence (AI). This system can effectively adjust

AI-based technical advancements to the art world's requirements and limitations. In their study, Suzuki et al. (2022) conducted a comparative analysis of AI-powered assessment tools and traditional paper and pen examinations, elucidating the respective merits and drawbacks of AI-powered assessment tools. Yan (2023) describes an artificial intelligence (AI)-enabled chatbot that can operate in real time while undergoing continuous assessment. Finally, Robbey et al. (2021) and Akramov & Anvarjonova (2022) have suggested that AI-driven arbitrators must evaluate both micro and macro-level social segments of consumers. In 2023, Valeria introduced Concurred, a content marketing tool driven by artificial intelligence (AI) technology. This product gives users comprehensive insights into AI-powered evaluation tools' functionalities, applications, and constraints.

AI-Based Tutoring Systems

Recently, AI-based tutoring systems have become popular and attempt to provide personalized teaching. These systems use artificial intelligence to analyze trends in students' responses and adapt to their learning styles, according to Hasse et al. (2019). Researchers have investigated combining AI-based systems with VR and other instructional technologies (Hasse et al., 2019). Interactive storytelling and command language systems research use AI-based instructional tools (Alofs, 2012). King et al. (2016) say AI teaching systems have helped spread the Internet and cell phones. These methods allow teachers to focus on struggling pupils, provide personalized instruction, and allow students to study at their own pace. However, AI-powered teaching has limits. Poor programming can cause errors. Students may also have different instructional levels than teachers. In conclusion, AI-based tutoring systems can help students. Before deploying AI-based tutoring systems, educators must fully comprehend their pros and cons.

AI-Based Tutoring Systems and Student Engagement

Tutoring systems driven by AI have improved student engagement. According to Hasse et al. (2019), increasing their engagement promotes learning and well-being. These systems can personalize learning and provide performance feedback, according to Hasse et al. (2019). Alofs (2012) has also studied integrating AI-based tutoring systems into traditional classrooms and online learning platforms. AI-based interactive storytelling systems can let students collaborate with AI-based education systems. King et al. (2016) suggest that AI-based tutoring systems reduce teachers' workloads and provide personalized instruction. AI-based tutoring systems may also identify student needs and provide personalized feedback, increasing student engagement. Thus, AI-based tutoring systems improve student engagement, learning, and well-being.

AI-Based Tutoring Systems and Student Learning

In traditional classrooms and online platforms, AI-based tutoring systems, or Intelligent Tutoring Systems (ITSs), are becoming more popular. These systems use machine learning algorithms to mimic student learning. They also let teachers customize the technology to their needs and methods. Information technology systems (ITSs) may also personalize education for individual learners by delivering information, assignments, and situations. AI-based teaching systems may be developed without AI programmers.

However, ensuring these systems are developed and implemented correctly is imperative to maximize their effectiveness. Additionally, continuous assessments are essential to identify instances where AI-based tutoring systems may produce harmful or erroneous outcomes. Furthermore, it is important to ensure that AI-based tutoring applications are developed with inclusivity, considering the various dimensions of diversity, such as gender, color, socioeconomic status, ability, and cultural background. The need for more transparency and comprehensibility regarding utilizing personal data in AI-driven tutoring systems poses issues in properly discerning emotional states and intrinsic motivation, giving rise to potential biases. AI-driven tutoring systems can discern the emotional state of students throughout their learning sessions, monitor their advancement, offer prompt guidance and feedback, and facilitate comprehension and application of the subject matter. It is critical to acknowledge that AI-based tutoring systems necessitate a comprehensive examination of learner requirements and may make erroneous assumptions regarding the student's learning process, as emotional states and intrinsic motivation play a crucial role in the efficacy of AI tutors. The extent to which AI can mitigate prejudice hinges upon the specific design of the AI instructor, given that previous instances have demonstrated biases within AI systems, resulting in adverse outcomes. Therefore, artificial intelligence (AI)-based tutoring systems significantly promise to mitigate prejudice and facilitate tailored learning experiences. However, it is important to regularly supervise the execution of these measures to verify their efficacy and prevent any potential misuse.

AI-Assisted Adaptive Learning

According to Xiao et al. (2021), AI-assisted adaptive learning combines AI with simulation to support one another. The objective is to develop an artificial intelligence (AI) model that may be utilized for power system model calibration, analysis, and control, as proposed by Xiao et al. (2021). Dynamic component modeling techniques using data-driven artificial intelligence models can achieve this goal. Artificial intelligence models can identify and articulate latent patterns inside the solution process, enhancing the effectiveness of the simulation. Moreover, the integration and simultaneous simulation of AI and physics-based models have been explored by Xiao et al. (2021). To develop an artificial intelligence model, it is necessary to possess a training dataset that comprises high-quality samples that accurately reflect the target population. The AI model is subsequently developed using a hypothesis set derived from the task and training data, as described by Xiao et al. (2021). The AI model is further trained using optimization techniques. Due to internal APIs, AI-assisted simulation is difficult to integrate into simulators. Xiao et al. (2021) recommends a learning simulation engine to make simulators AI-friendly. Simulation intelligence may revolutionize power system dynamic simulators. Simulation-assisted AI is essential for power system digital twins. The AI model created by AI-assisted adaptive learning may improve simulation precision and efficacy.

Benefits of AI-Assisted Adaptive Learning

AI-assisted adaptive learning is becoming increasingly prevalent. In many situations, AI-assisted adaptive learning can be beneficial. According to Nuhn (2021), tailored learning routes that match each learner's abilities, interests, and goals might be advantageous. Customized learning allows students to learn quickly and gain the

skills and knowledge they need to succeed. AI-assisted adaptive learning can also reduce school costs by eliminating the need for expensive physical resources and materials (Kalra et al., 2022). AI-assisted adaptive learning can also speed up skill development by providing personalized feedback and coaching. AI-assisted adaptive learning can improve learning by increasing engagement and involvement. AI's capacity to perceive and engage with learner emotions achieves this. These benefits make AI-assisted adaptive learning an appealing option for educational institutions and people looking to improve their learning experience.

Implementation of AI-Assisted Adaptive Learning in Classroom

AI-assisted adaptive learning in the classroom has proved effective (Nuhn, 2021). AI-assisted learning improves instructor and student learning, according to Xiao et al. (2021). The AI system uses vector and matrix classes to evaluate student aptitudes and preferences (Kalra et al., 2022). The system then adjusts the learning materials to the learner's speed. AI improves grading and exam accuracy and provides learner feedback. AI-assisted adaptive learning can also give students personalized learning paths, improving instructional planning and design (Nuhn, 2021). Teachers and students benefit from AI-assisted adaptive learning's improved grading, learning efficacy, and tailored learning trajectories. This strategy can provide a more effective and efficient classroom learning environment, according to Xiao et al. (2021). AI-assisted learning may also reduce Class 2 errors in schools (Kalra et al., 2022). This metric ensures the learner's development and maximum learning effectiveness.

References

Alkhalifah, B. (2023). *National Policy Frameworks of Using Artificial Intelligence in Health, Saudi Arabia* (Doctoral dissertation, Alfaisal University (Saudi Arabia)).

Ali, S., DiPaola, D., Lee, I., Sindato, V., Kim, G., Blumofe, R., & Breazeal, C. (2021). Children as creators, thinkers, and citizens in an AI-driven future. *Computers and Education: Artificial Intelligence*, *2*, 100040.

Ali, W. M. B., & Alhumaidi, M. S. (2023). Artificial Intelligence for Cancer Diagnosis & Radiology. *International Journal of Trends in OncoScience*, 13-18.

Akramov, A., & Anvarjonova, D. (2022). Artificial Intelligence and the Disappearing Human Arbiter. *Science and innovation*, *1*(C8), 53-59.

Alofs, T. (2012). *The interactive storyteller a multi-user tabletop board game interface to support social interaction in AI-based interactive storytelling* (Master's thesis, University of Twente).

Aruleba, K., Dada, O. A., Mienye, I. D., & Obaido, G. (2022, February). Demography of machine learning education within the K12. In *Innovations in Bio-Inspired Computing and Applications: Proceedings of the 12th International Conference on Innovations in Bio-Inspired Computing and Applications (IBICA 2021) Held During December 16–18, 2021* (pp. 467-474). Cham: Springer International Publishing.

Bhise, A., Munshi, A., Rodrigues, A., & Sawant, V. (2023). Overview of AI in Education. In *Artificial Intelligence in Higher Education* (pp. 31-62). CRC Press.

Brobbey, E. E., Ankrah, E., & Kankam, P. K. (2021). The role of artificial intelligence in integrated marketing communications. A case study of Jumia Online Ghana. *Inkanyiso: Journal of Humanities and Social Sciences*, *13*(1), 120-136.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *Ieee Access*, *8*, 75264-75278.

Chukwuedo, M., Katende, J. O., & Misra, S. (2019). MOOCs, Artificial Intelligence Systems, and the Dilemma of Tertiary Education in the 21st Century. *Handbook of Research on the Role of Human Factors in IT Project Management*, 14.

Eklund, J., & Isaksson, F. (2019). Identifying & Evaluating SystemComponents for Cognitive Trustin AI-Automated Service Encounters: Trusting a Study-& Vocational Chatbot.

Elsayed, M., & Erol-Kantarci, M. (2019). AI-enabled future wireless networks: Challenges, opportunities, and open issues. *IEEE Vehicular Technology Magazine*, *14*(3), 70-77.

Hajishirzi, R., & Costa, C. J. (2021, June). Artificial Intelligence as the core technology for the Digital Transformation process. In *2021 16th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-6). IEEE.

Hasse, A., Cortesi, S., Lombana-Bermudez, A., & Gasser, U. (2019). Youth and artificial intelligence: Where we stand. *Berkman Klein Center Research Publication*, (2019-3).

Johnson, J. (2022). Delegating strategic decision-making to machines: Dr. Strangelove Redux?. *Journal of Strategic Studies*, *45*(3), 439-477.

Kalra, J. J., Markewich, D., Rafid-Hamed, Z., & Seitzinger, P. (2022). Enhancing the Quality and Delivery of Healthcare: A Decade Review of Autopsy Data. *Healthcare and Medical Devices*, *51*, 91.

King, B., Lark, A., Lightman, A., & Rangaswami, J. P. (2016). *Augmented: Life in the smart lane*. Marshall Cavendish International Asia Pte Ltd.

Kulkarni, A. (2021). Towards Understanding the Impact of Real-Time AI-Powered Educational Dashboards (RAED) on Providing Guidance to Instructors. *arXiv preprint arXiv:2107.14414*.

Lamrani, I. (2020). *Operational Safety Verification of AI-Enabled Cyber-Physical Systems* (Doctoral dissertation, Arizona State University).

Lin, P., & Hazelbaker, T. (2019). Meeting the challenge of artificial intelligence: what CPAs need to know. *The CPA Journal*, *89*(6), 48-52.

Malik, P., Pathania, M., & Rathaur, V. K. (2019). Overview of artificial intelligence in medicine. *Journal of family medicine and primary care*, *8*(7), 2328.

Moursund, D. G. (2006, April 24). *Brief Introduction to Educational Implications of Artificial Intelligence*. https://scholarsbank.uoregon.edu/xmlui/handle/1794/3114

Nuhn, H. (2021). Organizing for temporality and supporting AI systems–a framework for applied AI and organization research. *Informatik 2021*.

Ozkaya, I. (2020). What is different in engineering AI-enabled systems?. *IEEE Software*, *37*(4), 3-6.

Pandey, M. K., & Sergeeva, I. (2022). World of Economics and Management. *World*, *22*(1), 147-164.

Rani, N. J., & Suresh, A. (2021). Consumer Discernment Towards Artificial Intelligence in Mobile Applications. *Prestige International Journal of Management and Research*, *14*(1/2), 12-16.

Saxena, A., & Upadhyaya, A. (2023, February). Consumer preference towards buying AI-enabled devices: A systematic Review. In *Proceedings of the 1st International Conference on Application of AI and Statistical Decision Making for the Business World, ICASDMBW 2022, 16-17 December 2022, Delhi, India*.

Schwartz, P. J., O'Neill, D. V., Bentz, M. E., Brown, A., Doyle, B. S., Liepa, O. C., ... & Hull, R. D. (2020, April). AI-enabled wargaming in the military decision making process. In *Artificial intelligence and machine*

learning for multi-domain operations applications II (Vol. 11413, pp. 118-134). SPIE.

Shakira Fathima, H., & Dilshad Begum, M. (2021). The role of AI in battling against COVID-19 crisis n India. *Advances in Parallel Computing*, 127-132.

Silverman, K. (2020). Why your board needs a plan for AI oversight. *MIT Sloan Management Review*, *62*(1), 1-6.

Suzuki, H., Kurosawa, S., Marcella, S., Kanba, M., Koretaka, Y., Tsuji, A., & Okumura, T. (2022). How AI application in pharmaceutical industries is beneficial to materials science. *Journal of Physics D: Applied Physics*, *55*(24), 243002.

Uunona, G. N., & Goosen, L. (2023). Leveraging Ethical Standards in Artificial Intelligence Technologies: A Guideline for Responsible Teaching and Learning Applications. In *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines* (pp. 310-330). IGI Global.

Valeria, G. F. (2023, February 24). *How do new ventures use AI to enhace creative marketing?* https://repository.urosario.edu.co/items/b6382253-be9c-4f8e-84ed-467df844b437

Wahyono, I. D., Putranto, H., Saryono, D., & Asfani, K. (2020, July). Development of a Personalized Virtual Laboratory Using Artificial Intelligent. In *International Conference on Learning Innovation 2019 (ICLI 2019)* (pp. 101-107). Atlantis Press.

Xiao, T., Chen, Y., Wang, J., Huang, S., Weilin, T., & He, T. (2021). Exploration of Artificial Intelligence-oriented Power System Dynamic Simulators. *Journal of Modern Power Systems and Clean Energy*. https://doi.org/10.35833/mpce.2022.000099

Yan, D. (2023, March 20). *How ChatGPT's automatic text generation impact on learners in a L2 writing practicum: an exploratory investigation*. https://hal.science/hal-04037687/

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators?. *International Journal of Educational Technology in Higher Education*, *16*(1), 1-27.

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Citation

Taş, N. (2023). Revolutionizing Education: Applications of Artificial Intelligence. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 21-30). ISTES Organization.

Chapter 3 - Envisioning the Future of Education with AI

Sunanda Vincent Jaiwant, Kiran Vazirani, Rameesha Kalra

Chapter Highlights

- This chapter highlights how AI and machine learning are having a powerful impact on the education sector. This impact is not only providing direct support to students but also making educators more attuned to student needs and less preoccupied with routine and repetitive tasks.
- Moreover, it emphasizes the necessity of AI for innovative approaches in education and points to a bright future in education. AI offers many benefits, such as enhancing learning, assisting teachers and promoting more effective individualized learning.
- This chapter also looks at how AI applications can be used in education. These applications include providing students with customized learning experiences, assisting teachers, and automated assessment and grading systems.
- In addition, this chapter addresses the ethical issues of using AI in education. In particular, it focuses on the ethical dimensions of teachers' and students' data privacy, security and learning processes.
- Finally, this chapter offers a future perspective on how AI can transform the education sector. It emphasizes the rapid increase in the use of artificial intelligence, especially at the global level, and its growing role in education.

Abstract

Artificial Intelligence (AI) and Machine Learning (ML) have significantly influenced the field of education, as it has not only provided direct assistance to students but has also enabled educators to better cater to individual learner requirements and reduce their involvement in monotonous and repetitive duties. There is a consensus that implementing novel methodologies in education is imperative, and it is widely acknowledged that artificial intelligence (AI) will serve as a significant enabling factor in fostering such innovation. Artificial intelligence (AI) holds much promise as a potential catalyst for transforming the future education landscape. Artificial intelligence (AI) plays a pivotal role in catalyzing transformative shifts within the field of education due to its numerous advantageous attributes. Artificial intelligence's use in education has significant promise in terms of augmenting learning outcomes, supporting educators, and facilitating personalized learning experiences. Ensuring equitable access for all students, regardless of their learning abilities or disabilities, is paramount. This is particularly significant due to the inherent variations in learning pace and skill sets across children. The utilization of artificial intelligence has the potential to enhance pupils' prospects for a successful future significantly. Integrating artificial intelligence (AI) into education has significant promise for revolutionizing the educational experience for all students. Numerous educational institutions worldwide have already implemented artificial intelligence (AI) technologies. This chapter provides a thorough examination of the application of artificial intelligence in the field of education. The authors discuss how artificial intelligence enhances educators' capabilities by providing them with improved teaching and learning methodologies. Artificial intelligence (AI) is revolutionizing educational methodologies and generating significant worldwide effects through the emergence of innovative educational models such as Massive Open Online Courses (MOOCs), blended learning, flipped classrooms, and other similar approaches.

Introduction and Theoretical Framework

The technology revolution is fuelling transformations in the education sector. AI is the new buzzword that is being adapted acceleratingly by education institutions and their stakeholders and is seen as a potential transforming agent in the teaching-learning process. The advent of the internet and mobile phones have propelled the education industry to a higher level of education ecosystem. The stakeholders of the education sector namely, students, parents, guardians, psychologists, instructors, and educational institutions have been impacted in their roles and functions by the arrival and adoption of technological advancement in the education sector.

Future online learning will integrate AI systems more thoroughly. It's vital to emphasize that the current study makes no claims that artificial intelligence systems would completely replace the need for human educators. Instead, AI systems and humans will collaborate closely in the future of online learning, thus it is crucial to employ these systems with awareness of their apparent benefits and limitations (Seo, et al., 2021).

All Students can have a customised education, because of Artificial Intelligence. Artificial intelligence (AI) has the potential to improve human teachers' skills to customize lessons to each student without throwing their class schedule off track. This would prevent teachers from having to provide stereotype instructions to the learners as

is commonly the case when students have a range of skill levels and learning abilities. Artificial intelligence's actual educational potential is found in the capacity the educators utilize it to interpret massive volumes of information about learners, educators, and their communications. AI ultimately has the potential to improve how well teachers understand their kids. In the coming years, artificial intelligence will play a significant role in the education industry though not upsetting the role of the teachers entirely. Education specialists strongly opined that artificial intelligence will enhance the teaching-learning experience not only for the learners but also for the instructors bringing a sea change in the teaching-learning process and will be adopted as one of the best practices to adopt and exercise (Ouyang, F. & Jiao, P., 2021).

AI is predicted to transform the way instructors perform their roles and duties and also revolutionize the way learners study and acquire knowledge. This prominent development will impact schools, colleges, and universities across the globe. The market research engine projects that by 2025, global spending on AI in education will reach $5.80 billion, with a yearly increase of 45 percent. (Harper, 2021).

Problem statement

Since most AI research is only conducted in STEM fields, collaborative efforts are required to address the growing uses of AI in education (AIEd) (Zawacki-Richter, et al., 2019). AI has been applied in education, more particularly in administration and teaching, and subsequently, influencing or impacting students' learning.

Research Questions

The following research questions have been addressed to elaborate upon AI and related technologies in education in this study:

1. What is the potential uses of AI technology and its academic advantages?
2. How is AI for educational purposes conceived and deliberated, and what ethical issues, difficulties, and risks are taken into account?
3. What kind and how broad are the uses of AI in various areas of learning?
4. What are the implications for future research and practice of AI in Education?

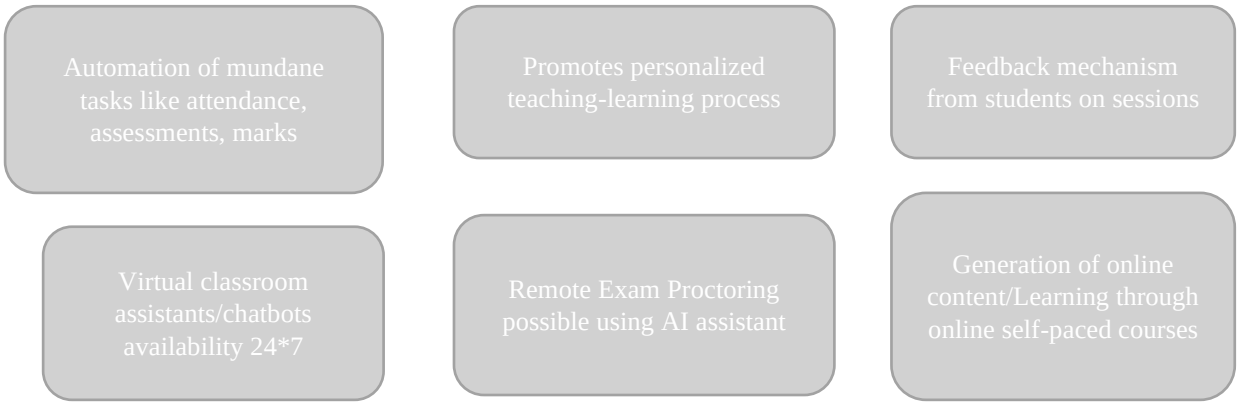
Brief Description of Claim and Position Statement

Educational technology is evolving to include artificial intelligence. Artificial intelligence will bring "human-like" features and agency into future technologies. Educational policy plays an important role in guiding the use of artificial intelligence in education to realize benefits while limiting risks.

Nature and Scope of AI Applications in Education

The overall development of a country depends upon its youth and undoubtedly quality education plays a significant role in driving a nation towards a better future. Not only does quality education serve as an important pillar of a nation's growth but also serves as a means to promote sustainability which is nothing but the ability to maintain processes over the long run. Sustainable development is an integrated approach that takes into consideration environmental and economic concerns in a balanced manner. To promote sustainable development, the United Nations has proposed 17 SDGs of which SDG4 aims to provide quality education and promotion of lifelong learning opportunities for everyone.

Technology has permeated many facets of our lives. As the education sector also embraces digital transformation, new tools and techniques are helping educators to customize learning plans for students based on their strengths and weaknesses. Since the needs of the students can be properly understood, individualized/personalized learning becomes possible for the learners. The education system in India suffers from the limitation of being theoretical without much emphasis on practical skills and experience. With the advent of AI in education, it is the right time for teachers to incorporate AI to automate their assessments and grading so that they can be provided with more time to concentrate on newer and innovative methods of teaching and also on student needs. Also, automation of mundane tasks like submission of attendance, automated grading, 24*7 access to resources, and so on. The inclusion of technology in education allows for new dynamics of interaction/implementation of learning methodologies in the classroom. (Leer, & Ivanov, 2013). AI can support the teaching-learning process in the following areas:



Source: Collated by authors

AI has huge potential in the education sector as it helps to automate routine/mundane tasks that can free the teachers to focus more on the generation of online content and prepare well for their sessions. One of the major challenges faced by educators is to ensure that the learning needs of all the learners are taken care of since the learners belong to the slow, medium, and advanced learner categories. This can be made possible through the use of AI in the form of differentiated/personalized learning which is impossible if educators have to manage the learning needs of various categories of students in a class. As per Hutchins (2017), personalized learning is "an approach that tailors educational content to the unique needs of the individual students."

Some of the applications and scope of AI in education have been explained below:

a. Personalized learning experience for learners
b. Development of digital content for different learning styles
c. Access to educational resources 24*7
d. Elimination of manual repetitive tasks that require more of the teacher's attention
e. Automated system of assessment and grading
f. Accessibility and immediate feedback about the sessions

The scope of AI in the education sector has indeed come a long way but technology won't be able to replace teachers anytime soon. Since teaching-learning is primarily based on human interaction, it will become impossible to incorporate technology into all facets of education. Implementation of AI is also giving a plethora of opportunities for the development of online courses. It is high time for universities and higher education institutions to plan their pedagogical models with AI solutions that will provide learners with lifelong learning.

International Bodies and AI in Education

Artificial Intelligence (AI) possesses great potential to accelerate a dramatic transformation and transition in the education sector. Some of the largest problems in education currently can be and are being skillfully addressed with AI. It is utilized to accelerate progress towards SDG 4 and innovative teaching and learning techniques. While ensuring that its use in educational contexts is guided by the fundamental principles of equitable and inclusive education (AI in Education), UNESCO is dedicated to assisting Member States in maximizing the potential of artificial intelligence (AI) technologies for attaining the Education 2030 Agenda (AI in Education). The mission of UNESCO encourages a people-first strategy for artificial intelligence. It proposes to broaden the contribution of AI to alleviating present educational inequality. Promoting AI will enhance accessibility to information, research, and a variety of social manifestations without widening the technological gaps within and between nations. UNESCO calls for an "AI for all" approach so that the benefits of innovation and knowledge through AI can be reaped by all stakeholders across the nations.

The publication created by UNESCO as part of the Beijing Consensus is also intended to help legislators in the field of education become better prepared for artificial intelligence. Practitioners and experts in the policy-making and educational sectors will find this publication, Artificial Intelligence and Education: Guidance for Policy-makers, of interest. It intends to foster an overall awareness of the possibilities for learning and difficulties presented by AI as well as the consequences for the fundamental skills required in the AI age.

UNESCO has initiated several projects that upholds the adoption of AI technology in academics aiming to augment learners' capabilities and to guard human from exploitation. AI can be effectively used for operative human-machine alliance teaching-learning processes leading to an overall sustainable development for all the

stakeholders. UNESCO hopes to collaborate with its patrons, partners, and international agencies to reinforce its leadership in AI in education and its status as an international think tank for innovative concepts., setting standards, framing policies, and building capacities.

Nations are encouraged to leverage emergent technologies like AI to strengthen the education sector to partner with UNESCO and benefit from technical, financial, and other contributions from UNESCO.

The development of laws, rules, and regulations about the application of artificial intelligence (AI) in education is heavily influenced by international organizations. These groups seek to make sure that AI is used efficiently and morally to improve educational outcomes. As we approach an era where artificial intelligence, an intersection of new technologies, is revolutionizing every part of the way we live, we need to reaffirm this commitment. We must drive this transformation with the proper objectives to raise living standards, lessen disparities, and advance a just equitable globalization.

UNESCO actively promotes the use of AI in education while placing a strong emphasis on equity, inclusivity, and ethical considerations. They seek to promote global cooperation, address potential issues, and create guidelines for AI in education. The Organization for Economic Co-operation and Development (OECD) carries out research and analysis on how developing technologies, such as AI, may affect education. They have released papers and suggestions on the use of AI in education, concentrating on topics including teacher preparation, data privacy, and digital literacy. The European Commission is heavily involved in the development of projects and policies relating to AI, notably those that concern education. Their "European Digital Education Plan" prioritizes integrating artificial intelligence and digital technologies into educational systems worldwide. ISTE (International Society for Technology in Education) is a multinational organization that promotes the use of technology in education, especially AI. To ensure the responsible and efficient use of AI in learning environments, they provide standards and guidelines for educators, decision-makers, and educational technology businesses. The International Telecommunication Union (ITU), an organization under the United Nations, strives to standardize AI technology, particularly those that are used in education. They encourage the creation of instructional tools powered by AI that follow international standards. Specifically in developing nations, the World Bank has been involved in projects that investigate the application of AI in education. They support the implementation of AI technologies for enhancing educational outcomes via financing and technological know-how. The Global Partnership for Education (GPE), which promotes education in developing nations, has acknowledged the potential of AI to address issues in education. They collaborate with partners to incorporate AI-driven programs into learning initiatives. The International AI in Education Society (IAIES) is an international group that is solely dedicated to using AI in education. They coordinate conferences, carry out research, and advance best practices in the application of AI to education. To address educational issues in the Global South, OpenAI, UNESCO, and the Commonwealth of Learning (COL) collaborated to create the AI in Education for Sustainable Development initiative. These global organizations work together with governments, academic institutions, and the corporate sector to create frameworks, rules, and guidelines that support the ethical and equitable use of AI in education. As a result of their work, educational possibilities are improved by AI technology while potential hazards and ethical issues are addressed.

AI in Education Conceptualized

Technology has at all times been a vital catalyst in the education sector, however, its present usage is excessively predominant unlike before owing to the amplified accessibility of smart devices and web-oriented educational programs, courses, and curricula. Owing to the upsurge of Artificial Intelligence in education processes and practices, there exist numerous platforms and methodologies that AI is being employed to benefit educators and learners. Artificial Intelligence possesses huge potential to revolutionize the entire education ecosystem and bring innovative changes for learners, educators, and educational institutions. It is viewed as a game-changer across the globe that has made education accessible, inclusive, and innovative, benefiting all the stakeholders of the education industry (Mohan, 2021).

Chatbots

Chatbots are the newly found AI educational apps now getting into the mainstream education activities and practices those learners have begun using increasingly. Schools are progressively implementing into their schoolrooms where students are taught to use computer systems, laptops, and other devices to communicate with chatbots that are developed to solve their queries and doubts regarding particular subjects or areas. Chatbots act like personal tutors for learners who not only clear their specific doubts but also teach certain topics and concepts in a personalized method. Chatbots are interactive ways of teaching for the students and are a big aid to the teachers.

Virtual Reality (VR)

Virtual Reality is a widely used technology in education. It makes teaching-learning very innovative and interesting. Virtual Reality is a digitally-powered setting that facilitates a deeper exploration and active interaction for the learners. Educators are using virtual reality in their classrooms integrating experiential learning making their learning process lively and interesting. VR brings the concepts, facts, information, events, etc. nearer to life and makes them real to the students making them feel connected to the concepts and each other. Students located in different classrooms and cities and even countries can get connected and interact conveniently discussing different topics and research areas. Educators can increase student engagement using VR making the teaching more engaging and interactive.

Learning Management System (LMS)

Learning Management System is not a very new technology for the educational sector. A learning management system offers a centralized, spontaneous teaching structure that manages most of the educational assignments and tasks of any educational institution. LMS technology and tools are utilized for several activities like coursework assignments, communicating with the learners, communicating with the parents, tracking the status and progress of the students, assessing the student's performance, generating reports, etc.

These systems make it possible to house all elements of a course in a single location, including instruction, assignments, tests, and grading. This implies that instructors are always free to offer input on any project or test. Without having to wait until the conclusion of the semester, students may view their marks right away. AI-based LMS empowers teachers to create interactive content and teaching materials for the students. Parents can monitor their children's performance and progress with the help of AI-powered LMS.

Robotics

Robotics powered by Artificial Intelligence are now increasingly used in education and have been seen as a great tool to engage students and give them more practical-oriented learning. Many schools and colleges have begun using robotics technology in their teaching-learning process. The educators and learners can dig deeper exploring new topics and concepts. Robotics allows the learners to give time to themselves and learn on their own. Robots facilitate self-learning that broadens the learning capacity of the learners. Robots offer an innovative learning platform that creates and develops problem-solving skills in learners. Allowing them to perceive the outcomes of their experiments and works. Educators also benefit from using robotics technology while teaching science, geography, and maths making their classes more creative and practical.

Ethical Implications

AI has branched out in every walk of human life. This, however, gives rise to misuse of AI and badly curated AI tools that cause irretrievable damage to human lives and property including the entire civilization. Artificial Intelligence ethics includes a combination of methods, standards, philosophies, practices, and techniques employing commonly recognized standards of ethical conduct in developing and deploying Artificial Intelligence technologies. AI ethics focuses on issues and impasses related to AI technologies and tools to ensure that such technologies and activities should not present a menace to human lives, society, or the environment in the coming years. AI Ethics navigates technologies that essentially assure a safe, secure, and eco-friendly self-governing system in interaction with human beings (Fourtané, 2020).

Business tycoons, AI scientists, and data science engineers have confessed the power of AI in human decision-making and business activities. This new age power of AI should be kept under control to end any kind of perilous possibilities of AI-fuelled destruction in the future (Johnson, 2019). Even global bodies like UNICEF and OECD have recognized the need for better transparency and accountability in AI-technology practices and activities to facilitate more meaningful and safe information dissemination and decision-making (Schaper, et al., 2020).

Research studies have revealed human-centered reflections raising the consideration of instructing people to be more socially responsible and ethical users (Teredesai, et al. 2020). Gong et al. established that learners give lesser heed to moral issues such as prejudice in AI and legal accountability, and intellectual property (Gong, et al., 2020). Studies revealed that AI ethics have a greater number of human-based issues like inclusivity, equality, responsibility, transparency, and integrity which outnumber concerns such as increasing learners' AI aptitudes, skills, and interests (Hagendorff, 2022). For example, Lin et al. (2021), developed a middle-school program that

focussed on AI literacy integrating AI-concepts, ethics, awareness and careers. The research work proposed a groundwork for forthcoming AI-based businesses that would be built on inclusiveness principles, offer equal opportunities, take into account numerous parties and possible consumers, and reduce the possibility of discrimination. It is now a fact that to build an inclusive environment it is needed to encapsulate and conceptualize AI literacy with human-centered deliberations.

Challenges and Risks in AI Application

Expeditious technological development inexorably brings numerous threats and difficulties that have surpassed policy discussions by a significant margin and governing structures. Erik mentioned in his article that AI will have a significant impact on how radiology and healthcare are practiced. Radiologists' performance can be enhanced by AI, and the combined performance of radiologists and AI will be superior to either one alone. In remote regions and underdeveloped nations, AI will be able to offer very efficient and affordable diagnostic services, hence boosting the availability of healthcare for countless individuals (Ranschaert, et al., 2019). Peter discussed the areas where AI can enhance the military application. Areas such as Surveillance, Underwater mine warfare, and Cyber Security can be supported and improvised by technology (Svenmarck, et al., 2018). Mentioned in his working papers are the AI potentials that are especially beneficial in achieving several of the world's SDG 4 international academic goals, including making sure all students receive accessible, equal education, and encouraging prospects for continuous education for everyone. The paper also discussed AI implications for instructions and AI applications for Schools and Management separately (Vincent-Lancrin, & Van der Vlies, 2020). The summary includes:

AI applications	
AI applications for teaching	• Personalizing learning with AI • Supporting students with special needs with AI • Online and blended learning – AI-enabled Chatbox • Different types of sensors and cameras to enhance student engagement and classroom dynamics • Using multi-lingual instructions
AI applications for system and school management	• unbiased assessments – qualitative and quantitative • early warning systems to reduce dropouts • A large number of audience/students can be monitored • Game-based or simulation methods of assessment to access complex skills

Source: Vincent-Lancrin, & Van der Vlies, 2020

Challenges

The use of artificial intelligence (AI) in education opens up several opportunities to enhance learning, but it also presents several obstacles that must be resolved. It is crucial for stakeholders, including educators, policymakers,

technology developers, and academics, to collaborate to design and execute ethical AI in education methods that put equality, ethics, and student well-being first to overcome these obstacles. This entails open data practices, continual professional development for teachers, and the creation of laws that support fair and equal access to AI-powered educational tools.

Trust: The unknowable nature of how deep learning models forecast the output is one of the most significant problems that worry AI. Some applications of AI might be infrastructure-based and covert, raising questions regarding transparency and reliability. AI frequently enters new applications with a mystic air, but educators and procurement rules demand that EDTech demonstrate effectiveness. AI may offer information that seems real but is false or has no basis in reality. The risk of scaling pattern detectors and automation that result in "algorithmic discrimination" (e.g., systematic unfairness in the learning opportunities or resources recommended to some populations of students) is among the most significant new risks that AI introduces in addition to the well-known data privacy and data security risks.

Privacy and Security: Technology always has to face this as a concern, where the data so stored by technology always has a threat of being hacked or misused. This has been one of the major challenges for technologists to ensure the updation of data security systems to safeguard the personalized micro and macro-level data for the right usage.

Determining the right and complex methods: Artificial intelligence is the technological system that helps human beings overcome routinized processes. But to execute these tasks with the help of machines, it is required to program the machine with all sorts of possible outcomes. It is required to understand every possible expectation and the right roadmap for the assessment.

Data storage: The advantage of AI is the data management in one system which can be used for reference at any point of time in the future. However, the major challenge that an AI-enabled system faces is the data storage system, which should have the capability of understanding and storing the programs as well as the interaction data.

Modelling issues: The programming of the right model, should have all the possible outcomes, which has all possible ways of assessing qualitative and quantitative skills. The right programming that can support the teaching and learning process should be the perfect model with all possible ways to provide solutions to the learners.
Chances of incorrect output: AI is a human-programmed system that will execute the task as instructed by human beings but at the same time it only gives the output as programmed. The programmer has to look forward to all possible outcomes, and all possible ways to assess the learner.

Robots stealing jobs: AI which runs with only machines will take away human jobs. Because the objective of AI-enabled applications is just to support humans with a few routined processes. And that’s how AI will act as a substitute for the jobs executed by human beings.

Conclusion

Global trends in different industries are focusing more on personalization in all their activities owing to the arrival of Artificial Intelligence. AI has revolutionized the entire education sector globally. AI is one of the biggest technological tools that is a big boon to teachers and facilitators who can have all the information related to their subjects and courses at the tip of their fingers. AI empowers educators to create innovative and interactive educational content that ensembles their learners in the best possible way and ensures effective personalized learning. AI also helps in automating routine and repetitive tasks, giving more fruitful and productive time for the instructors for an impactful teaching environment. However, the increased use of AI in the education sector leads to more possibilities of danger that ought to be addressed with strong AI systems. It is paramount that probable perils need to be identified that are triggered by faulty and poorly designed AI systems. Business organizations, policymakers, and government agencies should anticipate and plan effective actions to respond to and implement at the earliest. Individuals, corporate houses, and government can undertake efforts to avert future probable problems by creating an environment of responsible behavior towards innovation and integration of technologies to design and execute ethical, fair, and safe AI tools and systems. All stakeholders embroiled in designing, producing, and deploying projects should emphasize AI ethics and safety as a supreme priority.

References

Artificial Intelligence In Education. (n.d.). https://www.unesco.org/en/education/digital/artificial-intelligence.

Artificial Intelligence Research, Development and Regulation Adopted by the IEEE-USA Board of Directors, 10 Feb. 2017

Fourtané, S. (2020, August 27). Ethics of AI: Benefits and Risks of Artificial Intelligence Systems. Retrieved from https://interestingengineering.com/innovation/ethics-of-ai-benefits-and-risks-of-artificial-intelligence-systems

Gong, X., Tang, Y., Liu, X., Jing, S., Cui, W., Liang, J., & Wang, F. Y. (2020, October). K-9 artificial intelligence education in Qingdao: Issues, challenges and suggestions. In 2020 IEEE international Conference on networking, Sensing and control (ICNSC) (pp. 1-6). IEEE.

Hagendorff, T. (2022). Blind Spots in AI Ethics. *AI and Ethics*, 851–867. doi:https://doi.org/10.1007/s43681-021-00122-8

Harper, T. (2021, August 25). *Top 7 Ways Artificial Intelligence Is Used in Education*. Retrieved from https://trainingmag.com: https://trainingmag.com/top-7-ways-artificial-intelligence-is-used-in-education/

Hutchins D. AI Boosts Personalized Learning in Higher Education // EdTech. 2017

Johnson, K. (2019, November). AI Ethics Is All About Power. Retrieved from https://venturebeat.com/ai/ai-ethics-is-all-about-power/

Leer, R., & Ivanov S. (2013). Rethinking the future of learning - The possibilities and limitations of technology in education in the 21st century. Int. J. Organ. Innov, Vol. 5, 14–20.

Lin, P. Y., Chai, C. S., Jong, M. S. Y., Dai, Y., Guo, Y., & Qin, J. (2021). Modeling the structural relationship among primary students' motivation to learn artificial intelligence. Computers and Education: Artificial Intelligence, 2, 100006.

Mohan, P. (2021, Decemberr 10). Artificial Intelligence in education. Times of India. Retrieved from https://timesofindia.indiatimes.com/readersblog/newtech/artificial-intelligence-in-education-39512/

Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence, 2*. doi:https://doi.org/10.1016/j.caeai.2021.100020

Ranschaert, E. R., Duerinckx, A. J., Algra, P., Kotter, E., Kortman, H., & Morozov, S. (2019). Advantages, challenges, and risks of artificial intelligence for radiologists. Artificial intelligence in medical imaging: opportunities, applications and risks, 329-346.

Schaper, M., M., Malinverni, L., & Valero C. (2020). Robot Presidents: Who should rule the world? Teaching Critical Thinking In AI Through Reflections Upon Food Traditions. *11th Nordic Conference On Human-Computer Interaction: Shaping Experiences* (pp. 1-4). Shaping Society . doi:https://doi.org/10.1145/3419249.3420085

Seo, K., Tang, J., Roll, I. et al. (2021). The impact of artificial intelligence on learner–instructor interaction in online learning. *International Journal of Educational Technology in Higher Education , 18*(54). doi:https://doi.org/10.1186/s41239-021-00292-9

Svenmarck, P., Luotsinen, L., Nilsson, M., & Schubert, J. (2018, May). Possibilities and challenges for artificial intelligence in military applications. In Proceedings of the NATO Big Data and Artificial Intelligence for Military Decision Making Specialists' Meeting (pp. 1-16).

Teredesai, A., Ahmad, M., A., Eckert, C. (2020). Fairness, Accountability, Transparency in AI at Scale: Lessons from National Programs. *Proceedings of the 2020 ACM Conference on Fairness, Accountability, and Transparency*. doi:10.1145/3351095.3375690

Vincent-Lancrin, S., & Van der Vlies, R. (2020). Trustworthy artificial intelligence (AI) in education: Promises and challenges. OECD Education Working Papers No. 218.

Zawacki-Richter, O., Marín, V., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education -where are the educators? *International Journal of Educational Technology in Higher Education*, *16*, 1-27. https://doi.org/10.1186/s41239-019-0171-0

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Citation

Jaiwant, S. V., Vazirani, K., & Kalra, R. (2021). Envisioning the future of education with AI. In A. Kaban & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 31-43). ISTES Organization.

Chapter 4 - Artificial Intelligence in Instructional Pedagogy: Potential Benefits and Future Implications

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Chapter Highlights

- This study shows that AI is playing a big role in education. AI technologies such as virtual reality, 3D technology, and interactive simulations are being used to help students learn. Also, the use of robots as teacher assistants highlights the role of AI in education.
- AI offers a range of potential benefits for students and teachers, such as a personalized learning environment, tutoring, rapid response, personalized syllabi, customization of the academic curriculum, student assessment and ranking, admission and registration processes, adaptive group formation, and an intelligent teaching system.
- This study states that AI will significantly impact the future of education. AI will support teaching and learning processes and cause major changes in teaching.
- AI can help teachers assess student performance and create personalized learning plans for students. It can also identify students' learning deficiencies early and work on them.
- This study also notes that AI has broader applications in education. This includes the capacity to provide students with resources that can help students with different needs, such as multilingualism, hearing or visual impairments.

Abstract

The objectives of this qualitative study were (i) to overview the integration of AI in instructional pedagogy, (ii) to point out some potential benefits of AI in education, and (iii) to highlight future implications of AI in education. The analysis of previous research studies on artificial intelligence in education was used as the methodology for this study. Three research questions formulated for this study were: (i) What is the role of AI in instructional pedagogy? (ii) What are the potential benefits of AI in education? and (iii) What are the future implications of AI in education? The findings related to the research question (i): What is the role of AI in instructional pedagogy? Artificial intelligence technologies like robots, virtual reality, intelligent tutoring systems equipped with conversational and dialogue capabilities, animated conversational agents in Chabots or Cobots, deep tutors, and auto tutors are used in instructional pedagogy. The findings related to research question (ii): What are the potential benefits of AI in education? AI benefits teachers and students through the personalized learning environment, tutoring, quick response, personalized course programs, customization of the academic curriculum, AI-based resources, student assessment and grading, admissions and enrollment processes, adaptive group formation, and an intelligent tutoring system. The findings related to the research question (iii): What are the future implications of AI in education? Indicated that AI will significantly impact the future of education. It will support the process of teaching and learning.

Introduction

Background of the study

The term "artificial intelligence" (AI) was initially used by John McCarthy in 1955 to refer to a computer system that possesses the ability to execute a range of cognitive activities like those performed by humans, including communication, decision-making, learning, and problem-solving (Nilsson & Nilsson, 1998). As per Baker and Smith (2019), AI is a broad term encompassing many technologies and algorithms. In education, the earlier phases of AI often revolved around intelligent tutoring systems aimed at autonomously addressing challenges such as enhancing operator proficiency. Various definitions of Artificial Intelligence in instructional pedagogy, as stated by different researchers, are given in Table 1.

Table 1: AI in Instructional Pedagogy as Stated by Different Researchers

No	Author	Definition
1	Ross (1987)	A human-like and acceptable answer to the issues that the intelligent tutoring system sets for the user can be achieved with AI techniques. The intelligent tutoring system can then reason and comment on the solution process.
2	Hwang (2003)	AI in the realm of education can be characterized as an intelligent tutoring system designed to facilitate the management of system knowledge and operational data to enhance operator proficiency. Additionally, it involves the automated assessment of exercise progression and remedial actions during a training session by leveraging past student performance as a basis.

3	Johnson et al. (2009)	The authors defined AI as tutors that generate real-time responses using their understanding of the subject and evaluation of student analyses.

The rise of computer and information communication technologies has fueled artificial intelligence (Taş & Gülcü, 2019). AI is the ability of computers to adapt to new surroundings, address emerging circumstances, resolve issues, provide solutions, design plans, and do other jobs that require human-like intellect (Coppin, 2004). This description emphasizes that computers, computer-related technologies, machinery, and information and communication technologies have enabled computers to perform tasks that resemble human abilities, resulting in artificial intelligence. New educational technologies have made artificial intelligence widely used in education (Chen et al., 2020). Education is adopting AI technologies and algorithms every year. Figure 1 shows the rise in Web of Science and Google Scholar "AI" and "Education" research publications in 2010. Approximately 70% of the publications were published between 2015 and 2019.

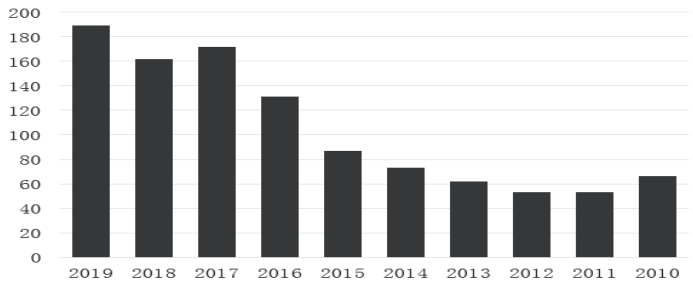

Figure 1. Papers Published in Different Data Sources on the Application of Artificial Intelligence in Education
Source (Chen et al., 2020)

The field of education is poised for substantial transformation through the impact of artificial intelligence (AI). AI has remarkable potential and can exert profound influence across various societal domains. AI has found application in diverse forms within educational institutions, encompassing instructional approaches enriched by tools designed to enhance student learning. These tools incorporate virtual reality, web-based platforms, robotic systems, video conferencing, audiovisual resources, and 3-D technology. As a result of these innovations, students receive a more individualized and profound educational experience from teachers who work more effectively and efficiently (Guan et al., 2020).

Statement of the Problem

Due to the improvement of technological tools, the teaching and learning settings have changed. Many mobile and internet devices are available, making the learning environment interesting, useful, and creative (Hafeez et al., 2022). The traditional methods of acquiring education cannot fulfill the requirements of society to compete

with the new challenges in the twenty-first century. So, it is time to integrate the advanced technological tools in education to make the education system more advanced and purposeful to compete with the current age requirements.

Objectives of the Study

The objectives of this study were: To overview the integration of AI in instructional pedagogy.

i. To point out some potential benefits of AI in education
ii. To highlight future implications of AI in education.

Review of the Literature

Concept of Artificial Intelligence

Computers or robots with "artificial intelligence" can perform intelligent tasks. This phrase generally refers to building AI systems with human-like thinking, semantic comprehension, generalization, and experience learning. Since the 1940s, digital computers have successfully proven mathematical theorems and played chess. Despite greater computer processing speed and capacity, programs can only match human flexibility in jobs requiring considerable baseline knowledge. AI machines have outperformed human experts in various domains. This limits AI applications in speech and handwriting recognition, search engines, and medical diagnostics (Roll & Wylie, 2016).

As Sadiku et al. (2021) define artificial intelligence (AI), a computer system may execute human cognitive skills like reasoning and learning, normally reserved for humans. AI technology gives education a new degree of adaptability and versatility, changing the educational environment and simplifying instructors' jobs. AI will transform education. Psychologists describe human intelligence as a mix of cognitive talents. Artificial intelligence research has focused on the following intelligence components:

Learning

In the context of artificial intelligence (AI), learning encompasses various approaches. The most straightforward form involves acquiring knowledge through trial and error. For instance, in the case of a basic computer program designed for solving mate-in-one chess scenarios, it may experiment with different moves until it identifies a winning move. The program may store the solution alongside the corresponding position to enable the computer to remember this solution for future encounters with the same situation. Another form of learning in AI involves role-playing or the simple memorization of discrete items and processes, which a computer can easily accomplish. However, the challenge lies in applying a concept known as generalization. Generalization uses past knowledge to address similar new circumstances. A software that memorizes the past tense of common English verbs would struggle to create the past tense of "jump" unless it has seen "jumped" before. Software with generalization capabilities may learn the "added" rule and generate the past tense of "jump" from its experiences with comparable verbs (Pedro et al., 2019).

Reasoning

Engaging in reasoning is to draw inferences relevant to a given context. Deductive and inductive reasoning are distinct approaches in this regard. An example of deductive reasoning is: "Fred must be located either in the café or the museum." If it is established that he is not in the café, then it logically follows that he must be in the museum. On the other hand, an instance of inductive reasoning can be seen in the statement: "Previous accidents of this nature were attributed to instrument failure; hence, it is concluded that this accident was also caused by instrument failure." The crucial difference between these two forms of reasoning is that in deductive reasoning, the premises' truth guarantees the conclusion's truth. In contrast, in inductive reasoning, the premises support the conclusion without offering absolute certainty. Science frequently relies on inductive reasoning, involving collecting data and the development of initial models to describe and predict future behavior, which may be adjusted as new, unexpected data emerges. However, deductive reasoning is often used in mathematics and logic to build complex systems of irrefutable theorems from a few basic axioms and principles. Deductive inferences have been successfully programmed into computers. However, genuine reasoning extends beyond the mere act of drawing conclusions; it entails reaching conclusions that are pertinent to addressing specific problems or situations. This challenge represents a significant issue in artificial intelligence (AI) (Ouyang & Jiao, 2021).

Problem Solving

Problem-solving, especially within the field of artificial intelligence, can be defined as a methodical exploration of various potential actions with the purpose of attaining a predetermined goal or solution. There are two primary categories of problem-solving techniques: specialized and general. A specialized approach is customized for a particular problem and often utilizes unique aspects of the problem's context. In contrast, a general-purpose approach can be applied to address a variety of different problems. A commonly employed general AI method for problem-solving is means-end analysis. This approach involves incrementally closing the gap between the current situation and the desired outcome, step by step. For example, in the context of a basic robot, this may entail actions like PICKUP, PUTDOWN, MOVEFORWARD, MOVEBACK, MOVELEFT, and MOVERIGHT until the desired objective is achieved. The program selects actions from a list of potential means to progress toward the goal. Artificial intelligence systems have played a central role in finding solutions to a diverse range of problems, including tasks like determining winning moves in board games, generating mathematical proofs, and manipulating "virtual objects" within artificially generated environments (Luan et al., 2020).

Perception

In the process of perception, the environment is systematically examined using a variety of authentic or simulated sensory organs, and the scene is deconstructed into individual elements arranged in different spatial configurations. Analyzing these elements can be challenging due to factors like an object's appearance changing depending on the viewing angle, the direction and intensity of the ambient lighting, and how distinct the object is from its surroundings. Artificial perception has advanced significantly, enabling optical sensors to identify

individuals, autonomous vehicles to safely travel at reasonable speeds on open roads, and robots to collect empty soda cans from buildings (Alam, 2021).

Language

A language is a system of symbols with established meanings through convention. This concept implies that language is not limited to spoken words. For example, traffic signs serve as a form of mini-language; in some countries, the symbol for "danger ahead" is represented as "." The distinctive feature of languages is that the meanings of linguistic units are determined by convention, setting them apart from what is known as natural meaning. Examples of natural meaning include phrases like "Those clouds indicate rain" and "The decrease in pressure implies that the valve is malfunctioning." Developing computer programs capable of seemingly fluent responses in human languages within highly constrained contexts is not a particularly challenging task. Although none of these systems can claim to comprehend the entirety of the English language, they may eventually acquire language skills comparable to those of an average human. However, the question of what constitutes genuine understanding remains complex and lacks a universally accepted answer. One theory holds that language comprehension depends on both behavior and history: to understand a language, one must learn, interact, and train with other language users to integrate into the linguistic community (Becker, 2017).

Nature of AI

AI has traditionally been closely associated with computers. However, an examination of numerous research papers, particularly those focused on the field of education, reveals a shift away from the notion that AI is solely tied to computers, their hardware and software, or their equipment. Thanks to embedded computers, sensors, and new technologies, AI has expanded to include machines, robots, and buildings (Chassignol et al., 2018). The dual-sided definition and summary of AI by Chassignol et al. (2018) is that AI is a theory and a field of study. AI is a discipline of computer science that addresses cognitive difficulties, including learning, problem-solving, and pattern recognition, and adapts them (Chen et al., 2020).

Technical Aspects of AI in Education

AI-assisted education encompasses intelligent guidance, advanced virtual learning experiences, data analysis, and predictive capabilities. AI has broadened the scope of education by catering to diverse learning requirements. Both educators and students now enjoy the advantages of timely, customized training and feedback facilitated by intelligent educational systems. These systems harness a range of computing technologies, with a strong focus on machine learning, which closely aligns with statistical models and cognitive learning theories, ultimately enhancing the value and effectiveness of the learning journey. AI-based educational systems employ a multitude of strategies rooted in machine learning, data mining, and knowledge models, encompassing elements such as learning analysis, instructional components, and knowledge acquisition. At its core, an AI-powered educational system comprises instructional materials, data, and intelligent algorithms, further classifiable into system models

and intelligent technologies (Han, 2018). Table 2 provides insights into various scenarios and methodologies for the integration of AI in education.

Table. 2: Techniques for Scenarios of AI in Education

Scenarios	Techniques
Assessment of Pupils and Institutes	Academic analytics, adaptive learning technique, and individualized learning approach
Grading and Evaluation of Exams	Computer vision, image recognition, and prediction system
Individualized intelligent instruction	Baycsin knowledge interference data mining, intelligent teaching systems, and learning analytics
Smart School	Face and speech recognition, virtual laboratories, audio and video recognition, hearing, and sensing technologies
Online and mobile distance learning	Real-time analysis, edge computing, and virtual personal assistants

AI Education Model

In AI-based learning systems, the incorporation of learner models plays a pivotal role in the enhancement of self-directed learning abilities. These learner models are constructed by assimilating data pertaining to learner actions observed during the instructional process. The evaluation of learners' self-directed learning skills involves an assessment of their reasoning abilities and cognitive aptitude. Subsequently, a knowledge analysis is conducted to gauge the extent of learners' mastery of the subject matter. The objective of learner modeling is to create associations between educational outcomes and a range of elements, such as teaching approaches, learning materials, and instructional resources (Kim & Park, 2017).

Knowledge models serve as comprehensive informational structures within learning materials. They often encompass expert knowledge, and guidelines addressing common learner errors, and misconceptions. The instructional model, which combines both the knowledge domain model and the learner model, establishes guidelines for accessing the knowledge domain. This empowers educators to tailor their teaching methods and interventions according to specific student needs. As students progress in their education, they tend to exhibit more favorable behaviors, take proactive steps, and seek assistance as required. Tutoring models incorporate predefined teaching strategies that AI systems can consistently employ to provide guidance. Through various input and output mediums, the user interface serves to elucidate the students' performance levels. The advanced human-machine interface incorporates AI-related functionalities, including speech recognition, emotion recognition, and natural language interaction with learners (Terzopoulos & Satratzemi, 2019).

Intelligent Education Technologies

Educational technologies such as data mining, machine learning, and learning analytics are closely intertwined. Presently, two distinct communities have emerged in the domains of educational data mining and learning analytics. These communities share common objectives and methodologies, drawing support from various

academic disciplines, including machine learning, data mining, statistics, psychometrics, and data modeling. In the realm of learning analytics, particular emphasis is placed on large-scale test results and learning content management systems. The field of intelligent tutoring systems, which primarily deals with highly detailed cognitive processes, has given rise to the practice of data mining (Pinkwart, 2016). The intelligent education technologies under discussion encompass:

Machine Learning

Machine learning is fundamentally centered on the concept of knowledge discovery, which entails the examination of sample datasets referred to as "training data" in order to reveal significant patterns and organized information.

For instance, machine learning can be applied to assist students in making course and college selections by utilizing information like student preferences, goals, and past successes to match them with institutions where their potential can be maximized. Moreover, this technology can aid educators in understanding how students are comprehending various subjects. This insight enables teachers to adapt their teaching methods based on aggregated student performance data, potentially enhancing students' grasp of the subject matter. For example, machine learning's abilities in image recognition and prediction can be utilized to rapidly and accurately evaluate student assignments and exams, surpassing human assessment in both efficiency and precision. It's noteworthy that deep learning, a subfield of machine learning, has garnered substantial popularity. Within the domain of machine learning, decision tree learning, inductive logic programming, clustering, reinforcement learning, and Bayesian networks are some of the commonly employed methods.

Deep learning, from a technical perspective, focuses on the development of increasingly meaningful representations through the incorporation of additional layers. These layered models referred to as neural networks, are constructed with successive layers stacked upon each other to extract intricate layer-specific characteristics (Sonntag et al., 2017).

Learning Analytics

Learning analytics primarily concentrates on the collection of data concerning student attributes and knowledge entities acquired from learner models and knowledge domain models.

This approach introduces a novel technology, machine learning, into the non-technical domain of education. The overarching aim is to tailor teaching strategies to individual learners' needs and abilities. This may entail taking action to assist students who are at risk or delivering valuable feedback and educational resources. Learning analytics relies on techniques derived from a range of disciplines, including the learning sciences, data visualization, machine learning, and semantics. For example, AI-driven competency-based learning, which collects critical student data, can efficiently reveal insights about individual students and forecast the primary

competencies they should focus on. This proactive strategy empowers educational institutions to make well-informed decisions to aid their students (Rienties et al., 2020).

In addition to competency-based learning, learning analytics also leverages the adaptive learning functionalities of AI. Artificial intelligence can take into account multiple factors to classify potential students according to their risk of discontinuing their education, creating early warning systems and providing valuable insights for educational institutions. The forthcoming challenge for learning analytics is to broaden its applicability beyond its existing areas of emphasis to include disciplines like literature, the arts, interpersonal skills, and others.

These areas introduce a higher level of complexity when it comes to measuring and assessing competencies or learning outcomes. Striking a balance between applying learning analytics in specific learning environments while ensuring its adaptability for use across various courses and institutions remains a challenge. The increasing adoption of learning analytics holds promise for enhancing learning outcomes for students, teachers, administrators, and educational institutions as a whole (Salas-Pilco et al., 2022).

Data Mining

Data mining in education provides systematic and automatic answers. AI-based educational data mining establishes internal association rules and gives students personalized knowledge pieces. A few written tasks can be utilized to assess student demographics and grade data. Machine-learning regression can predict student performance and execute this study. Data mining is a powerful tool for boosting learning and understanding educational situations and students (Navale et al., 2016). Data mining uses pattern recognition and predictive modeling to reveal hidden information, helping educators improve curriculum creation. Personalizing learning experiences using knowledge domain data is a major use of AI-driven data mining.

This lets students learn at their own speed with AI. Individualized learning lets students choose subjects and lets teachers tailor lessons to their interests. Data mining helps AI build intelligence more accurately, improving results (Yahaya et al., 2020).

The Role of AI in Education

The education sector is anticipated to experience significant transformation due to the substantial potential of AI. AI possesses considerable power and has the capacity to affect various aspects of society, inciting substantial changes within them. Evidently, AI has found acceptance and practical application in the field of education, leading to significant advancements in various aspects of the industry. The utilization of AI in education, particularly in areas such as administration and instruction, has had an influence on students' learning outcomes (Zhai et al., 2021).

A variety of AI applications have been created within educational environments, as revealed by the academic sources examined in this study. These applications encompass the automation of administrative functions and

processes, the creation of educational curricula and course materials, teaching methodologies, and the enhancement of student learning procedures. AI has notably increased the effectiveness of administrative tasks, which include tasks such as overseeing students' progress, grading assignments, and delivering feedback. This enhancement has been achieved through the automation of these tasks via web-based platforms or computer programs (Hwang & Tu, 2021; Aggarwal & Girdhar, 2022).

AI has found applications within the education sector, contributing to the creation of curricula, educational materials, and lesson plans. These educational resources leverage a variety of tools and technologies, including virtual reality, web-based platforms, robotics, video conferencing, audiovisual materials, and 3-D technology. This integration of AI tools has resulted in more efficient and effective teaching practices, leading to more personalized and comprehensive learning experiences for students (Aldosari, 2020). Furthermore, a deeper examination of various sources has uncovered noteworthy insights. It has become apparent that AI's application in education has the potential to transcend the physical limitations imposed by national and international borders. This is achieved by hosting learning resources on the Internet and the World Wide Web, allowing access from virtually anywhere. Moreover, the incorporation of AI features, such as language translation tools, enables students to learn in a manner that aligns with their unique abilities and language preferences. Whether through online learning or web-based educational platforms, educational content has become readily accessible to learners across the globe (Jain & Jain, 2019).

The several publications we studied show that more focused applications of AI in education come in a variety of shapes. The broad use of AI in a variety of fields, including content development, teaching strategies, student evaluation, and teacher-student communication, was emphasized by Chassignol et al., (2018). For instance, the study by Chassignol et al., (2018) found that AI has been heavily incorporated into assessment, teaching and pedagogical approaches, curriculum building, and student-teacher communication.

Research Questions

- **RQ1:** What is the role of AI in instructional pedagogy?
- **RQ2:** What are the potential benefits of AI in education?
- **RQ3:** What are the future implications of AI in education?

Results

RQ1: What is the Role of AI in Instructional Pedagogy?

AI in Instructional Pedagogy

The analysis of selected papers reveals a prominent application of AI systems that has experienced significant growth, which is the domain of teaching and instructional support. AI has played a pivotal role in simplifying the development and utilization of highly effective teaching aids, thereby enhancing the quality of education. The various papers under scrutiny explore and highlight diverse platforms and applications of AI as an instructional tool. Mikropoulos & Natsis (2011) underscore the use of virtual reality, 3-D technology, and highly interactive simulations as educational tools that facilitate students' comprehension of various subjects. Similarly, Wartman

& Combs (2018) emphasize the application of AI in medical education through virtual reality and simulations, which guide students in practical aspects of their education, including performing procedures and understanding human anatomy. Another significant aspect of AI in education as an instructional tool is the creation and deployment of robots as teaching assistants and collaborators, often referred to as cobots. These robots are capable of conducting both basic and complex educational activities, such as teaching children how to read and pronounce words, as demonstrated by Chiu & Chai (2020). Sharma et al. (2020) highlight that the integration of AI into education, particularly in conjunction with other technologies, has led to the development and utilization of enhanced teaching tools, further enriching the instructional landscape. AI gives humanoids and other robots the ability to reason and make decisions, as well as to communicate and converse, which makes it possible to employ them as teaching and educational aids. The application of AI in instructional pedagogy is shown in Figure 2.

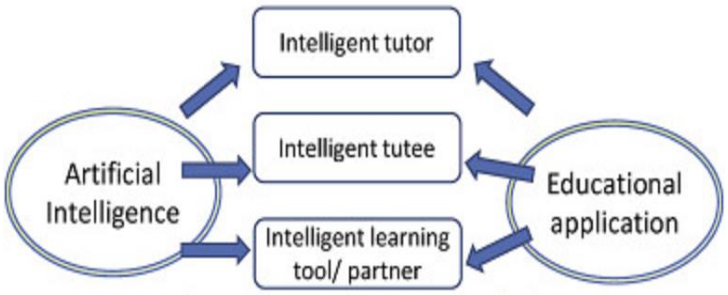

Figure.2: Artificial Intelligence in Instructional Pedagogy

Several research studies have explored the applications of intelligent tutoring systems (ITS) from various perspectives. For instance, Rus et al. (2015) discovered that ITS, capable of engaging in discussions and dialogues and integrated with animated conversational agents such as chatbots or cobots, has significantly enhanced teaching effectiveness. These findings are consistent with the ideas presented by Pokrivcakova (2019) regarding the use of artificial intelligence (AI) in education. Pokrivcakova discussed the application of AI in computer-assisted language learning (CALL), which offers customized guidance to students and helps language learners with writing and translation. Kahraman et al. (2016) explored the incorporation of AI in web-based education, particularly through AIWBES (AI in Web-Based Educational Systems). This approach imbues the platform with teacher-like capabilities, making it a powerful educational tool. Similarly, Peredo et al. (2011) investigated intelligent and adaptive web-based systems (IWBE) that view teachers as social agents within the system. The goal of this system is to understand and support teachers in their roles, providing guidance to students to ensure effective and systematic use of web-based educational technology for an enhanced learning experience. AI has been integrated into various technologies and approaches, either as a standalone educational tool or as a means to assist teachers in fulfilling their educational duties.

Performance of Instructor and Student

It would be intriguing to investigate the potential impact of artificial intelligence on both student and teacher performance within intelligent educational systems. AI systems have the potential to significantly alleviate the workload of teachers, particularly as the number of students in educational institutions continues to rise. These AI

systems can assist educators in analyzing the curriculum and course materials, subsequently offering tailored content recommendations. Furthermore, post-analysis, these systems can even generate and evaluate examinations. This automation allows teachers to allocate more of their attention to pressing issues, such as student performance (Chan & Zary, 2019). AI solutions also hold promise in effectively assessing student data in personalized teaching and self-directed learning contexts. This capability empowers teachers to develop individualized lesson plans for each student, enhancing the educational experience. Addressing the issue of human bias is another evolving challenge in the integration of AI in education. To mitigate bias, AI systems can assess essays and exams based on predefined criteria and standards. Computer vision-based AI systems, which can read and recognize handwritten documents and images, play a pivotal role in this process. These technologies not only help reduce bias but also safeguard against plagiarism and cheating (Renz & Hilbig, 2020).

AI systems have detected learning gaps in students and are proactively addressing these issues during their early education by analyzing student data. Unlike the traditional educational system, which provides uniform treatment to the majority of students, AI recognizes that optimal teaching performance cannot be achieved by applying the same teaching approach to all students (Lin et al., 2018; Verma, 2018).

As a conclusion, AI offers enormous promise for speeding up and automating administrative duties for both institutions and teachers. The marking of essays and assignments can already be automated by AI, freeing up teachers' time to deal with pupils one-on-one. New approaches to grading essays and examinations are being developed by AI developers. AI develops adaptable learning digital interfaces for students of different ages and grade levels in terms of educational resources. In addition, AI makes it possible for teachers to obtain knowledge for their students based on the complete learning ecosystem (Carin, 2020).

RQ2: What are the potential benefits of AI in education?

Some of the potential benefits of AI in education are discussed in the following lines:

Personalized Learning Environment

AI-based solutions have the capability to adapt to students' academic levels, their pace of learning, and their current educational objectives. This capacity can be instrumental in helping students select the most suitable courses for their requirements. Programs related to artificial intelligence can evaluate individuals' prior learning experiences, pinpoint their areas of weakness, and suggest relevant courses accordingly.

Tutoring

Many students need support beyond the traditional classroom setting, whether it's for exam preparation or help with homework. Finding professors with enough time to address these individual needs can be challenging. AI chatbots and tutors can provide students with personalized guidance for their unique learning styles outside the classroom. AI technologies can play a crucial role in helping students identify and enhance their areas of weakness.

Quick Response

During the educational journey, students often need assistance in resolving their queries, and this assistance is typically sought from specialized experts. Artificial intelligence (AI) can provide rapid responses to students' inquiries, ensuring that learning resources are accessible around the clock, seven days a week. With the assistance of AI, students have the flexibility to study from any location and at any time. This enables them to access high-quality education without incurring additional costs associated with living or travel expenses.

Personalized Course Programs

AI-based tools may assess students' learning abilities and history to offer teachers an overview of their weak points that demand assistance. It enables the creation of tailored educational curricula by collecting and analyzing student data. An appropriate learning program can now be established in the future.

Customization of the Academic Curriculum

Artificial intelligence (AI)-powered machines have the ability to tailor academic curricula to individual needs. The integration of AI technologies in global classrooms enables the inclusion of students with hearing or vision impairments, as well as those who are ill and unable to attend classes. In the traditional educational system, instructors evaluate students based on their assignments and tests, which can be time-consuming. However, when AI is introduced into this context, it can efficiently handle these tasks. Furthermore, AI assists in offering guidance on addressing learning gaps.

AI Provides Resources

People who speak different languages, those with hearing or vision impairments, or individuals conversant in various languages can all derive advantages from the capabilities of artificial intelligence (AI). One example of an AI-driven application is Presentation Translator, which provides real-time subtitles. For instance, with the assistance of Google Translate, students can both read and hear content in their native language. Contemporary technologies such as virtual reality (VR) and gamification prove valuable for fostering greater engagement in meetings and interactions.

Student Assessment and Grading

Multiple choice examinations were previously occasionally assessed by computers, and now advancements are being made that would allow written solutions, such as paragraphs and assertions, to also be rated by computers. As a result, a teacher's job is made simpler, there is no time wasted, and the time saved can be used to focus more on the growth and assessment of each individual student.

Admissions and Enrollment Processes

In the future, artificial intelligence (AI) has the potential to play a significant role in managing the processes related to admissions and enrollment, although its complete capabilities remain to be fully realized. AI has the capacity to assist students in improving their at-home study routines and in planning for exams. In the future, AI will have the capability to adapt to diverse learning approaches. The advancement of more advanced tutoring and study systems can be attributed entirely to AI. The educational sector is presently exploring various applications of AI, including the concept of AI mentors to support students.

Adaptive Group Formation

Students can be divided into groups by AI that are most suited for specific assignments. Adaptive group formation is the term for this. Software using artificial intelligence that can evaluate student essays right away. These writings are added to a central database, and the database's prior essays may be used to compare future articles. Computer-based AI in education enables individualized, flexible, and perceptive instruction.

Intelligent Tutoring System

The Intelligent Tutoring System promotes one-on-one individualized tutoring. They can make a verdict against an individual student based on neural networks and algorithms. Students are already being exposed to a plethora of higher education options because to AI. AI has the potential to completely transform the sector of education. Robots can improve grammatical accuracy and generate digital material. Teaching in the schools has already begun to be digitalized.

RQ3: What are the future implications of AI in education?

A suitable exam may be swiftly created using AI to understand a student's needs. It can instantly create a customized learning plan for each student, repeat classes as necessary, and demonstrate to pupils their level of knowledge. Artificial intelligence (AI) might give teachers a virtual teaching assistant, freeing up the teacher's time to roam around the classroom and encourage learning. Involving parents in the educational process and giving them the knowledge, they require to support their children's success outside of the classroom may boost parents as well as teachers and students more broadly. Teachers should take advantage of this chance to become knowledgeable about the potential applications of AI and to be open to dialogues with students. The future evolution of Artificial Intelligence in Education is shown in Figure 2.

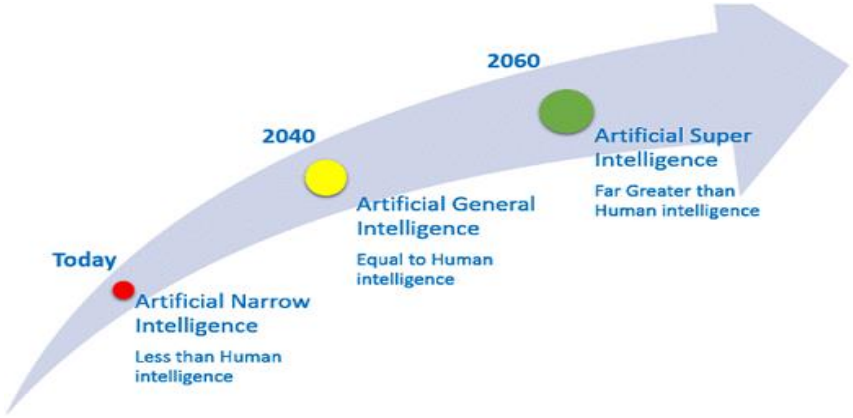

Figure. 2: Future Evolution of Artificial Intelligence in Education (Ongsulee, 2017)

Recommendations

On the basis of the results of the study following recommendations have been stated:

1. More studies should be done on the application of artificial intelligence in education especially in instructional pedagogy to explore the more beneficial knowledge of AI in education.
2. Artificial intelligence should be included in the curriculum at all levels of education for the practical implications of Artificial Intelligence in education.
3. There should be a project related to the application of artificial intelligence in education at the higher education level to gain hands-on experience in artificial intelligence.

Discussion for Implications

AI is an advancing technology with the potential to revolutionize various aspects of our social interactions. In the realm of education, AI has initiated the development of innovative teaching and learning solutions, currently undergoing testing in various scenarios (Panigrahi, 2020). A fundamental objective of AI in education is to offer personalized learning assistance or support to individual students, taking into account their learning progress, preferences, and personal traits. For instance, an AI system can replace a tutor by monitoring students' learning processes, assessing their academic progress, and providing immediate support tailored to their needs. Through interdisciplinary collaboration, an intelligent tutoring system can be created to cater to students' anticipated needs. This system not only enables students to study, practice, and interact with peers and professors but also offers guidance, assistance, and support based on their specific circumstances or requirements. Conversely, if educators possess an understanding of AI technology's capabilities and attributes, they can incorporate appropriate AI applications into their courses to enhance students' learning outcomes, motivation, and engagement.

This study aimed to explain how AI is used in instructional pedagogy. The study was formulated to find the answers to three research questions. The findings related to each research question are discussed as:

Findings Related to RQ1

The first research question of this study was "What is the Role of Artificial Intelligence in Instructional Pedagogy?" The findings related to this research question are discussed in the following lines:

a. AI has simplified the development and utilization of highly efficient teaching aids, significantly enhancing educational quality.
b. The simulation-based lessons give students an actual or practical learning experience by utilizing various technologies, such as virtual reality, to illustrate or teach pupils concepts or realistically exhibit contents.
c. Better teaching tools have been created and are now being used as a result of the integration or use of AI in education, more specifically as instructional tools and in conjunction with other technologies.
d. AI gives humanoids and other robots the ability to reason and make decisions, as well as to communicate and converse, which makes it possible to employ them as teaching and educational aids.
e. The realization of teaching efficacy has been aided by intelligent tutoring systems that are equipped with conversational and dialogue capabilities as well as animated conversational agents in the form of chatbots or cobots.
f. Writing and translation aids in language learning, as well as computer-assisted language learning that gives students or learners personalized instructions.
g. Intelligent Web-Based Education (IWBE) systems in which teachers are examined and portrayed as social agents. The system then aims to comprehend and support teachers in carrying out their mandates, to give instructions and directions to students, with the goal of ensuring that the technology, web-based education, used in education is an effective and methodical way to improve learner experience.
h. Deep Tutor and Auto Tutor are examples of learner-centered systems that encourage customization and individualized material based on the learner's skills and requirements, therefore improving the learner's experience and supporting the attainment of the stated learning objectives.

Findings Related to RQ2

The second research in this study pertained to the potential advantages of artificial intelligence in education. The conclusions regarding this research question are presented in the following lines:

AI Benefits for Students

Personalization: Personalization is a significant trend in education, facilitated by the incorporation of AI. This trend allows students to experience tailored learning programs that consider their unique backgrounds and interests. AI plays a crucial role in this by adapting to each student's level of knowledge, pace of learning, and educational objectives, ensuring that every student can optimize their learning experience. Furthermore, AI-driven tools can evaluate students' past academic performance, identify areas requiring improvement, and suggest suitable courses, thereby creating numerous opportunities for a customized and highly effective learning environment.

Tutoring: Personalization is a prominent trend in education, marked by the individualized approach to learning programs made possible by the integration of AI. Through AI, students now receive customized learning experiences tailored to their unique backgrounds and interests. AI has the capacity to adapt to each student's level of knowledge, pace of learning, and ultimate educational objectives, ensuring that every student maximizes their learning potential. Moreover, AI-driven tools can analyze students' previous academic achievements, identify areas in need of improvement, and suggest relevant courses, thereby creating numerous opportunities for a personalized learning environment.

Quick Responses: Few things are as frustrating as posing a question and waiting three days for a response. Teachers and staff often encounter a daily deluge of repetitive inquiries. AI, equipped with support automation and conversational intelligence, can promptly furnish answers to the most commonly asked questions by students. This not only alleviates a significant burden on teachers' time but also reduces the time students need to seek information or await responses to their inquiries.

AI Benefits for Teachers

Personalization: AI can customize educational programs for kids and teachers alike. By examining students' learning styles and prior performance, AI can furnish instructors with valuable insights into which courses and lessons require reassessment. Armed with this data, teachers can devise highly effective learning programs tailored to each student's specific needs. Moreover, educators can adapt their curriculum to address prevalent knowledge gaps or areas of concern before a student falls significantly behind, thus ensuring a more personalized and effective educational experience for all.

Answering Questions: AI-powered chatbots can respond to a range of common and repeated inquiries posed by students without consulting a faculty person since they have access to the complete body of information at a given institution. By avoiding the teacher, AI gives them more time to devote to lesson planning, curriculum research, or enhancing student engagement.

Findings Related to RQ3

The third inquiry in this study revolved around the prospective implications of artificial intelligence in education. The conclusions related to this research query are presented below:

The impact of AI on the future of education is poised to be substantial, with AI playing a supportive role in teaching and learning processes. The domain of education is not immune to the rapid advancements in technology, particularly in areas such as artificial intelligence (AI), machine learning (ML), and robotics. To fully harness AI's potential for the benefit of all, it is essential to introduce the younger generation to AI at an early stage and integrate this technology into the classroom. Teachers have already observed that many students are active users of social media platforms, indicating their receptiveness to the educational possibilities presented by AI.

Conclusion

The development of artificial intelligence has marked the onset of a new era in computer-assisted learning. AI systems can assume roles such as intelligent tutors, tools, or tutees, enhancing decision-making processes in educational settings by incorporating human intelligence. The convergence of AI and education opens a new window of opportunity to significantly elevate the quality of instruction and learning. Intelligent technologies that support tasks like assessments, data collection, learning enhancement, and innovative instructional strategies can be valuable assets for educators. Asynchronous learning and intelligent tutoring systems have the potential to improve students' learning outcomes. Moreover, the integration of AI with education represents a transformative shift not only in the field of education but also in human knowledge, cognition, and civilization. Consequently, AI in education is rapidly emerging as a prominent research area within the domain of computer-assisted learning and is poised to be a topic of considerable debate in the future.

References

Aggarwal, R., & Girdhar, N. (2022). The role of artificial intelligence in the education sector: possibilities and challenges. Machine Learning, Block chain, and Cyber Security in Smart Environments, 17-39.

Alam, A. (2021, November). Possibilities and Apprehensions in the Landscape of Artificial Intelligence in Education. In 2021 International Conference on Computational Intelligence and Computing Applications (ICCICA) (pp. 1-8). IEEE.

Aldosari, S. A. M. (2020). The future of higher education in the light of artificial intelligence transformations. International Journal of Higher Education, 9(3), 145-151.

Baker, T., Smith, L., & Anissa, N. (2019). Education AI rebooted? Exploring the future of artificial intelligence in schools and colleges. Retrieved May, 12, 2020.

Becker, B. (2017). Artificial intelligence in education: what is it, where is it now, where is it going. Ireland's Yearbook of Education, 2018, 42-46.

Carin, L. (2020). On artificial intelligence and deep learning within medical education. Academic Medicine, 95(11S), S10-S11.

Chan, K. S., & Zary, N. (2019). Applications and challenges of implementing artificial intelligence in medical education: integrative review. JMIR medical education, 5(1), e13930.

Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. (2018). Artificial Intelligence trends in education: a narrative overview. Procedia Computer Science, 136, 16-24.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. Ieee Access, 8, 75264-75278.

Chiu, T. K., & Chai, C. S. (2020). Sustainable curriculum planning for artificial intelligence education: A self-determination theory perspective. Sustainability, 12(14), 5568.

Coppin, B. (2004). Artificial intelligence illuminated. Jones & Bartlett Learning.

Guan, C., Mou, J., & Jiang, Z. (2020). Artificial intelligence innovation in education: a twenty-year data-driven historical analysis. International Journal of Innovation Studies, 4(4), 134-147.

Hafeez, M., Ajmal, F., & Zulfiqar, Z. (2022). Assessment of Students' Academic Achievements in Online and Face-to-Face Learning in Higher Education. Journal of Technology and Science Education, 12(1), 259-

273.

Han, L. (2018, December). Analysis of new advances in the application of artificial intelligence to education. In 2018 3rd International Conference on Education, E-learning and Management Technology (EEMT 2018) (pp. 608-611). Atlantis Press.

Hössjer, O., Díaz-Pachón, D. A., & Rao, J. S. (2022). A formal framework for knowledge acquisition: going beyond machine learning. Entropy, 24(10), 1469.

Hwang, G. J. (2003). A conceptual map model for developing intelligent tutoring systems. Computers & Education, 40(3), 217-235.

Hwang, G. J., & Tu, Y. F. (2021). Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review. Mathematics, 9(6), 584.

Jain, S., & Jain, R. (2019). Role of artificial intelligence in higher education—An empirical investigation. IJRAR-International Journal of Research and Analytical Reviews, 6(2), 144z-150z.

Kahraman, S. A. İ. R. (2016). Estimating the penetration rate in diamond drilling in laboratory works using the regression and artificial neural network analysis. Neural Processing Letters, 43(2), 523-535.

Kim, K., & Park, Y. (2017). A development and application of the teaching and learning model of artificial intelligence education for elementary students. Journal of The Korean Association of Information Education, 21(1), 139-149.

Lin, P. H., Wooders, A., Wang, J. T. Y., & Yuan, W. M. (2018). Artificial intelligence, the missing piece of online education? IEEE Engineering Management Review, 46(3), 25-28.

Luan, H., Geczy, P., Lai, H., Gobert, J., Yang, S. J., Ogata, H., ... & Tsai, C. C. (2020). Challenges and future directions of big data and artificial intelligence in education. Frontiers in psychology, 11, 580820.

Mikropoulos, T. A., & Natsis, A. (2011). Educational virtual environments: A ten-year review of empirical research (1999–2009). Computers & education, 56(3), 769-780.

Navale, G. S., Dudhwala, N., Jadhav, K., Gabda, P., & Vihangam, B. K. (2016). Prediction of stock market using data mining and artificial intelligence. International Journal of Computer Applications, 134(12), 9-11.

Nilsson, N. J., & Nilsson, N. J. (1998). Artificial intelligence: a new synthesis. Morgan Kaufmann.

Ongsulee, P. (2017, November). Artificial intelligence, machine learning and deep learning. In 2017 15th international conference on ICT and knowledge engineering (ICT&KE) (pp. 1-6). IEEE.

Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. Computers and Education: Artificial Intelligence, 2, 100020.

Panigrahi, C. M. A. (2020). Use of artificial intelligence in education. Management Accountant, 55, 64-67.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). Artificial intelligence in education: Challenges and opportunities for sustainable development.

Peredo, R., Canales, A., Menchaca, A., & Peredo, I. (2011). Intelligent Web-based education system for adaptive learning. Expert Systems with Applications, 38(12), 14690-14702.

Pinkwart, N. (2016). Another 25 years of AIED? Challenges and opportunities for intelligent educational technologies of the future. International journal of artificial intelligence in education, 26(2), 771-783.

Pokrivčáková, S. (2019). Preparing teachers for the application of AI-powered technologies in foreign language education. Journal of Language and Cultural Education.

Renz, A., & Hilbig, R. (2020). Prerequisites for artificial intelligence in further education: identification of drivers,

barriers, and business models of educational technology companies. International Journal of Educational Technology in Higher Education, 17(1), 1-21.

Rienties, B., Køhler Simonsen, H., & Herodotou, C. (2020, July). Defining the boundaries between artificial intelligence in education, computer-supported collaborative learning, educational data mining, and learning analytics: A need for coherence. In Frontiers in Education (Vol. 5, p. 128). Frontiers Media SA.

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. International Journal of Artificial Intelligence in Education, 26(2), 582-599.

Ross, P. (1987). Intelligent tutoring systems. Journal of Computer Assisted Learning, 3(4), 194-203.

Rus, V., Niraula, N., & Banjade, R. (2015, March). DeepTutor: An effective, online intelligent tutoring system that promotes deep learning. In Twenty-ninth aaai conference on artificial intelligence.

Sadiku, M. N., Ashaolu, T. J., Ajayi-Majebi, A., & Musa, S. M. (2021). Artificial Intelligence in Social Media. International Journal of Scientific Advances, v2, i1.

Salas-Pilco, S. Z., Xiao, K., & Hu, X. (2022). Artificial Intelligence and Learning Analytics in Teacher Education: A Systematic Review. Education Sciences, 12(8), 569.

Sharma, K., Giannakos, M., & Dillenbourg, P. (2020). Eye-tracking and artificial intelligence to enhance motivation and learning. Smart Learning Environments, 7(1), 1-19.

Sonntag, D., Zillner, S., Smagt, P. V. D., & Lörincz, A. (2017). Overview of the CPS for smart factories project: Deep learning, knowledge acquisition, anomaly detection and intelligent user interfaces. In Industrial internet of things (pp. 487-504). Springer, Cham.

Taş, N., & Gülcü, A. (2019). *Bilgisayar Destekli Öğretimin Temelleri [Fundamentals of Computer Aided Instruction]*. Erzurum: Ertual Akademi.

Terzopoulos, G., & Satratzemi, M. (2019, September). Voice assistants and artificial intelligence in education. In Proceedings of the 9th Balkan Conference on Informatics (pp. 1-6).

Verma, M. (2018). Artificial intelligence and its scope in different areas with special reference to the field of education. Online Submission, 3(1), 5-10.

Wartman, S. A., & Combs, C. D. (2018). Medical education must move from the information age to the age of artificial intelligence. Academic Medicine, 93(8), 1107-1109.

Yahaya, L., Oye, N. D., & Garba, E. J. (2020). A comprehensive review on heart disease prediction using data mining and machine learning techniques. American Journal of Artificial Intelligence, 4(1), 20-29.

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., ... & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. Complexity, 2021.

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Citation

Hafeez, M., Ajmal, F., & Zulfiqar, Z. (2023). Artificial intelligence in instructional pedagogy: Potential benefits and future implications. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 44-64). ISTES Organization.

Chapter 5 - Design of Artificial Intelligence (AI) Education for Primary Schools: Arts-based Approach

Iris Heung Yue Yim

Chapter Highlights

- The study aims to design an AI curriculum framework with a pedagogical strategy and assessment method to support students in developing their AI literacy in a primary school setting.
- Theoretically, by adding the new element of AI thinking with the considerations of data justice and ethics into the existing theoretical AI literacy framework, this research presents a holistic and inclusive AI curriculum for primary school students, with the considerations of all humans, non-humans, and nature.
- This curriculum can demystify AI concept skills traditionally taught at secondary schools and universities. The educational implication is that it may empower students with the agency for critically creating and evaluating AI models while considering minimizing any potential bias and its societal, ethical, and environmental implications.
- Apart from shedding light on the suitability of AI curriculum in primary school settings, this study contributes to our understanding of the effectiveness of pedagogical strategy in AI curriculum implementation. It also adds value to assessment groundwork to evaluate AI literacy.

Introduction

Artificial Intelligence (AI) is defined as "the science and engineering of creating intelligent devices, particularly intelligent computer programs" (McCarthy, 2007, p. 2). AI literacy has become an essential component of national strategies for digital citizenship education (Seldon & Abidoye, 2018). Even though many youngsters have grown up engaging with AI algorithms, the majority of them still do not understand the technologies underlying smart toys and AI applications (McStay & Rosner, 2021; Ottenbreit-Leftwich et al., 2021), while some even hold misconceptions and misinformation about AI (Mertala et al., 2022; Dai et al., 2023). Many academics believe that younger children should be taught how to interact with and use AI-powered applications since AI education nurtures creativity, enhances problem-solving skills, and develops persistence, allowing students to meet the needs of the 21st century (Touretzky et al., 2021; Taguma et al., 2018). The urgency for AI literacy education is further heightened by the prevalent dark side of AI, including the algorithm bias reinforcing the existing social, economic, and political bias in AI training datasets (Benjamin, 2019; Crawford, 2021). They will significantly impact humans and natural ecosystems in the 21st century (Bozhurt et al., 2021; Crutzen, 2002). AI also threatens children's rights to privacy, safety, and security (Maio et al., 2022), so recent discussions have focused on how important it is to learn AI ethics (Gong et al., 2020; Hagendorff, 2020), data justice (Atenas et al., 2023; Raffaghelli & Gouseti, 2021), and how to teach children to think critically in an age of intelligence (Floridi et al., 2018). Furthermore, there have been calls for including primary school students in AI literacy education to maximize digital inclusion and eliminate the digital divide (Yang, 2022). Given the extent to which AI technologies have infiltrated various aspects of our lives, AI education should be promoted in primary school settings with the consideration of all humans, non-humans, and the natural world rather than being limited to secondary school or university settings (Chiu et al., 2021b; Su et al., 2022).

Given the urgent need to teach primary school students about AI literacy, this study aims to design a holistic AI curriculum, including AI thinking with data justice and ethics, with the collaborative arts-based pedagogical strategy and assessment method. It strives to empower young students with AI literacy to be a social, ethical, and environmentally responsible AI generation to advance a more equitable, just, and sustainable world. It provides an engaging and content-appropriate AI curriculum for primary school students. The contribution of this study is fourfold: (1) the holistic arts-based AI curriculum for inclusive primary education proposed in this study serves as a valuable reference for educators and the government; (2) it sheds light on the suitability of AI primary education curriculum and contributes to the understanding of the effectiveness of the pedagogical strategy in the implementation of AI curriculum; (3) it designs and provides suitable content, teaching methods with engaging and age-appropriate AI learning tools, teaching activities, assessment suggestions in the AI primary education field to inform teachers and practitioners for iterative and sustainable AI literacy educational development; (4) it empowers students with AI literacy with a collaborative arts-based pedagogical approach and inspires them to be a AI creator who creates for projects using AI technology.

Research Aims and Questions

The study aims to design an AI curriculum framework with a pedagogical strategy and assessment method to

empower students in developing their AI literacy in a primary school setting. The following research questions will guide the proposed study.

- RQ1: What learning content should be included in AI education at the primary school level?
- RQ2: What are the teaching methods in group activities?
- RQ3: What are the assessment suggestions in AI education at the primary school level?

Literature Review

AI Literacy and Conceptual Framework

AI literacy has become essential in the 21st century, including fundamental grammar and survival competence across several fields (Miao et al., 2022; Touretzky et al., 2022). It has grown to include a range of ideas, knowledge, abilities, and attitudes (Long & Magerto, 2020). Some academics describe it as knowing and comprehending AI, using and applying AI, assessing and constructing AI, and AI ethics (Ng et al., 2021), which are as vital as reading, writing, and computer skills. Machine learning, algorithm design, and natural language processing are also considered AI subfields of computer science (Akgun & Greenhow, 2021). More crucially, primary school research must be addressed in favor of secondary schools (Chiu et al., 2021b) and universities (Su et al., 2022).

Recently, the Machine Learning Education Framework (Lao, 2020), Digital Competence Framework For Citizens (Guitert et al., 202a), and AI4K12 initiative (i.e., a scientific-related industry partnership https://ai4k12.org/) of Five Big Ideas in AI (Touretzky et al.,2019) have been adopted to design an AI curriculum for students. For example, researchers introduced the Five Big Ideas in AI, which comprises perception, reasoning, representation, machine learning, and language understanding, to K-12 students (Tkáčová et al., 2020; Eguchi et al., 2021; Touretzky et al.,2021). These guidelines are informed by the learning sciences and computer science education research and aligned with the CSTA's K-12 Computer Science Standards, Common Core, and Next Generation Science Standards (Touretzky et al.,2022). Therefore, the learning of AI literacy education is often incorporated into the computer science curriculum (Kanemune et al., 2017) and mapped into the Science curriculum (Heinze et al., 2010). Due to gender differences (Dai et al., 2020), situated AI literacy education may bar certain groups of students (Lin et al., 2021), particularly girls, from engaging in learning.

In addition, many argue that data is the core of the contemporary approach to AI development, which contributes to the numerous challenges centered on ethics, justice, and algorithmic bias (Benjamin, 2019), as well as accountability and transparency for inclusive and sustainable development (Pedro et al., 2019). AI has the potential to amplify hidden biases and prejudices in its initial data analyzed and trained by humans, potentially reinforcing its underlying assumption (Crawford, 2021). For example, the design of AI personal assistants such as Alexa and Siri is inherently anthropomorphic (Pfeuffer et al., 2019), and they were given female names, perpetuating discriminatory stereotypes of female secretaries and male bosses. Adam (2006) even argues that AI

is a model of gender that reinforces women's subordination to men (Nadeem et al., 2022). This is a fundamental question that AI literacy education should address to advance what it represents to be fully human. Given that the learning content of AI thinking about data justice and ethics is often undermined in the framework and curriculum design for young students (Touretzky et al.,2019), teaching them about the critical role of data in AI training datasets is paramount (Mertala et al., 2022).

AI Literacy Primary Education

One of the biggest challenges is scaffolding AI concepts to primary school students engagingly (Yang, 2022). There have often been unresolved debates over how young students' engagement can be maximized when learning about AI concepts (Sakulkueakulsuk et al., 2018) and what pedagogical strategies and learning tools are appropriate (Steinbauer et al., 2021). Previous empirical research has indicated that AI learning content can be taught through project-based (Narahara & Kobayashi, 2018; Ho et al., 2019), game-based (Voulgari et al., 2021) and collaborative learning (Toivonen et al., 2020; Vartiainen et al, 20.20) with the use of constructivist methodologies in primary school classrooms (Ho et al., 2019; Lee et al., 2020). These approaches align with UNESCO reports that current AI literacy education reflects the dominant belief of constructivism and constructivist ideologies (Miao et al., 2021). Although they are considered effective in encouraging students to learn by doing according to their interests (Miao et al., 2022), they proposed that knowledge can only exist within the human mind (Bada & Olusegun, 2015), which suggests the exclusion of other ways of knowing (Colucci-Gray et al., 2019) and that it is not connected to the relationality of the embodied interaction (Dai et al., 2023), the materials and natural world (Braidotti, 2019). In addition, this variation in pedagogy could also be influenced by various factors in the teaching and learning process, such as students' age, gender, background knowledge, educational settings, and available learning tools.

Previous studies have also demonstrated that incorporating the arts into various disciplines, such as STEM (acronyms of Science, Technology, Engineering, and Mathematics), can enhance girls' interest (Martínez et al., 2021; Ma et al., 2022), promote students' participation at all ages (Papavlasopoulou et al., 2019) and help them learn new knowledge and skills (Ballard et al., 2023; Kuri, 2020). Although the educational purpose of the arts is to unlock students' multiple perspectives by reviewing their roles in ongoing interactions and relationships with other humans, non-humans, and the natural world (Colucci-Gray et al., 2019), an arts-based approach in AI literacy learning is absent.

In the age of Generative AI, human and AI interaction is evident in almost all aspects of everyday life. Though many children are digital natives who grow up while interacting with AI algorithms, most of them are still AI illiterates. Children frequently treat AI models as black boxes, failing to understand computational thinking concepts, underlying assumptions, or AI model constraints (Shamir & Levin, 2021; Burgsteiner et al., 2016). However, there are increasingly more learning tools available, including hardware-focused learning tools such as robots (Narahara & Kobayashi, 2018) and Raspberry Pi (Mathe et al., 2022); software-focused learning tools such as Scratch (Li & Song,2019), intelligent agents such as Google Teachable Machine, Learning ML (Toivonen et al., 2020; Rodríguez-Garciá et al., 2020); and unplugged activities such as role play (Henry et al., 2021). Even

though algorithm bias can be visualized and taught at the primary school level (Narahara & Kobayashi, 2018; Melsion et al., 2021), the majority of these tools are employed to scaffold the basic AI concepts and knowledge to teach students about future AI consumers and users rather than critically understand the role of data for future AI designers and creators (Ng et al., 2021). Given that early exposure to AI literacy can prepare students to adapt to future needs (Burgsteiner et al., 2016), AI literacy education should be prioritized to build a future generation that is digitally, globally, and socially responsible. Nonetheless, AI remains contested due to the scarcity of research on what to learn, how to teach, and the effectiveness of pedagogical strategies and tools in teaching young students in primary school settings (Steinbauer et al., 2021; Yang, 2022).

AI Curriculums and Activities Design Under Current Primary Educational Settings

Recently, many researchers have been designing, experimenting with, and advocating for an AI curriculum to be included in the primary school curriculum. Many have worked with governments such as the Ministry of Education of the People's Republic of China (Dai et al., 2020), the Victorian Curriculum and Assessment Authority of Australia (Heinze et al., 2010), the city-wide educational program in Israel (Shamir & Levin, 2021), and the "Digital Technologies in Society curricula" of Slovakia (Tkáčová et al., 2020). Others have worked closely with non-governmental organizations, such as the AI4ALL initiative (Touretzky et al., 2019; Eguchi et al., 2021) and the MIT Media Lab (Ali et al., 2019). Constructionism (Ali et al., 2019; Shamir & Levin, 2022) and the AI4K12 Five Big Ideas Framework (Tkáčová et al., 2020; Eguchi et al., 2021) have been applied to design AI curricula in current primary school contexts. Although previous researchers have identified the types of content knowledge and theoretical frameworks to be included in school-based curricula for primary students, most studies use subjective measures such as artifact assessments (Ali et al., 2019; Li & Song, 2019; Shamir & Levin, 2021), self-reported surveys, and interviews (Chai et al., 2021a; Dai et al., 2020; Melsion et al., 2021) to understand their learning outcomes. These measures reflect the inadequacy of measurable applications or evaluations of knowledge mechanisms in assessing the quality of suggested methodologies for primary school students. According to UNESCO 2022, evidence based on AI curriculum quality, suitability, and effectiveness is needed (Miao et al., 2022). As a result, there is a need to expand on the existing work on AI in primary school contexts.

Research Gaps

The literature review reveals several gaps. First, AI education is primarily implemented at universities and secondary schools. Despite the availability of more age-appropriate learning tools for young students, there are insufficient efforts to promote the element of AI thinking with data justice and ethics. Second, many researchers advocate for developing and implementing AI curriculum and activities to educate students about AI knowledge, skills, and AI ethics issues from an early age; however, AI curriculum for primary school students is typically limited. There is an urgent need to design age and content-appropriate curricula to enrich the existing literature. While previous research has proposed various approaches to AI education, this study expands on the existing studies using the arts-based approach. Moreover, since ethics and AI technology are inextricably linked, research on incorporating AI thinking with the consideration of data justice and ethics into the AI curriculum is required. Assessment suggestions on assessing students' and teachers' perceptions of AI literacy education, investigating

the suitability of the curriculum, and evaluating AI literacy, typically lacking in previous studies, are also developed in this study for improving learning outcomes.

The Researcher's AI Curriculum Design

This section will describe the AI curriculum design administered by the researcher for the objective of this study. It aims to explore a dynamic interaction of material and discursive learning settings – the entanglement of arts-based AI learning contents, arts-based materials, and AI educational tools. Considering all humans and non-humans and the nature of sustainable and inclusive AI literacy education, six learning modules are designed by the researcher to empower students with AI knowledge, skills, and a critical mindset, together with AI attitudes about AI thinking about data justice and ethics.

AI Curriculum Design for Primary Education

Based on the frameworks of the Five Big Ideas (Touretzky et al., 2019), an AI arts-based curriculum is designed by adding the Sixth Big idea, AI thinking with data justice and ethics (Figure 1). It encourages students to consider all humans and the nature of their study, reflect on the credibility of AI-based training and analytical techniques in data justice and ethics, and understand how the AI dataset should be created and used critically to avoid bias. AI thinking was first introduced by Zeng (2013) to harness cognitive computational data analytics, leading to enhanced learning by interpreting new findings from the machine learning exploration of hidden data patterns (How et al., 2020). It values the interwoven existence of human and non-human nature and its actions, promoting a more equitable and sustainable AI literacy education for all.

Big idea 1: Perception - By using sensors, computers can perceive the world
Big idea 2: Representation and reasoning - AI agents have representations of the world for reasoning purposes
Big idea 3: Learning - Computers can learn from data
Big idea 4: Natural interaction - AI agents require various types of knowledge to interact with humans naturally
Big idea 5: Societal, ethical, and environmental impact - AI poses both positive and negative impacts.
Big idea 6: AI thinking with data justice and ethics - AI dataset should be created and used critically to avoid bias

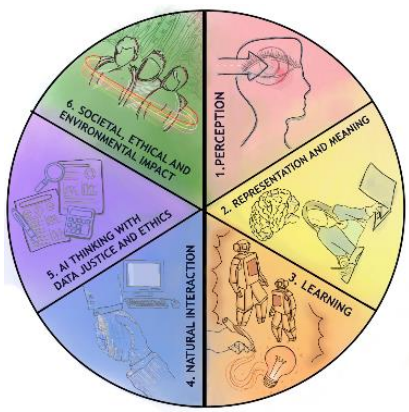

Figure 1. The Big Six Ideas designed by the researcher (adapted and modified from Touretzky et al., 2019)

As illustrated in the UNESCO report, AI literacy is an orientation of three main learning goals in AI curriculum, namely 1) AI foundations (i.e., Knowledge), 2) Understanding, using, and developing AI (i.e., Skills), and Ethics and social impact of AI (i.e., Attitudes and values to all humans, non-human and nature as proposed in this study) (Miao et al., 2021 & 2022). The AI curriculum framework design for primary education of this study (adapted from Su & Zhong, 2022) is then mapped to these three learning goals (Table 1).

Table 1. The AI curriculum framework (adopted from Su and Zhong, 2022)

AI Knowledge	AI Skills	AI Attitudes
K1: Definition of AI & examples of AI	S1: Using AI tools	A1: Societal impact A2: Global and Environmental Impact A3: Dialogic and collaborative with AI and humans
K2: The SIX Big Ideas in AI	S2: Computational Thinking	
K3: Machine Learning	S3: Communication and Collaboration	
K4: AI Applications	S4: Critical Thinking and Problem-Solving	
K5: AI Ethics and Data Justice	S5: Creativity	
	S6: AI Thinking with data justice and ethics	

The structure of the AI primary curriculum consists of six modules, which lasted for twelve weeks (Table 2). The six modules are 1) Basic AI, 2) Machine Learning, 3) Teachable Machine, 4) AI Applications and Implications 5) Group Arts-Project, and 6) Group Presentation and Dialogic Learning. Each module is designed with two 1.5-hour sessions. Each session has specific learning goals, learning tools, activities, and suggested assessment methods (Table 3).

Table 2. The structure of the arts-based AI primary curriculum

Modules	Knowledge	Skills	Attitudes/ Value	Level of Difficulty	Sample Learning Activity
Module 1: Basic AI	K1, K2	S5, S6	A1, A2, A3	1	Turing test, "Imagine AI and arts-making" activity "Quick and Draw" activity *https://quickdraw.withgoogle.com*;
Module 2: Machine Learning	K1, K3, K4, K5	S1, S2, S5, S6	A1, A2, A3	2	"Confusing the AI" activity, "Biasing the AI" activity MachineLearningforkids, RaspberryPi *https://machinelearningforkids.co.uk/* *https://www.raspberrypi.com/*
Module 3:	K1, K3, K4, K5	S1, S2,	A1, A2,	2	"Dance with the codes" activity

Teachable machine		S5, S6	A3		Google teachable machine *https://teachablemachine.withgoogle.com/*
Module 4: AI applications and implications	K1, K3, K4, K5	S1, S2, S5, S6	A1, A2, A3	2	"Draw Bot" activity Video, digital books and related learning material (e.g Better off Ted "Racial sensitivity", "Fake Obama") *https://www.youtube.com/watch?v=XyXNmiTIupg* https://www.youtube.com/watch?v=AmUC4m6w1wo Youtube redesign *https://www.media.mit.edu/*
Module 5: Group Arts-based Project	K1, K2, K3, K4, K5	S1, S2, S3, S4, S5, S6	A1, A2, A3	3	AI computer vision car, AI arts generation, computer visions and virtual space applications
Module 6: Group Presentation and Dialogic Learning	K1, K2, K3, K4, K5	S1, S2, S3, S4, S5, S6	A1, A2	3	AI computer vision car

Table 3. Six modules of AI primary curriculum

Module	**Lesson Goals**	**Pedagogical strategies**	**Assessment suggestions**
Module 1: Basic AI	Understand the what AI is, the history of AI, why now, any misconceptions, and Six Big Ideas	Arts-based	Knowledge test, survey, interview Artifacts- and arts-process assessment
Module 2: Machine Learning	Understand what is ML, how machines learn, the critical role of data (justice and ethics)	Arts-based, project-based	Artifacts, and arts-process -assessment
Module 3: Teachable machine	Apply with understanding of who can use ML, how ML is used, Why ML is used, and the importance of AI thinking in relation to data justice and ethics	Arts-based, project-based	Artifacts, and arts-process -assessment
Module 4: AI applications and implications	Understand, Create, and Evaluate the technologies underlying AI applications as well as their humanistic, societal, global environmental, ethical, and data justice implications	Arts-based, project-based	Knowledge tests, surveys, interviews
Module 5: Group Arts-based project	Applying knowledge, skills, and attitudes in group projects and solving a real-world challenge with	Arts-based, project-based	Artifacts, and arts-process -assessment

	the consideration of humans, non-human and nature orientation	
Module 6: Group Presentation and Dialogic Learning	Collaborate with humans and computers, be a problem solver	Project-based

Module One- Basic AI

The basic AI concepts will be introduced to primary students in the first module. Through the exploration of dynamic interactions of material discursive learning settings, the objective is to build a conceptual understanding of what AI is, understand the misconceptions, the history of AI, and the reasons for learning about AI literacy. The researcher designs the activities to allow the entanglement of arts-based AI learning contents, materials, and AI educational tools. For example, to recognize that learning can be a collective process of knowing, doing, and being (Barad, 2007), the activity of "Imagine AI and arts-making" is designed (Figure 2). It allows understanding of students' perceptions of AI (Mertala et al., 2022). The tools and platforms such as "Quick and Draw" (https://quickdraw.withgoogle.com/) are introduced (Tkáčová et al., 2020), which adopts a neural network artificial intelligence to guess what the drawings represent. Pietikäinen and Silven (2022) argue that the history of AI and the Turing Test is important as they can clearly explain what AI is and demonstrate the machine's intelligent behavior, equivalent to humans' (Figure 3). As such, educational tools such as ChatGPT will be used in the "Turing Test" activity for dialogic learning to enhance students' understanding of AI, data justice, and ethics issues.

Figure 2. The "Imagine AI and arts-making" activity designed by the researcher

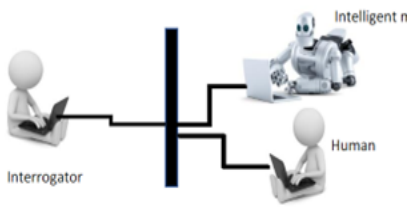

Figure 3: Turing Test (Pietikäinen and Silven 2022)

Module Two: Machine Learning

The learning objective of the second module is to understand what machine learning is, how machines learn with demonstrations and examples, and to evaluate or create a machine learning model to minimize any potential bias in the training datasets. Machine learning focuses on the use of data and algorithms to mimic how humans learn and improve automatically through experience, which is considered as a vital part of future computational skills (Jordan & Mitchell, 2015). Instead of relying on the explicitly hand-coded (e.g.if-then rules), many machine learning initiatives focus on using open-ended tools to guide primary students to train machine learning models by scaffolding the machine learning concept (Voulgari et al., 2021). "Machine Learning for Kids" allows students to understand basic block programming and explore the machine learning classification (Lane, 2021), while the use of Raspberry Pi helps to explore the machine learning data and its application (Norris, 2020). As machine learning is a subset of AI, a type of data-driven thinking, it aids the development of decision-making models based on various mathematical data sets, such as computer vision, face, voice, and text recognition (Webb et al., 2021). The "Confusing The AI" and "Biasing The AI" projects (Lane, 2021) will allow students to understand the unintentional and intentional bias involved in the data training that humans provide. The artifacts of their training models can be used as data collection for AI assessment.

Module Three: Teachable Machines

In the third module, the Google teachable machine will be introduced to students for creating and applying machine learning models. The learning objective is to allow students to understand who can use machine learning, how and why machine learning is used, and how AI thinking considers data justice and ethics. Google Teachable Machine is a viable and appropriate tool for students with little or no prior programming or related experience to learn AI (Prasad et al., 2022). Toivonen et al. (2020) reveal that using Google teachable machines to teach convolutional neural networks to classify images, voice, and text for understanding ML concepts in a primary school context is technologically and pedagogically feasible and effective. It is a web-based solution that combines powerful classification algorithms with an easy-to-use graphical user interface. It allows students to apply their knowledge, be actively involved in the machine learning training process, and become a designer and creators of their education (Prasad et al., 2022). This module will then adapt Carney et al. (2020) to use Google teachable machines for students to create, use their classification models, and explore enhancing the model's accuracy (Figure 4). The assessment can be drawn from the prediction accuracy of Google Teachable Machine based on the work of students (Figure 5).

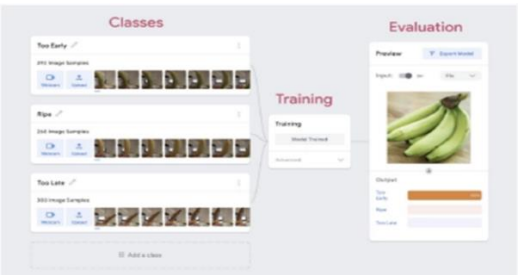

Figure 4. Teachable Machine Interface (Carney et al., 2020)

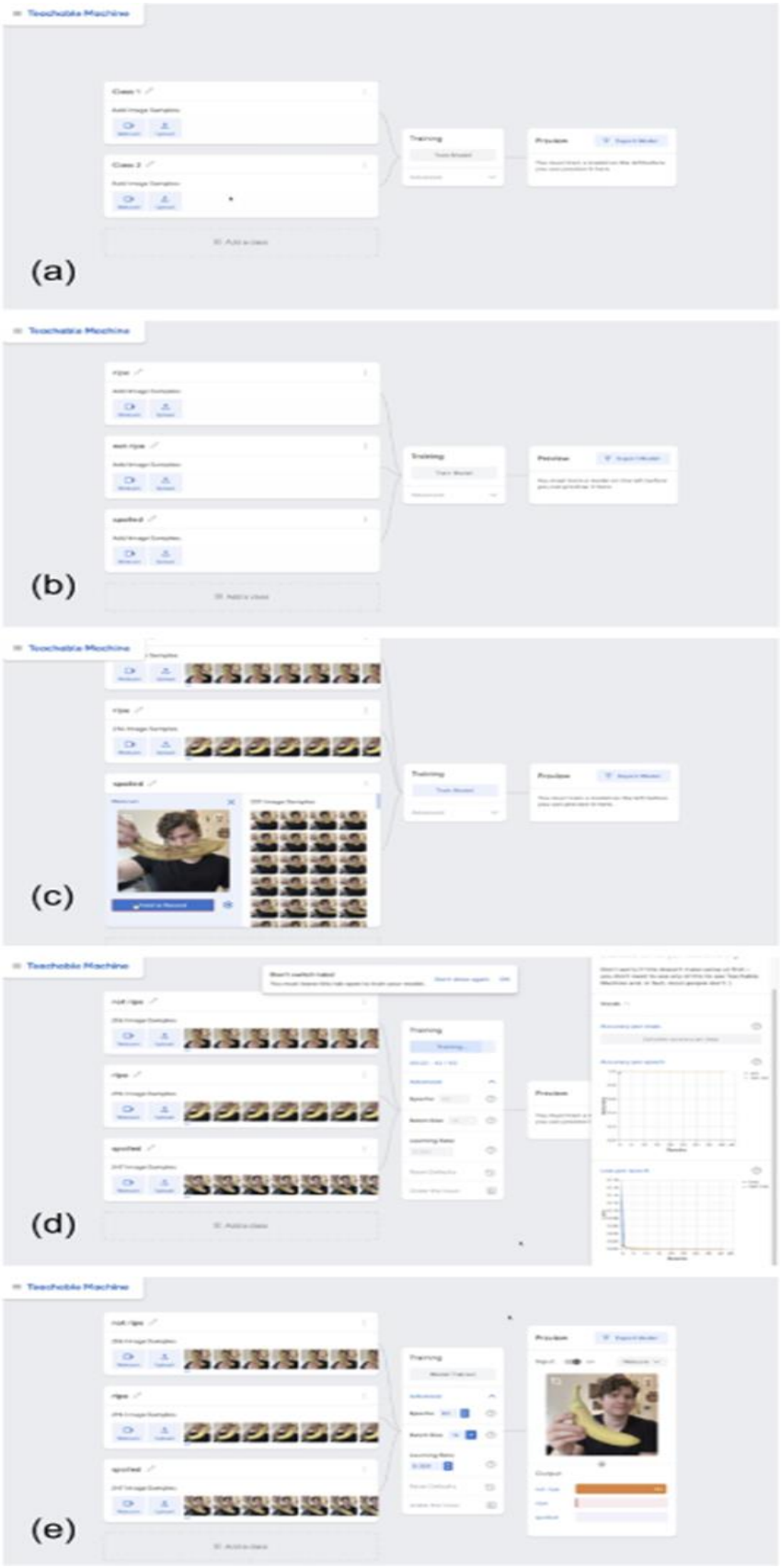

Figure 5. Teachable Machine Training Steps (Carney et al., 2020)

Module Four: AI applications and implications

AI has been applied in almost every aspect of life such as medical care, education, transportation and economy (Sestino & De Mauro, 2022). The learning objective of module four is to allow students to understand the technologies underlying AI applications as well as its humanistic, societal and ethical implications (Kaspersen et al., 2021). "Draw Bot" activity is designed to show students the AI light sensors embedded, which can be used for drawing line detention and the limitations of AI in relation to the data. Videos and digital books about the related AI applications learning resources will also be used in class. For example, the video of "Better off Ted Racial Sensitivity" illustrates the critical role of AI data justice and ethics by exploring the issue of AI aggravating existing social and racial discrimination in society. The video of "Fake Obama" that was created by the researcher of New York University which used AI tools to put any words into the synthetic Barack Obama's mouth (https://www.youtube.com/watch?v=AmUC4m6w1wo) will also be discussed. Students will engage in high-order thinking activities such as group discussions, opinion lessons and debates. "Youtube redesign" will be introduced to students to allow them to apply what they have learnt and construct an ethical matrix of Youtube recommendation algorithms. Through the identification of stakeholders and their values in algorithms, AI societal and ethical implications can be explained (Akgun & Greenhow, 2021).

Module Five: Group Arts-based Project

The learning objective of module five is to assemble and construct an AI intelligent vision car that allows students to apply their knowledge in a collaborative arts-based project to solve real-life challenges. Through the "Dance with codes" activity, students are introduced to the concept of AI algorithms and coding and designing steps for AI strategy to complete a task. An AI computer vision car will then be introduced in this module (Figure 6). It is a robotic vehicle kit based on a graphical, block, and Python program. It requires students to assemble and train the model with road signage, number, color, tag, and landmarks recognition data. The teaching task decomposition and teaching points of this project are shown in Table 4. Students will be asked to form a group and design an AI road map with safety measures with human and non-human orientations for an AI self-driving game to demonstrate their application of knowledge, skills, and attitudes. Through peer collaboration and dialogic human-computer interactions, it provides opportunities for students to engage in high-order thinking and examine the power and threats of AI.

Figure 6. The example of "AI Computer Vision Car"

Table 4. The teaching decomposition of "AI Computer Vision Car"

Project	Teaching task decomposition	Teaching Points
AI	assemble and construct a AI intelligent vision robot car	A hands-on project to stimulate students' interests to learn, collaborate with teams and be a problem solver as well as know how to communicate across different technology platforms.
Computer Vision Car	Block-based programming	use block-based programming that allow students to develop their computational thinking skills
	AI recognition such as Road Signage, Number, Color and tag/landmark recognition	Allow students to input data to train the model to recognize Road Signage, Number, Color, Tag and landmarks recognition
	AI vision tracking	Apply AI recognition, students design their AI traffic map for AI computer vision car game so as to enhance student ability of comprehensive application of knowledge as well as understand the AI thinking in relations to data justice and ethics
	AI ethics and data justice	Through learning from design. Dialogic learning with AI and all humans. Students should be able to understand the benefits and threats of this AI computer vision car to society

This curriculum design has incorporated projects with arts-based pedagogy in the learning process. This project is adopted from the seven-phase project-based learning model of Jalinus et al. (2017), which summarizes the core elements to enhance students' competencies through real learning experiences following problems and needs (Table 5).

Table 5. Seven-phase project-based learning (adopted from Jalinus et al., 2017)

Project-based learning	Seven Steps	Using AI Computer vision car as an example
Skills Competency debriefing	1. The formulation of expected outcome	By using a contextual teaching and learning approach and motivate students to make connection between the knowledge and the real world situation (e.g. the conceptual understanding of AI algorithms and codings are introduced through embodied interaction and dance)
	2. Understanding the teaching materials	Students actively involved in discussions about AI Computer vision car and its functions being studied as an instructional media (e.g.Al vision for color, label and number recognition)
	3. Skills training	Through demonstration and practice, students master the technical content and operational machinery skills before carry out the project tasks (e.g.graphical, block and Python programming)
Project work	4. Designing the project theme	Discuss, identify and define the real-world challenges as the theme of the project tasks through sources of information such as interviews and

		internet sites. (e.g. students design the AI roadmap with safety measures in relation to human and non-human orientation for AI computer vision cars).
	5.Making the project proposal	It consists of problems and solutions, availability, cost and suitability of resources for production.
	6.executing the tasks of project s	Practical activity required team works, carry out the learning process through inquiry investigation and constructing work on project tasks
Evaluation	7. Presentation of the project report	Students present own perception, evaluate one another critically, learn from feedback and reflection

Module Six: Group Presentation and Dialogic Learning

The last module aims to provide an opportunity for students to share their collaborative production experience by creating complex artifacts and presenting their solutions in physical and virtual collaboration spaces (Figure 7). Students will be asked to form a team to promote collaboration and communication. They must formulate the expected outcome, understand the teaching materials, practice skills, create AI arts, design the project, and execute it following their roles. Encouraging students to construct their artifacts for assessment, examine and question the trustworthiness of AI applications, and present their solutions in real-life context skills (Long & Magerko, 2020) and in virtual space can develop their critical thinking and problem-solving. Reflection on their dialogic learning process with AI and peers and presentation of their artifacts can demonstrate their AI literacy development while improving social interaction.

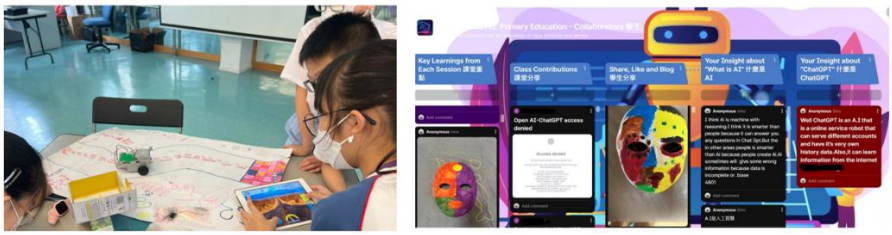

Figure 7: Collaborative arts-based projects presentation and dialogic learning

Suggestions on Assessment

As suggested by UNESCO (Miao et al., 2021 & 2022), the goals and learning outcomes of AI curricula should focus on the knowledge, values, and skills needed not only for schools but also for work and life in the AI era. Researchers face challenges in scaffolding young students to understand AI concepts due to technical complexity and the fact that most students do not have prior AI knowledge (Steinbauer et al., 2021). As AI learning assessments have not yet been rigorously validated (Su et al., 2022), this study suggests using a mixed method not for selection but for improving learning and teaching for sustainability.

First, pre and post-tests are designed by the researcher based on the arts-based AI curriculum to assess students's knowledge (Table 6), which can become an effective assessment method to understand their learning outcomes in AI knowledge and skills (Lin et al., 2020). Second, it is found that students need to have self-efficacy, AI readiness, AI for social goods, and behavioral intention to promote the development of their AI literacy (Ayanwale et al., 2022; Chat et al., 2021a). They acknowledge teachers' and students' perceived readiness to teach and learn AI, respectively, and their willingness to be engaged in AI literacy education in the long run (Chai et al., 2020a; Chai et al., 2021). Third, interviews with teachers are needed to support their voices for the readiness of AI literacy teaching (Clark, 2011), as teachers' efforts and classroom practices are indispensable in AI education (Roll & Wylie, 2016). Fourth, an artifacts creativity process assessment is recommended. This assessment is an observation based on the international OECD assessment rubric for evaluating the arts-making and learning process and the artifacts so that teachers can give feedback, understand students' performance, and propose better teaching strategies (Vincent-Lancrin et al., 2019). A diversity of assessment methods is suggested to bridge the learning gap following students' demonstrated needs. At the same time, these measurable applications can triangulate students' AI literacy learning outcomes (Kandlhofer et al., 2016).

Table 6. AI Knowledge Test designed by the researcher

Knowledge Test Questions	**Correct Answer**
1. All robots are Artificial Intelligence?	FALSE
2. Which of the following is (are) correct?	(I), (II) and (III)
(I) Artificial means "non-human"	-
(II) Artificial means "not just machine"	-
(III) Intelligence means "intellectual power such as strength, speed, specific knowledge a particular task required"	-
(IV) Intelligence means "omniscient, all knowing and perfect"	-
3. Which of the following is (are) the Big Six ideas of AI	(D)
A. Perception, representation and reasoning,	-
B. Learning, natural interaction,	-
C. AI thinking with data justice and ethics	-
D. All of the above (correct answer)	-
4. What does the "Imagine AI and arts making" project help you to understand?	(A)
A. The conceptual understand of what is AI literacy meant to me (correct answer)	-
B. The history of Artificial intelligence development	-
C. The limitations of AI	-
D. The AI technologies are ubiquitous in daily lives	-
5. What does the "Quick and Draw" AI applications help you to understand?	(I), (II) and (III)
(I). An online game developed by Google	-
(II). It challenges me to draw a picture of an object or	-
(III). It uses a neural network artificial intelligence to guess what my drawings represent	-
6. What does the "Draw Bot" AI educational tool help you to understand?	(I), (II) and (III)
(I). A robot that follows the black line I draw	-

(II). Light sensors help to trace Draw Bot detect and trace the black trail automatically	-
(III). I can learn while drawing	-
7. What does the "Dance with the codes" project help you to understand?	(I), (II) and (III)
(I). The conceptual understand of what is artificial intelligence algorithm (correct answer)	-
(II). The steps to AI strategy to complete a task	-
(III). How does coding work	-
8.Who is the father of Artificial Intelligence?	Alan Turing
9. What kind of jobs will not likely be replaced by Artificial Intelligence	(C)
A. Taxi driver	-
B. Warehouse worker	-
C. Computer Scientist (correct answer)	-
D. Customer service representative	-
10.Which of the following test can examine whether a machine is intelligent?	Turing Test
11.Which of the following is the reason for promoting the development of AI?	(D)
A. Big data, and increased computing power	-
B. The development of cloud network	-
C. The cost of hardware has lowered.	-
D. All of the above (correct answer)	-
12. Which of the following innovative applications is (are) promoted by Artificial intelligence and machine learning ?	(D)
A. Facial recognition	-
B. Natural language processing	-
C. Virtual assistants	-
D. All of the above (correct answer)	-
13.A simple Artificial Intelligence neural network has at least ____ layer(s)	Three
14. Which of the following applications uses AI technology?	(D)
A. Self-driving car	-
B. ChatGPT	-
C. Drawing Bot	-
D. All of the above (correct answer)	-
15. Which of the following is the main machine learning method used by Google Teachable Machine?	Supervised learning
16. Which method of Machine Learning is used for Alpha Go	Reinforcement learning
17. Which of the followings can be data sets of Artificial Intelligence?	(D)
A. Text, Words, Symbols	-
B. Image	-
C. Voice	-
D. All of the above (correct answer)	-
18. Put the event of machine learning in a correct order machine learning	3.1.2.4

1) Pattern recognition	-
2) Key features extraction	-
3) Data collection	-
4) Decision making	-
19. What should we consider when using AI applications?	(D)
A. The purpose and necessity of data collection	-
B. The protection of the personal data privacy	-
C. The safety storage of data	-
D. All of the above (correct answer)	-
20. Which of the following industries use AI-enabled applications?	(D)
A. Banking industry	-
B. Law and legal services	-
C. Human resources	-
D. All of the above (correct answer)	-
21. Which of the following is (are) the potential problem of AI-powered language model such as ChatGPT?	-
A. Accuracy problems	(D)
B. Discrimination and bias response	-
C. Plagiarism and cheating	-
D. All of the above (correct answer)	-
22. What does the “Confusing the AI project” help you to understand	(D)
A. Machine learning systems are not perfect or all-knowing	-
B. Unintentional bias are introduced by the training that human give them	-
C. It is important to have variation in training sets	-
D. All of the above (correct answer)	-
23. What does the “Biasing the AI project” help you to understand	(D)
A. Intentional bias are introduced by the training that human give them	-
B. The societal and ethical issues related to how AI systems are used	-
C. It is important to have a transparency and disclosure of how machine learning systems are trained	-
D. All of the above (correct answer)	-
24.What are the most common issues about Artificial Intelligence	(D)
A. Data Bias and injustice	-
B. Black box in nature	-
C. Require Big Data for potential exploitation of human and natural resources	-
D. All of the above (correct answer)	-
25.Which of the following tool(s) or application(s) can be used to create machine learning models	(C)
A. YouTube	-
B. Draw Bot	-

C. Machine learning for kids (https://machinelearningforkids.co.uk/) (correct answer)	-
D. Quick and Draw (https://quickdraw.withgoogle.com/)	-

Findings and Discussions

Summary of findings

The study's findings reveal the learning content of AI curriculum design from a holistic perspective with the appropriate pedagogical strategy and assessment mechanism in its implementation in primary school settings. First, this curriculum design has incorporated the domains of learning content, which are 1) Basic AI, 2) Machine Learning, 3) AI technologies such as teachable machines and 4) AI applications, 5) AI societal, ethical, and environmental implications through engaging students to learn AI literacy as well as 6) the AI thinking with the consideration of data justice and ethics in group projects. Previous studies reveal that AI foundations for knowledge (Chai et al., 2021; Lee et al., 2020), use and application of AI skills (Ho et al., 2019; Li & Song, 2019); the machine learning principles and application (Shamir & Levin, 2021; Toivonen et al., 2020), and AI thinking with data justice and ethics (Akgun & Greenhow, 2021; Melsion et al., 2021) are important learning content that should be included in AI education at the primary school level.

Second, the findings reveal that arts-based is an age-appropriate and engaging strategy often absent in AI literacy learning. At the same time, projects are often used to scaffold AI concepts such as rule-based if-then statements and big data concepts (Ho et al., 2019) and to demystify machine learning principles (Toivonen et al., 2020). It offers authentic experiences and promotes active learning, such as controlling a toy car on a physical track to learn about convolutional neural networks (Narahara & Kobayashi, 2018) and building a number-guessing robot to understand the optimization algorithm of machine learning (Ho et al., 2019). Toivonen et al. (2020) conducted a series of co-design machine learning projects with primary school students using teachable machine learning. These projects are well-received. The result validates that a teachable machine is an effective tool in teaching machine learning principles such as training data sets, prediction accuracy, and class labels, even for primary school students.

Thirdly, under the current primary landscape, self-report surveys (Chai et al., 2021; Dai et al., 2020), artifact-based assessments (Li & Song, 2019) and interviews (Lee et al., 2020; Ottenbreit-Leftwich et al., 2021) is often used in data collection procedures, whereas the use of games and competitions (Voulgari et al., 2021) has increased in data collection for assessment purposes. These studies reveal the inadequacy of rubric-based and evaluative mechanisms to analyze artifacts created by the students. Apart from Ali et al. (2019), who mentioned the Torrance test for assessment, only a few studies used pre- and post-test or knowledge measures (Rodríguez-Garciá et al., 2021; Toivonen et al., 2020) to assess the learning outcomes of AI literacy. To assess students' AI literacy, this study reveals that a mixed method, including interviews, artifacts assessments, pre- and post-questionnaires, and knowledge tests, could be used. It is expected that measurable applications, in conjunction with qualitative evidence of this assessment suggestion, can triangulate students' AI literacy learning across affective, behavioral, and cognitive domains.

Discussions

This study aims to design a holistic AI curriculum framework, as well as a pedagogical strategy and assessment method, to promote AI literacy among primary school students and inspire them to create projects using AI technology. Previous studies focus on AI learning tools and platforms such as Google Teachable Machine (Toivonen et al., 2020) and LearningML (Rodríguez-Garciá et al., 2020). Still, the design of AI curriculum and activities for young students have received less attention (Chiu & Chai, 2020). This study designs an AI curriculum with the inclusion of six modules, which are 1) Basic AI; 2) Machine Learning; 3) Teachable Machine; 4) AI Applications and Tools; 5) Group Arts-based Project; and 6) Group Presentation and Dialogic Learning. The proposed AI curriculum is believed to enhance students' AI knowledge and literacy skills. The collaborative nature of the arts-based learning approach helps students to develop 21st-century skills such as collaborative skills, communication skills, critical skills, and problem-solving skills (Colucci-Gray et al., 2019).

This study also designs an AI curriculum for primary education, which incorporates three main learning orientations: AI knowledge, skills, and AI thinking with data justice and ethics as well as its societal, ethical, and environmental impacts. Bozkurt et al. (2021), who reviewed studies of AI education from 1970 to 2020, showed a dearth of literature dealing with AI ethics. There should be a stronger emphasis on AI ethics in AI literacy education. This curriculum framework assists in the improvement of the teaching of AI ethics to young children to combat disinformation and bias (Kandlhofer et al., 2016), educate on AI-ethics issues (Ali et al., 2019), and embrace the value of human creativity (Ouyang & Jiao, 2021).

This study proposes various assessment methods with goals other than selection, specifically ensuring sustainable learning for work and life in the AI era (Miao, 2022) and bridging the learning gap by demonstrating needs. Furthermore, in addition to pre and post-tests for AI knowledge, the content suitability of AI curriculum surveys designed by the researcher and a diversity of assessment methods such as perception questionnaires, interviews, and artifact assessments may be considered.

Conclusion and Limitations

AI literacy education in the primary education context is still in its infancy. This study proposes future directions for researchers and educators by designing an AI primary education curriculum with the critical role of data in learning content, arts-based pedagogical strategy, teaching activities and learning tools, and assessment suggestions. It incorporates three main learning orientations: AI knowledge, skills, AI thinking for data justice, and attitudes, which allow students to meet the needs of the 21st century.

This study has two major contributions. First, by adding the new element of AI thinking with the considerations of data justice and ethics into the existing theoretical AI literacy framework, this research presents a holistic and inclusive AI curriculum for primary school students, with the considerations of all humans, non-humans, and nature. Second, this curriculum can demystify AI concepts and skills traditionally taught at secondary schools and universities. The educational implication is that it may empower students with the agency for critically

creating and evaluating AI models while considering minimizing any potential bias and its societal, ethical, and environmental implications. Since studies on AI curriculum in primary education are insufficient in the existing literature, this study serves as a valuable reference and guideline for future researchers. Furthermore, using a group arts-based pedagogical approach, this study empowers students with AI literacy, inspires them to create projects using AI technology, and be responsible AI citizens in the AI era of the twenty-first century.

This study presents a well-designed arts-based AI primary curriculum with an arts-based pedagogy and the inclusion of AI thinking for data justice to scaffold knowledge, skills, and attitudes to primary school students. However, there is no data to support the effectiveness of its implementation, nor does it provide results indicating reliability and validity. Although many researchers and governments have realized the importance of making AI literacy education accessible for all, the curriculum design still needs a rigorous examination and regular evaluation. Evaluation methods such as pilot testing, expert reviews, and external evaluation can help develop ways to enhance the pedagogical and instructional design of this proposed AI literacy curriculum.

Acknowledgments or Notes

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Adam, A. (2006). *Artificial knowing: Gender and the thinking machine*. Routledge.

Akgun, S., & Greenhow, C. (2021). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics, 2*(3), 431-440.

Ali, S., Payne, B. H., Williams, R., Park, H. W., & Breazeal, C. (2019, June). Constructionism, ethics, and creativity: Developing primary and middle school artificial intelligence education. In *International workshop on education in artificial intelligence k-12 (eduai'19)* (pp. 1-4).

Atenas, J., Havemann, L., Kuhn, C., & Timmermann, C. (2023). Critical data literacy in higher education: teaching and research for data ethics and justice. In *Data Cultures in Higher Education: Emergent Practices and the Challenge Ahead* (pp. 293-311). Cham: Springer International Publishing.

Ayanwale, M. A., Sanusi, I. T., Adelana, O. P., Aruleba, K. D., & Oyelere, S. S. (2022). Teachers' readiness and intention to teach artificial intelligence in schools. *Computers and Education: Artificial Intelligence, 3*, 100099.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education, 5*(6), 66-70.

Benjamin, R. (2020). Race after technology: Abolitionist tools for the new jim code.

Braidotti, R. (2019). A theoretical framework for the critical posthumanities. *Theory, Culture & Society, 36*(6), 31-61.

Bozkurt, A., Karadeniz, A., Baneres, D., Guerrero-Roldán, A. E., & Rodríguez, M. E. (2021). Artificial intelligence and reflections from educational landscape: a review of AI studies in half a century.

Sustainability, *13*(2), 800.

Burgsteiner, H., Kandlhofer, M., & Steinbauer, G. (2016, March). Irobot: Teaching the basics of artificial intelligence in high schools. In *Proceedings of the AAAI conference on artificial intelligence* (Vol. 30, No. 1).

Carney, M., Webster, B., Alvarado, I., Phillips, K., Howell, N., Griffith, J., ... & Chen, A. (2020, April). Teachable machine: Approachable Web-based tool for exploring machine learning classification. In *Extended abstracts of the 2020 CHI conference on human factors in computing systems* (pp. 1-8).

Chai, C., Lin, P., Jong, M., Dai, Y., & Chiu, T. (2020a). Primary students' readiness for learning of artificial intelligence: A case study in Beijing. In *Proceedings of the 28th international conference on computers in education. Australia: Asia-pacific Society for Computers in education*.

Chai, C. S., Lin, P. Y., Jong, M. S. Y., Dai, Y., Chiu, T. K., & Huang, B. (2020b). Factors Influencing Students' Behavioral Intention to Continue Artificial Intelligence Learning. In *2020 International Symposium on Educational Technology (ISET)* (pp. 147-150). IEEE.

Chai, C. S., Lin, P. Y., Jong, M. S. Y., Dai, Y., Chiu, T. K., & Qin, J. (2021). Perceptions of and behavioral intentions towards learning artificial intelligence in primary school students. *Educational Technology & Society*, *24*(3), 89-101.

Chiu, T. K., Meng, H., Chai, C. S., King, I., Wong, S., & Yam, Y. (2021b). Creation and evaluation of a pretertiary artificial intelligence (AI) curriculum. *IEEE Transactions on Education*.

Clark, J. (2011). Using Diamond Ranking activities as a visual methods research tool. In *BERA Visual Methods Seminar*. Newcastle University.

Colucci-Gray, L., Burnard, P., Gray, D., & Cooke, C. (2019). A critical review of STEAM (science, technology, engineering, arts, and mathematics). *Oxford Research Encyclopedia of Education*.

Crawford, K. (2021). *The atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.

Crutzen, P. J. (2016). Geology of mankind. *Paul J. Crutzen: A pioneer on atmospheric chemistry and climate change in the Anthropocene*, 211-215.

Dai, Y., Chai, C. S., Lin, P. Y., Jong, M. S. Y., Guo, Y., & Qin, J. (2020). Promoting students' well-being by developing their readiness for the artificial intelligence age. *Sustainability*, *12*(16), 6597.

Dai, Y., Lin, Z., Liu, A., & Wang, W. (2023). An embodied, analogical and disruptive approach of AI pedagogy in upper elementary education: An experimental study. *British Journal of Educational Technology*.

Eguchi, A., Okada, H., & Muto, Y. (2021). Contextualizing AI education for K-12 students to enhance their learning of AI literacy through culturally responsive approaches. *KI-Künstliche Intelligenz, 35*(2), 153-161.

Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Vayena, E. (2018). AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations. *Minds and Machines, 28*(4), 689-707.

Gong, X., Tang, Y., Liu, X., Jing, S., Cui, W., Liang, J., & Wang, F. Y. (2020, October). K-9 Artificial Intelligence education in Qingdao: Issues, challenges and suggestions. In *2020 IEEE International Conference on Networking, Sensing and Control (ICNSC)* (pp. 1-6). IEEE.

Fiedler, K. (2023). Teaching Students to Question: Dialogic Teaching in the Age of Artificial Intelligence.

Guitert, M., Romeu, T., & Baztán, P. (2021). The digital competence framework for primary and secondary schools in Europe. *European Journal of Education, 56*(1), 133-149.

Hagendorff, T. (2020). The ethics of AI ethics: An evaluation of guidelines. *Minds and Machines, 30*(1), 99-120.

Heinze, C. A., Haase, J., & Higgins, H. (2010, July). An action research report from a multi-year approach to teaching artificial intelligence at the k-6 level. In *First AAAI Symposium on Educational Advances in Artificial Intelligence*.

Hetherington, L., Hardman, M., Noakes, J., & Wegerif, R. (2018). Making the case for a material-dialogic approach to science education. *Studies in Science Education, 54*(2), 141-176.

Ho, J. W., Scadding, M., Kong, S. C., Andone, D., Biswas, G., Hoppe, H. U., & Hsu, T. C. (2019, June). Classroom activities for teaching artificial intelligence to primary school students. In *Proceedings of International Conference on Computational Thinking Education* (pp. 157-159).

Hoffman, S. G., Joyce, K., Alegria, S., Bell, S. E., Cruz, T. M., Noble, S. U., ... & Smith-Doerr, L. (2022). Five big ideas about AI. *Contexts, 21*(3), 8-15.

How, M. L., Cheah, S. M., Chan, Y. J., Khor, A. C., & Say, E. M. P. (2020). Artificial intelligence-enhanced decision support for informing global sustainable development: A human-centric AI-thinking approach. *Information, 11*(1), 39.

Jalinus, N., Nabawi, R. A., & Mardin, A. (2017). The seven steps of project based learning model to enhance productive competences of vocational students. In *International Conference on Technology and Vocational Teachers (ICTVT 2017)* (pp. 251-256). Atlantis Press.

Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. *Science, 349*(6245), 255-260.

Kandlhofer, M., Steinbauer, G., Hirschmugl-Gaisch, S., & Huber, P. (2016, October). Artificial intelligence and computer science in education: From kindergarten to university. In *2016 IEEE Frontiers in Education Conference (FIE)* (pp. 1-9). IEEE.

Kanemune, S., Shirai, S., & Tani, S. (2017). Informatics and programming education at primary and secondary schools in Japan. *Olympiads in Informatics, 11*(1), 143-150.

Kong, S. C., Lai, M., & Li, Y. (2023). Scaling up a teacher development programme for sustainable computational thinking education: TPACK surveys, concept tests and primary school visits. *Computers & Education, 194*, 104707.

Kreinsen, M., & Schulz, S. (2021, October). Students' conceptions of artificial intelligence. In *The 16th workshop in primary and secondary computing education* (pp. 1–2).

Lane, D. (2021). *Machine learning for kids: A project-based introduction to artificial intelligence*. No Starch Press.

Lao, N. (2020). *Reorienting machine learning education towards tinkerers and ML-engaged citizens* (Doctoral dissertation, Massachusetts Institute of Technology).

Lee, S., Mott, B., Ottenbriet-Leftwich, A., Scribner, A., Taylor, S., Glazewski, K., ... & Lester, J. (2020, June). Designing a Collaborative Game-Based Learning Environment for AI-Infused Inquiry Learning in Elementary School Classrooms. In *Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 566-566).

Li, K., & Song, S. (2019, June). Application of Artificial Intelligence in Primary and Secondary Schools: A Case

Study of Scratch. In *International Conference on Applications and Techniques in Cyber Security and Intelligence* (pp. 2026-2030). Springer, Cham.

Lin, P. Y., Chai, C. S., Jong, M. S. Y., Dai, Y., Guo, Y., & Qin, J. (2021). Modeling the structural relationship among primary students' motivation to learn artificial intelligence. *Computers and Education: Artificial Intelligence*, *2*, 100006.

Long, D., & Magerko, B. (2020, April). What is AI literacy? Competencies and design considerations. In *Proceedings of the 2020 CHI conference on human factors in computing systems* (pp. 1-16).

Ma, L., Luo, H., Liao, X., & Li, J. (2022). Impact of Gender on STEAM Education in Elementary School: From Individuals to Group Compositions. *Behavioral Sciences*, *12*(9), 308.

Mathe, S. E., Pamarthy, A. C., Kondaveeti, H. K., & Vappangi, S. (2022, February). A review on raspberry pi and its robotic applications. In *2022 2nd International Conference on Artificial Intelligence and Signal Processing (AISP)* (pp. 1-6). IEEE.

Martínez Moreno, J., Santos, P., & Hernandez-Leo, D. (2021, October). Maker Education in Primary Education: Changes in Students' Maker-Mindset and Gender Differences. In *Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'21)* (pp. 120-125).

McCarthy, J. (2007). From here to human-level AI. *Artificial Intelligence*, *171*(18), 1174-1182. https://doi.org/10.1016/j.artint.2007.10.009

McStay, A., & Rosner, G. (2021). Emotional artificial intelligence in children's toys and devices: Ethics, governance and practical remedies. *Big Data & Society*, *8*(1), 2053951721994877.

Melsión, G. I., Torre, I., Vidal, E., & Leite, I. (2021, June). Using Explainability to Help Children Understand Gender Bias in AI. In *Interaction Design and Children* (pp. 87-99).

Mertala, P., Fagerlund, J., & Calderon, O. (2022). Finnish 5th and 6th grade students' pre-instructional conceptions of artificial intelligence (AI) and their implications for AI literacy education. *Computers and Education: Artificial Intelligence*, *3*, 100095.

Miao, F., Holmes, W., Huang, R., & Zhang, H. (2021). *AI and education: A guidance for policymakers*. UNESCO Publishing.

Miao, F., & Shiohira, K. (2022). K-12 AI curricula. A mapping of government-endorsed AI curricula.

Nadeem, A., Marjanovic, O., & Abedin, B. (2022). Gender bias in AI-based decision-making systems: a systematic literature review. *Australasian Journal of Information Systems*, *26*.

Narahara, T., & Kobayashi, Y. (2018). Personalizing homemade bots with plug & play AI for STEAM education. In *SIGGRAPH Asia 2018 Technical Briefs* (pp. 1-4).

Ng, D. T. K., Leung, J. K. L., Chu, K. W. S., & Qiao, M. S. (2021). AI literacy: definition, teaching, evaluation and ethical issues. In *Proceedings of the Association for Information Science and Technology*, *58*(1), 504-509.

Ng, D. T. K., Luo, W. Y., Chan, H. M. Y., & Chu, S. K. W. (2022). An examination on primary students' development in AI Literacy through digital story writing. *Computers & Education: Artificial Intelligence*, 100054.

Norris, D. J. (2020). Machine Learning with the Raspberry Pi. Berkeley, CA: Apress.

Ottenbreit-Leftwich, A., Glazewski, K., Jeon, M., Hmelo-Silver, C., Mott, B., Lee, S., & Lester, J. (2021, March). How do Elementary Students Conceptualize Artificial Intelligence?. In *Proceedings of the 52nd ACM*

Technical Symposium on Computer Science Education (pp. 1261-1261).

Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence, 2*, 100020.

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2019). Exploring children's learning experience in constructionism-based coding activities through design-based research. *Computers in Human Behavior, 99*, 415-427.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). Artificial intelligence in education: Challenges and opportunities for sustainable development.

Pietikäinen, M., & Silven, O. (2022). Challenges of Artificial Intelligence--From Machine Learning and Computer Vision to Emotional Intelligence. arXiv preprint arXiv:2201.01466.

Pfeuffer, N., Benlian, A., Gimpel, H., & Hinz, O. (2019). Anthropomorphic information systems. *Business & Information Systems Engineering, 61*, 523-533.

Prasad, P. Y., Prasad, D., Malleswari, D. N., Shetty, M. N., & Gupta, N. Implementation of Machine Learning Based Google Teachable Machine in Early Childhood Education. *International Journal of Early Childhood*, *14*(3), 2022.

Raffaghelli, J. E., & Gouseti, A. (2021). Exploring critical digital literacy dimensions: Data literacy.

Rodríguez-García, J. D., Moreno-León, J., Román-González, M., & Robles, G. (2020, October). Introducing artificial intelligence fundamentals with LearningML: Artificial intelligence made easy. In *Eighth international conference on technological ecosystems for enhancing multiculturality* (pp. 18-20).

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education, 26*, 582-599.

Sakulkueakulsuk, B., Witoon, S., Ngarmkajornwiwat, P., Pataranutaporn, P., Surareungchai, W., Pataranutaporn, P., & Subsoontorn, P. (2018, December). Kids making AI: Integrating machine learning, gamification, and social context in STEM education. In *2018 IEEE international conference on teaching, assessment, and learning for engineering (TALE)* (pp. 1005-1010). IEEE.

Seldon, A., & Abidoye, O. (2018). *The fourth education revolution*. Legend Press Ltd.

Sestino, A., & De Mauro, A. (2022). Leveraging artificial intelligence in business: Implications, applications and methods. *Technology Analysis & Strategic Management*, *34*(1), 16-29.

Shamir, G., & Levin, I. (2021). Neural network construction practices in elementary school. *KI-Künstliche Intelligenz, 35*(2), 181-189.

Shamir, G., & Levin, I. (2022). Teaching machine learning in elementary school. *International Journal of Child-Computer Interaction, 31*, 100415.

Solyst, J., Xie, S., Yang, E., Stewart, A. E., Eslami, M., Hammer, J., & Ogan, A. (2023, April). "I Would Like to Design": Black Girls Analyzing and Ideating Fair and Accountable AI. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-14).

Steinbauer, G., Kandlhofer, M., Chklovski, T., Heintz, F., & Koenig, S. (2021). A differentiated discussion about AI education K-12. *KI-Künstliche Intelligenz, 35*(2), 131-137.

Su, J., & Zhong, Y. (2022). Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. Computers and Education: *Artificial Intelligence, 3*, 100072.

Su, J., Zhong, Y., & Ng, D. T. K. (2022). A meta-review of literature on educational approaches for teaching AI

at the K-12 levels in the Asia-Pacific region. *Computers and Education: Artificial Intelligence*, 100065.

Taguma, M., Feron, E., & Lim, M. H. (2018, October 29-31). Future of education and skills 2030: conceptual learning framework [Paper presentation]. *Education and AI: preparing for the future & AI, Attitudes and Values*, OECD Conference Centre, Paris, France.

Thomas, J. A., Williams, M., & Zalasiewicz, J. (2020). *The anthropocene: A multidisciplinary approach*. John Wiley & Sons.

Tkáčová, Z., Šnajder, L. U., & Guniš, J. (2020, October). Artificial Intelligence–a new topic in Computer Science curriculum at primary and secondary schools: challenges, opportunities, tools and approaches. In *2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO)* (pp. 747-749). IEEE.

Toivonen, T., Jormanainen, I., Kahila, J., Tedre, M., Valtonen, T., & Vartiainen, H. (2020, July). Co-designing machine learning apps in K–12 with primary school children. In *2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT)* (pp. 308-310). IEEE.

Touretzky, D., Martin, F., Seehorn, D., Breazeal, C., & Posner, T. (2019, February). Special session: AI for K-12 guidelines initiative. In *Proceedings of the 50th ACM technical symposium on computer science education* (pp. 492-493).

Touretzky, D. S., & Gardner-McCune, C. (2021). Artificial Intelligence Thinking in K-12. In S. C. Kong & H. Abelson (Eds.), *Computational Thinking Education in K-12: Artificial Intelligence Literacy and Physical Computing*. Cambridge, MA: The MIT Press.

Touretzky, D., Gardner-McCune, C., & Seehorn, D. (2022). Machine learning and the five big ideas in AI. *International Journal of Artificial Intelligence in Education*, 1-34.

Vartiainen, H., Tedre, M., & Valtonen, T. (2020). Learning machine learning with very young children: Who is teaching whom? *International Journal of Child-Computer Interaction, 25*, 100182.

Voulgari, I., Zammit, M., Stouraitis, E., Liapis, A., & Yannakakis, G. (2021, June). Learn to machine learn: designing a game based approach for teaching machine learning to primary and secondary education students. In *Interaction design and children* (pp. 593-598).

Webb, M. E., Fluck, A., Magenheim, J., Malyn-Smith, J., Waters, J., Deschênes, M., & Zagami, J. (2021). Machine learning for human learners: opportunities, issues, tensions and threats. *Educational Technology Research and Development, 69*(4), 2109-2130.

Yang, W. (2022). Artificial intelligence education for young children: Why, what, and how in curriculum design and implementation. Computers and Education: *Artificial Intelligence, 3*, 100061.

Zeng, D. (2013). From Computational Thinking to AI Thinking [A letter from the editor]. *IEEE Intelligent Systems*, *28*(06), 2-4.

Zhakata, N. (2022). Creativity in the Fourth Industrial Curricula with Artificially Intelligent Technologies. In *Proceedings of NEMISA Summit and Colloquium* (Vol. 4, pp. 102-109).

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Citation

Yim, I. H. Y. (2023). Design of artificial intelligence (AI) education for primary schools: Arts-based approach. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 65-90). ISTES Organization.

Chapter 6 - A Model of Pedagogical AI-Enabled Smart Learning Environment

Yusufu Gambo

Chapter Highlights

- This chapter explores how advancements in smart and mobile technologies are reshaping traditional learning environments. It delves into the concept of smart learning environments, which adapt and provide support to learners based on their individual behaviors and needs.
- It discusses the role of technology in personalizing learning experiences, emphasizing the importance of adapting content, providing feedback, and addressing real-world contexts to meet the diverse needs of learners.
- This section reviews various models of smart learning environments developed in the literature, highlighting their strengths and limitations in terms of pedagogical support and learning visualization.
- The chapter introduces a novel model, the "Pedagogical AI-Enabled Smart Learning Environment." This model integrates pedagogical support, learning visualization, and AI technologies to provide a comprehensive framework for inclusive learning experiences.
- The chapter outlines the cyclical learning process within this new model, which includes learner profiling, pedagogical support, adaptive content, performance evaluation, learning visualization, and learner support. It describes how these components work together to enhance the learning experience.
- The chapter also highlights how emerging technologies like smart cameras, cloud storage, virtual labs, and smart web interfaces can enhance the teaching and learning process within this new smart learning environment.
- It concludes by discussing potential future developments, such as the integration of augmented reality and AI algorithms, to further enhance the pedagogical AI-enabled smart learning environment and provide accurate support for learners' needs.

Abstract

The advancements in smart and mobile technologies are changing the design of learning environments. These technologies can create a smart learning environment that can personalize learning content for different learners based on their learning behaviors and needs. A smart learning environment uses technology to modify and give relevant assistance in the right places and times based on individual learners' learning behaviors. This can be discovered by examining their learning behaviors, performances, and the real-world circumstances in which they find themselves. Several smart learning environment models have been developed based on distinct foundations and research perspectives to serve varying learning demands. However, a well-defined model that explicitly includes pedagogical support and learning visualization modules to assist learners in the learning process for inclusive experiences is lacking. This chapter combined pedagogical support and learning visualization with the modules in a smart learning environment to develop a novel model known as a pedagogical AI-enabled smart learning environment. This integrated model can provide learning support and skill development and drive the design of a learning environment for inclusive learning experiences.

Introduction

The increasing developments in learning analytics, sensing, smart, mobile, and wearable technologies are changing the sphere of the learning environment. These technologies can be used to develop a smart learning environment that can provide a personalized adaptive system to support diverse learning behaviors (García-Tudela et al., 2021; Peng et al., 2019;). A smart learning environment is " a technology-supported learning environment that makes adaptations and provides appropriate support in the right places and at the right time based on individual learners' learning behavior and needs" (Hwang et al., 2008). This might be determined by analyzing their learning behaviors, performances, and the real-world contexts in which they are situated. The idea of a one-size-fits-all class has not effectively delivered the learning needs of students in a contextual setting (Egielewa et al., 2021; Zhu et al., 2016). Thus, several research works have advocated for designing a learning environment that can provide personalized learning content based on learner learning behavior to provide inclusive learning experiences (Egielewa et al., 2021; Khan & Alotaibi, 2021; Serbia & Loan, 2020).

Several models of smart learning environments have been developed based on various foundations and research perspectives to support diverse learning needs (Egielewa et al., 2021; Hwang, 2014; Rosmansyah et al., 2022; Serrano et al., 2021; Zhu et al., 2016). However, there is a lack of a well-defined model that includes pedagogical support and learning visualization to support the learning process for inclusive learning experiences. Hwang (2014) developed a model of a smart learning environment with the following learning modules: "An adaptive learning content, learning performance evaluation module, adaptive learning task module, personal learning support, and inference engine." The literature has used and referenced the model to develop a smart learning environment. However, the model lacks explicit integration of pedagogical support and learning visualization modules to guide the learning process and provide a means for evaluating learning performances. The question addressed in this chapter is: How can a pedagogical AI-enabled smart learning environment model be developed to provide learning support for inclusive experiences? Addressing this question will provide insights into how the

learning modules in a smart learning environment are integrated with pedagogical support and learning visualization to support skills and knowledge development for inclusive learning experiences.

Theoretical Background and Related Works

Smart Learning Environment

The advancement in smart, mobile, and wearable technologies is transforming how people compute and interact daily. These technologies are transforming the design of learning environments into smart learning environments capable of personalizing inclusive learning experiences. A smart learning environment considers a learner's characteristics and tailored learning content and offers feedback on the learner's learning process (Chen et al., 2016; Hwang, 2014). The smart learning environment and the smart devices can interact with a learner and make learning decisions based on the learners' actions. Data analytics can provide learners success by visualizing their learning progress, and tutors can utilize it to deliver helpful feedback by providing personalized assistance. Smart learning environments provide tailored learning materials, supportive tools, and learning ideas at the appropriate time and format for inclusive learning experiences (Freigang et al., 2018; García-Tudela et al., 2021; Peng et al., 2019).

A smart learning environment is a hybrid learning system that provides learners and other stakeholders with a motivational learning process while simultaneously achieving learning outcomes due to intelligent tools and techniques. This emerging learning environment can support learning diversities (Rosmansyah et al., 2022). It comprises contextual awareness, location awareness, real-world scenarios, recommendation systems, numerous engagement channels, assistance, personalization, and adaption (Hwang, 2014). Learners are more motivated to attain their goals when these features support inclusive learning experiences (Egielewa et al., 2018; Serbia & Loan, 2020).

Smart Learning Environment and Pedagogical Approach

The rapid development of advanced technologies enables flexible and efficient learning processes based on students' behavior. This process permits mixing content knowledge and skills to understand learners' needs (Dash et al., 2017). Students produce understanding through critical thinking and learning skills, which are significant to fostering learning abilities. Students accept learning processes and skills development that match their learning needs (Hwang, 2014; Khan & Alotaibi, 2021; Rosmansyah et al., 2022). In traditional education, these differences are less concerning as the learning content design is "one-size-all" (Shunk, 2002; Westbrook et al., 2014). However, this practice is ineffective in meeting individual students' learning experiences (Egielewa et al., 2021; Serrano et al., 2021; Zhu et al., 2016).

Thus, a new pedagogy should consider the needs and allow for active engagement of students, skills development, collaborative model of teaching and learning, learner responsibilities, interests, preferences, and intrinsic motivation that promote personalized expertise among students (Canţer, 2013; Egielewa et al., 2021; Zhu et al., 2016). It means both self and peer assessments are useful for formative evaluation. In contrast, peer assessment

involves students taking responsibility for assessing the work of their peers. This kind of assessment can offer an opportunity for engagement and is a powerful strategy for reinforcement of learning and skills development. It is crucial to advocate for integrating technology and pedagogy to establish a cohesive ecosystem that offers continuous and immediate documentation of knowledge advancements while fostering the development of skills that can be effortlessly transferred to learners as they transition between different learning environments (Chen et al., 2016). Furthermore, a smart pedagogy that provides opportunities for collaboration, peer assessment, critical thinking, and self-assessment must be integrated into the design of a smart learning environment for active learning engagement (Chen et al., 2016; Egielewa et al., 2021). More specifically, pedagogies such as self-regulated learning processes, social constructive learning, Collaborative learning, reflective and inquiry-based learning processes, etc., can support active engagement in a smart learning environment. These pedagogies have supported interaction and engagement in a learning process. They can support the needs of digital learners who need not only knowledge but skills for high-order thinking to contribute to the development of a society and workforce (Cao et al., 2020; Iqbal et al., 2020; Nguyen et al., 2022; Rosmansyah et al., 2022).

Models of Smart Learning Environment

Several models of a smart learning environment have been discussed in the literature that can support personalized adaptive systems for inclusive learning experiences (García-Tudela et al., 2021; Khan & Alotaibi, 2021; Peng et al., 2019; Rosmansyah et al., 2022; Serbia & Loan, 2020; Serrano et al., 2021). These models were developed from various foundations and perspectives, providing bases for research and discussion.

Rosmansyah et al. (2022) developed a simple model of a smart learning environment based on mapping existing smart learning environment models, frameworks, and best practices. The components of this model are standard policy, curriculum (represents the philosophical and ideological foundation of education), domain module (contains learning material), learner module (learner behavioral characteristics), pedagogy module (learning process), interface module (collaboration & communication), and supporting resources (administrative & support policies). Similarly, Khan Alotaibi (2021) developed an architecture of a smart learning environment based on soft computing. This architecture comprises user learning data, AI and agents, and smart learning-based tools. The goal of the model is to use AI-based technology to process user inputs. Additionally, it serves as a platform for managing inputs, reports, and data analysis tools. While these models provided components for designing a smart learning environment, they lack a well-defined structure and how they can be connected and modeled to provide a pedagogy for supporting personalized adaptive learning experiences.

Serba and Loan (2020) created QLearn, a web-based smart learning environment. This smart learning environment provides useful feedback and excellent exam preparation. It is based on a collaborative game-based learning technique that enables students to create learning experiences. The QLearn quantifies students' coverage rate of the course material or the level of knowledge supplied. The AI component of QLearn analyzes these measures to forecast students' exam results, determine which topics need more practice, and offer learning strategies based on individual students' needs. Moreover, Vesin et al. (2018) proposed and developed a model for a programming tutoring system (ProTus). It is intended to offer students personalized courses in a range of subjects. The

interactive system enables students to use instructional materials created for various courses and assess their learning progress. The model is made up of the following modules: interactive visualizations (learning activities based on a collection of disparate data sources), personalization (creates recommendations of learning resources for each student and tailors the content to a specific learner), and customization (allows students to change the look of the user interface by displaying or hiding internal frames and turning off/on recommendations). In addition, Hwang (2014) developed a model of a smart learning environment based on the characteristics and capabilities of technology, which consists of the following modules: "An adaptive learning content, learning performance evaluation module, adaptive learning task module, personal learning support, and inference engine." These models provided the theoretical background for a smart learning environment. However, the modules are not integrated and lack pedagogical support and learning visualization to guide the learning process and monitor learning progress.

Thus, it is clear from the literature that research in the smart learning environment is increasing, and the need for developing an AI-enabled learning environment is at the forefront. Additionally, the need for designing intelligent learning environments to inspire various learners while considering their abilities, learning preferences, and interests is increasing (Hoel & Mason, 2018; Rosmansyah et al., 2022; Spector, 2014). However, there is a lack of a well-defined model of an AI-enabled smart learning environment supported by a pedagogy to guide the learning process and learning visualization to monitor learning progress

Pedagogıcal AI-Enabled Smart Learnıng Envıronment

Several applications of a smart learning environment have been discussed in the literature to support personalized adaptive systems for inclusive learning experiences (Freigang et al., 2018; Hwang, 2014; Khan & Alotaibi, 2021; Rosmansyah et al., 2022; Serbia & Loan, 2020; Serrano et al., 2021). However, most of these applications lack specific models underpinning their development. Furthermore, most models lack a pedagogy to guide the learning process and explicit integration of AI. There is a scarcity of a well-defined pedagogical model of a smart learning environment that integrates pedagogical support and learning visualization modules to guide the learning process for inclusive learning experiences. Hwang (2014) provided the foundation for developing a model of a smart learning environment for supporting inclusive learning experiences. However, this model lacks the integration of pedagogical support, learning visualization, and explicit integration of the AI-enabled learning process. Furthermore, the structure of the model is not well-defined to support a pedagogical process. There is a need to include pedagogical support and learning visualization that supports a variety of learning styles and helps learners in the learning process for inclusive learning experiences (Huang et al., 2013; Sumadyo et al., 2018).

Thus, following the methodological approach of Canţer (2013), this chapter integrated pedagogy to support the learning process and learning visualization with modules in the smart learning environment (Hwang, 2014) to develop a novel model of a smart learning environment model called pedagogical AI-enabled smart learning environment. The integrated application supported by this model can provide an opportunity for skills and knowledge development to live and function in society and contribute to the digital workforce. Figure 1 shows

the model of a pedagogical AI-enabled smart learning environment, and each module is discussed for clarity and usage.

Learner profile: This module contains learner learning goals, current knowledge, and personal information. The goal can be a set of achievements that can be achieved at the end of the course. These attributes form a learning portfolio and benchmark for learners' cognitive ability profiles.

Pedagogical support: This module directs learning activities during the learning process. These are guidelines, tools, or resources that support teaching and instruction. For example, social constructive learning, self-regulated learning process, and collaborative learning support can be integrated into the pedagogical support module to guide smart learning activities to improve knowledge and skills. The learning resources or portfolio can be PDF, audio, videos, or other external resources. Pedagogical support provides key performance indicators for the delivery of teaching and learning. It assesses its impact on learners or if there is a need to change the pedagogical approach based on learning technology's prevalent situation or dynamism. The pedagogical support can be integrated into formal or informal learning and online or offline teaching depending on the need and contextual setting.

Inference engine: This is the knowledge base used to evaluate the "value" of potential learning tasks, strategies, and tools, as well as the possible pairings of these elements. The knowledge base comprises tutoring expertise and knowledge from educators and students. It might also consist of the guidelines for making decisions developed from studying both successful and unsuccessful cases in the past. The inference engine is a computer program that evaluates the current case, including the student's situation and the surrounding contexts, and then makes decisions based on the rules in the knowledge base (Hwang, 2014; Wu et al., 2013a).

Learning performance evaluation: This module evaluates and documents students' performance through online or in-person tests. For a real-world exam, students might be required to observe or engage in real-world forums to discover the solution to a test item (i.e., the real-world objects related to the learning goals) (Hwang, 2014).
Adaptive learning content: This module modifies user content based on each learner's progress, performance, personal characteristics, and the situation in the real world. The learning system organizes and recommends learning materials to suit individual learner's needs (Hwang, 2014).

Learning visualization: This module includes instructions for enhancing learning performance and skills as well as learner learning behavior. This may be action-related, content-related, learner-related, or socially related, and it can help students develop their skills in learning. The learner's learning goal, performance, pedagogy, learning content, and personalized message are all included in the learning visualization modules to help make learning more effective. Students can access this module through the application portal using their login information.

Learner support: This module allows tutors to support learners based on their unique learning requirements. Learning support can take the form of a learning task or learning content guideline, a hint for the task, feedback on their work, or help with learning effectively and efficiently. When determining the type of assistance to be

provided, the features of the learning tasks and content and the learners' learning performance, personal factors, and real-world status are considered.

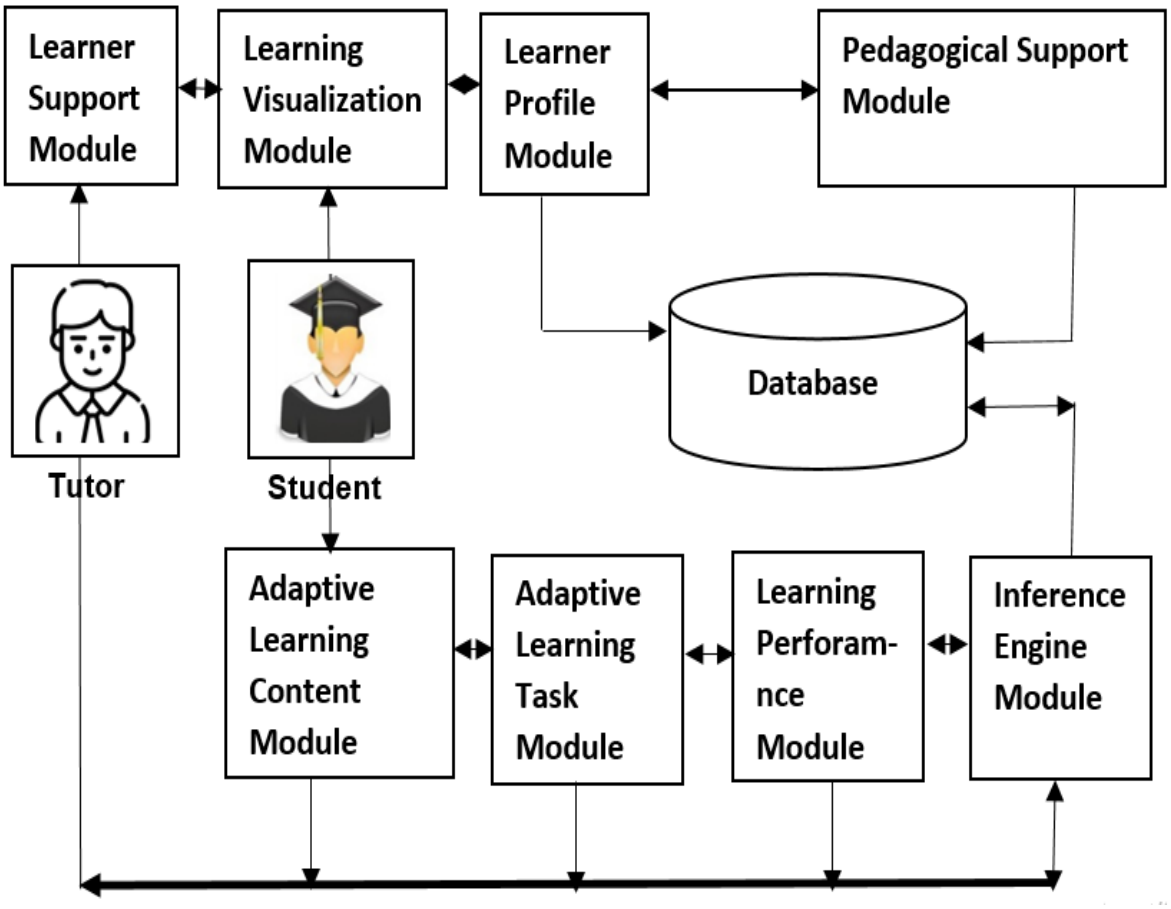

Figure 1: Model of Pedagogical AI-Enabled Smart Learning Environment

The learning process in this model is cyclical and aimed at improving learning experiences. The learner creates an account and logs in through the learner profile module; the module contains personal data and learning goals. After logging into the app, the learner accesses learning resources supported by the pedagogical support module. Pedagogical support provides learning activities and guides the learner in the learning process. All these data are captured into the database module for further analysis. With the help of an AI algorithm, the inference engine will provide adaptive tasks, learning performance evaluation, and adaptive content based on the learner's learning behavior and profiling. The learning performance evaluation module will provide an assessment to gauge learners' level of knowledge and understanding of the course. The adaptive learning task module and adaptive learning content module are the learning activities and the recommended content, respectively, to help learners in the learning experiences. The learning visualization module will provide learner learning behavior and recommendations regarding the learning goal, performance score, pedagogy, and frequently used learning content. This information can be accessed by individual learners and updated learner's profile as the learning continues. The learning support module allows tutors to help with a personal message to improve learners' learning experiences.

The new generation of teaching is more than just books and lecture notes. Technology advancements have made it possible to use various sources for teaching and learning. A smart camera deployed inside classrooms can also capture live lectures and save them to the cloud for later use. If students miss a classroom session, they can watch the lectures whenever they choose because they are saved on the cloud and accessible from anywhere. This bridges the digital gap while also allowing for more learning time. It also eliminates the requirement for copying lecture notes from peers at later levels.

Teachers can also offer homework to their students using a smart web interface that allows them to grade the homework and provide comments to their students. This eliminates physical labor while enhancing instructor and student efficiency. Hands-on practice with the concepts can be provided using the virtual lab setting. Students can access these laboratories using any handheld device or laptop with basic internet connectivity. This can significantly minimize the cost of purchasing lab equipment, machinery, computers, and other such items, as well as the physical space required.

Conclusion

The development of technologies that are smart, mobile, and capable of sensing mobile environments enables the creation of a smart learning environment that can cater to a variety of educational requirements. Nonetheless, despite a growing corpus of research on the smart learning environment, there is a scarcity of well-defined models that describe how the modules of a smart learning environment can be represented and incorporated into a pedagogical AI-smart learning environment. This chapter explored and extended the modules in the smart learning environments with pedagogical support and learning visualization modules, which can support inclusive educational opportunities to meet the needs of diverse learners and promote interaction and authentic learning experiences.

The model can be built and supported by algorithms based on artificial intelligence and technology related to smart and mobile devices to develop an integrated application for individualized learning assistance. Augmented reality can help promote the creation of a smart learning environment. This technology incorporates learning difficulties into a digital world similar to the actual world to assist students in studying at their own speed. For example, an AI algorithm can be integrated into the inference engine of the modules to support recommended systems for adaptive learning contents, performance evaluation, learning status, etc. The model will be experimented with to validate its applicability to produce accuracy in predicting students' learning behavior and needs using an AI algorithm. The algorithm will then be integrated and developed with other modules into an application to support inclusive learning experiences.

Acknowledgments or Notes

The support of Adamawa State University Mubi-Nigeria is well acknowledged.

References

Cao, W., Wang, Q., Sbeih, A., & Shibly, F. H. A. (2020). Artificial intelligence based efficient smart learning framework for education platform. *Inteligencia Artificial*, *23*(66), 112-123.

Canţer, M. (2013, July). A hybrid model for an e-learning system which develops metacognitive skills in students. In *International conference on human Interface and the Management of Information* (pp. 9-15). Springer, Berlin, Heidelberg.

Chen, N. S., Cheng, I., & Chew, S. W. (2016). Evolution is not enough: Revolutionizing current learning environments to smart learning environments. *International Journal of Artificial Intelligence in Education*, *26*(2), 561-581.

Dash, S., Mohapatra, C & Behera, P. (2017). Technologies for smart learning. Developing countries. University of Sussex, 2014.

Egielewa, P., Idogho, P. O., Iyalomhe, F. O., & Cirella, G. T. (2021). COVID-19 and Digitized education: Analysis of online learning in Nigerian higher education. *E-Learning and Digital Media*, *19*(1), 19-35.

Freigang, S., Schemer, L., & Koehler, T. (2018). An Interdisciplinary Framework for Designing Smart Learning Environments. In *Challenges and Solutions in Smart Learning* (pp. 17-20). Springer, Singapore.

García-Tudela, P. A., Premeds-Espinosa, P., & Solano-Fernandez, I. M. (2021). Smart learning environments: basic research towards the definition of a practical model. *Smart Learning Environments*, *8*(1), 1-21.

Hwang GJ, Tsai CC, & Yang SJH (2008). Criteria, strategies, and research issues of context-aware of ubiquitous learning. *Educ. Technol. Society*, 11(2):81–91.

Hwang, G. J. (2014). Definition, framework, and research issues of smart learning environments context-aware ubiquitous learning perspective. *Smart Learning Environments*, *1*(1), 1-14.

Huang, R., Yang, J., & Zheng, L. (2013). The components and functions of smart learning environments for easy, engaged, and effective learning. *International Journal for Educational Media and Technology*, *7*(1), 4-14.

Iqbal, Hafiz, Roberto Parra-Saldivar, Ricardo Zavala-Yoe & Ricardo A. Ramirez-Mendoza. "Smart educational tools and learning management systems: supportive framework." *International Journal on Interactive Design and Manufacturing (IJIDeM)* 14, no. 4 (2020): 1179-1193.

Khan, F., & Alotaibi, S. R. (2021). A Novel Architecture for Smart Learning based on Soft Computing. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *12*(6), 1-10.

Mulyadi, D., Huda, M., & Gusmian, I. (2022). Smart learning environment (SLE) in the fourth industrial revolution (IR 4.0): practical insights into online learning resources. *International Journal of Asian Business and Information Management (IJABIM)*, *13*(2), 1-23.

Mulyadi & Gusmian, 2022; Nguyen *et al*., 2022; Iqbal et al., 2020; Cao *et al*., 2020; Sumadyo, et al., 2018; Huang, R., Yang, J., & Zheng, L. (2013).

Nguyen, Lan Thi, Issara Kanjug, Grichawat Lowatcharin, Theeradej Manakul, Kornwipa Poonpon, Weerachai Sarakorn, Anucha Somabut, Niwat Srisawasdi, Saksuriya Traiyarach, and Kulthida Tuamsuk. "How teachers manage their classroom in the digital learning environment–experiences from the University Smart Learning Project." *Heliyon* 8, no. 10 (2022): e10817.

Vesin, B., Mangaroska, K., & Giannakos, M. (2018). Learning in smart environments: user-centred design and

analytics of an adaptive learning system. *Smart Learning Environments*, *5*(1), 1-21.

Peng, H., Ma, S., & Spector, J. M. (2019). Personalized adaptive learning: An emerging pedagogical approach enabled by a smart learning environment. *Smart Learning Environments*, *6*(1), 1-14.

Sumadyo, M., Santoso, H. B., & Sensuse, D. I. (2018, March). Metacognitive components in the smart learning environment. In *Journal of Physics: Conference Series* (Vol. 978, No. 1, p. 012025). IOP Publishing.

Schunk, D. H. (2002). Learning Theories An Educational Perspective Third edition.

Rosmansyah, Y., Putro, B. L., Putrid, A., Utami, N. B., & Suhardi. (2022). A simple model of the smart learning environment. *Interactive Learning Environments*, 1-22.

Serba, C & Loan, L. (2020). QLearn: Towards a framework for smart learning environments. 24th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems. Procedia Computer Science 176 (2020) 2812–2821

Serrano Iglesias, S., Spikol, D., Bote Lorenzo, M. L., Ouhaichi, H., Gómez Sánchez, E., & Vogel, B. (2021). Adaptable Smart Learning Environments supported by Multimodal Learning Analytics. In *European Conference on Technology Enhanced Learning, EC-TEL 2021*

Westbrook J. Durrani N. Brown R. Orr D. Pryor J. Boddy J. & Salvi F. (2014). Pedagogy, curriculum, teaching practices, and teacher education in developing countries. University of Sussex

Zhu, Z. T., Yu, M. H., & Riezebos, P. (2016). A research framework of smart education. *Smart learning environments*, *3*(1), 1-17.

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Gambo Y. (2023). A model of pedagogical AI-enabled smart learning environment. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 91-100). ISTES Organization.

Chapter 7 - From Data to Insights: The Power of Learning Analytics

Abdullatif Kaban

Chapter Highlights

- In this section, we'll dive into Learning Analytics and its importance in education. We'll define what it is and explain how it can boost student success.
- We'll also be exploring the relationship between Learning Analytics and educational technologies. These two can work together to enhance the learning experience for students.
- Furthermore, we'll discuss how predictive models created through Learning Analytics can improve educational processes and teaching methods.
- Visualizing Learning Analytics data and understanding student behavior is crucial for effective learning. In this section, we highlight the significance of this practice.
- Social Learning Analytics is an innovative approach that can enhance student engagement and foster better interactions among students. We'll delve into this topic as well.
- It's important to address ethical and security concerns when utilizing Learning Analytics. In this section, we'll provide suggestions on how to safeguard data privacy.
- Lastly, we'll discuss future advancements and trends in Learning Analytics. Analytical approaches in education are expected to become more widespread, and we'll explore what this means for the future of education.

Definition of Learning Analytics

Learning Analytics

Learning analytics is the process of collecting, analyzing, and interpreting data to understand, measure, and improve student learning processes. This field is crucial in higher education, enabling educators, administrators, researchers, and the academic community to track and evaluate students' performance, progress, and learning outcomes. Learning analytics is a fascinating field that has garnered significant attention among educators and researchers in higher education. Its implications are far-reaching, as it has the potential to impact students, teachers, administrators, researchers, and the academic community (Guzmán-Valenzuela et al., 2021). By emphasizing the importance of data-driven decision-making in education, learning analytics can significantly contribute to the development of future educational practices.

The process of Learning Analytics involves analyzing data from multiple sources using methods like data mining, business intelligence, and big data analytics. This data-driven approach aims to predict individual learning outcomes by combining information from various fields (Leitner et al., 2017). Educators gain a deeper understanding of students' learning behaviors, habits, and performances by conducting thorough analyses. This enables them to identify student needs more accurately, customize course content, and manage educational processes more effectively. Data collection and analysis play a crucial role in improving student learning in this domain.

The utilization of Learning Analytics in education policies and practices highlights the significance of data-based decision-making. It can help to enhance the performance of educational institutions, leading to an improvement in student achievement and learning experiences. However, despite its potential, there is limited proof to suggest that it can effectively enhance student achievement, and its use has not yet been widely embraced or fully utilized ethically (Viberg et al., 2018). It is crucial to remember the significance of ethical and privacy issues when using Learning Analytics and managing data securely and responsibly. It is particularly important to consider ethical and privacy concerns when assessing the potential impacts of this technology. As a result, more research and critical studies are necessary in the field of Learning Analytics.

To put it simply, learning analytics is a vital field of research and application that aims to enhance student success, elevate education quality, and streamline educational processes through a data-driven approach. This technology is recognized as a valuable tool for shaping the future of education systems and maximizing students' potential. In essence, the progress made in learning analytics underlines the power and importance of data analysis in education. Research conducted in this area, to better understand students' learning outcomes and improve educational processes, can have a significant impact on shaping future education policies and practices. Further research and development based on learning analytics can make a meaningful contribution to enhancing students' learning experiences and improving the quality of education.

The Purpose of Learning Analytics

In the field of education, learning analytics aims to do more than just collect and analyze data. Its mission is to assist students in regulating their learning. To achieve this, personalized learning features, such as detailed analysis and recommendations, should be provided (Schumacher & Ifenthaler, 2018). By doing so, students can manage their learning processes more effectively and efficiently. Essentially, learning analytics employs a data-driven approach to comprehend, measure, and enhance student learning processes. This entails gaining a deep understanding of students' learning behaviors, habits, and performances, as well as providing them with useful personalized learning features like detailed analysis and recommendations.

Understanding the needs of students is crucial for effective education, and Learning Analytics plays a significant role in this. By taking into account all aspects of students' learning, learning analytics should be created to respond to their learning processes. The tools used for learning analytics must be compatible with self-regulated learning theory, feedback, and instruction to avoid any negative educational outcomes (Schumacher & Ifenthaler, 2018). Learning Analytics systems should also focus on providing visualizations and descriptive information that can help students monitor their progress without hindering their self-regulating learning processes. The goal of Learning Analytics is to predict individual learning outcomes by combining data from various sources. This allows educators to identify students' learning needs and customize the course content to suit them, resulting in more effective educational processes. Additionally, learning analytics aims to provide student profiles that can be used to design appropriate educational interventions.

Educational institutions can benefit from learning analytics as it helps them to understand the learning needs of students and improve their educational processes (Taş, 2021). By profiling students with appropriate descriptors, studies in this area aim to design educational interventions that are suitable for them. Additionally, the insights gained from learning analytics can help to enhance teaching practices, leading to better learning outcomes and experiences (Slade & Prinsloo, 2013). The ultimate aim is to transform learning feedback from learning analytics applications into effective learning interventions, thereby improving both social and technical infrastructure (Schumacher & Ifenthaler, 2018).

To put it briefly, learning analytics is a method that utilizes data to enhance the learning process of students. Research in this field offers valuable insights and information to personalize the learning experiences of students and optimize their learning outcomes. Educators can effectively employ learning analytics to improve academic performance and foster students' ability to take charge of their learning (Taş & Gülcü, 2019). Nevertheless, it is crucial that the practices in this domain are grounded in research and that the privacy of students is safeguarded.

The Difference Between Learning Analytics and Traditional Data Analysis

In recent years, the field of learning analytics has emerged as a crucial area of study that seeks to analyze data from online learning environments to enhance the learning experience. Unlike traditional data analysis methods that focus solely on individual data points, learning analytics takes a more comprehensive approach that evaluates

data in interactions and considers these interactions as the fundamental unit of analysis (Agudo-Peregrina et al., 2014). By doing so, this approach enables us to gain a holistic perspective of students' behaviors and interactions in their learning environment, which can be used to identify areas of improvement and enhance the overall learning experience.

Learning analytics can interpret and contextualize data more comprehensively than traditional data analysis. Traditional data analytics offers a corporate perspective while learning analytics focuses on the learner, providing the opportunity to personalize the learning experience. This approach allows students to develop flexible and effective educational strategies that cater to their individual needs and support their learning journey. Moreover, learning analytics plays a crucial role in designing early warning processes and interventions to improve student achievement (Agudo-Peregrina et al., 2014). By assisting students with their unique requirements, a more successful learning experience can be achieved.

In the realm of education, it is crucial to have a thorough understanding of student behaviors, interactions, and learning styles. While traditional database tools may fall short in providing the necessary insights, the utilization of learning analytics can provide educators with ad-hoc tools to process vast amounts of data and filter out relevant information. What makes learning analytics truly unique is the process of contextualization and interpretation that it involves. This process allows for a deeper understanding of the learning experience and enables more effective interventions, making it a student-focused and comprehensive approach that sets it apart from traditional data analysis methods. By leveraging the power of learning analytics, educators and students alike can gain a more comprehensive understanding of the learning process, paving the way for more effective teaching and learning strategies. (Agudo-Peregrina et al., 2014)

Benefits of Learning Analytics

Advantages Of Using Learning Analytics

The utilization of learning analytics has become increasingly popular in educational institutions as it provides valuable insights into student performance and learning. This data is essential in gaining a deeper understanding of students' academic success and needs. By analyzing academic performance and behavior, educators can make informed decisions, such as identifying students who may be at risk and providing them with targeted support and interventions (Roberts et al., 2016). Moreover, learning analytics can assist teachers in adjusting their teaching methods and identifying effective teaching strategies, enabling them to personalize the educational process and enhance the learning experience for students. This enables a more proactive approach to education, where students' success and well-being are at the forefront of decision-making (Slade & Prinsloo, 2013).

The utilization of learning analytics has enabled educational institutions to make informed decisions based on data. The insights gathered from analyzing student performance and behavior have been instrumental in creating more effective educational strategies. The ability to tailor educational experiences to cater to individual student needs and challenges has resulted in a more personalized learning environment. Educators and institutions alike, by leveraging the data obtained through learning analytics, can make informed decisions aimed at increasing

student achievement and improving the overall learning environment. The use of data-driven approaches has thus become an essential tool in the arsenal of educators and institutions committed to providing the best possible education for their students (Roberts et al., 2016).

The field of learning analytics holds immense promise in terms of enhancing the educational journey of students and elevating their academic achievements. By delving into the learning and behavioral patterns of students, educators can offer targeted and customized assistance to help them succeed (Slade & Prinsloo, 2013). This data analysis can also aid educational institutions in making informed decisions regarding the allocation of resources and the development of educational programs, thereby streamlining the learning process and maximizing its efficacy. Ultimately, this approach to learning analytics has the potential to enrich students' experiences as they navigate the complex world of education.

In the academic world, learning analytics can be a game-changing asset that provides significant benefits. By prioritizing data-driven decision-making, learning analytics has the potential to offer valuable insights into student learning and performance. The information generated can enable educators to provide a more personalized and effective learning experience, while also making the learning process more efficient and effective for educational institutions. Through the use of learning analytics, the academic community can identify at-risk students and enhance their educational offerings to improve student achievements. Therefore, it's safe to say that learning analytics is a critical tool that highlights the potential of data-driven transformation in education.

Learning Analytics Enhances the Educational Experience

The use of learning analytics is becoming more popular as it can enhance student learning and improve their overall educational experience. This technology has many potential uses, such as closely monitoring students' progress, predicting their performance, identifying students who may be at risk, providing valuable data about students' learning characteristics and patterns, and identifying any undesirable learning behaviors or emotional states (Wong, 2017). Additionally, learning analytics helps teachers to evaluate and improve the effectiveness of their pedagogy and instructional designs. Teachers can use this technology to provide students with targeted support and interventions (Quadri & Shukor, 2021).

Incorporating learning analytics into online classrooms and computer-assisted education has the potential to significantly enhance the learning process and overall experience for students. This cutting-edge technology can identify materials that are particularly relevant and effective for individual learners, improve curricula to better meet the needs of students, and even predict cognitive states and behaviors to optimize the learning environment (Quadri & Shukor, 2021; Troussas et al., 2020). Furthermore, learning analytics can closely monitor student performance, dropout rates, and retention, providing educators with valuable insights and actionable data. This data can be used to create personalized learning paths and assessments for students, ensuring that each individual is receiving the support and attention they need to succeed. Ultimately, learning analytics helps create a more inclusive and supportive learning environment, identifying and addressing the needs of students who require extra

support and attention. By leveraging this technology, educators and students alike can work together to optimize the learning experience and achieve greater academic success.

Learning analytics can offer learners, instructors, and administrators Learning analytics provides new insights for learners, instructors, and administrators, allowing teachers to plan supportive interventions for functional groups such as course teams. It offers a comprehensive view of student engagement and can improve pedagogy in adaptive learning, facilitate networked learning, visualize hidden patterns and connections in students' activities, and predict academic performance (Wong, 2017). By raising students' awareness of their learning engagement, presenting their educational data in a meaningful way, and interpreting information accurately through visualizations and dashboards, learning analytics enhances the educational experience and provides numerous benefits.

In the field of education, learning analytics is a valuable tool that can enhance student learning and improve their educational experience. By monitoring progress, forecasting performance, identifying students at risk, and providing useful data, learning analytics gives educators the chance to refine their teaching approaches and offer personalized support to students. Additionally, this tool helps provide data-driven feedback and guidance to students, assists educational institutions in making informed decisions, and optimizes the educational process. In essence, learning analytics has the potential to revolutionize education with data-driven transformation, leading to better learning experiences for students.

Improving Educational Decision-Making Through Learning Analytics

The use of learning analytics plays a crucial role in improving the decision-making process in the field of education. Higher education institutions can significantly benefit from data analytics, which provides them with valuable insights to inform their decision-making. The implementation of learning analytics facilitates the decision-making process by capturing, processing, and representing training data (García-Peñalvo, 2020). As a result, higher education institutions can strengthen their capabilities and reap the benefits of continuous improvement (El Alfy et al., 2019). By leveraging learning analytics, institutions can measure student performance, obtain real-time and predictive insights, and receive recommendations (Ifenthaler, 2017). Moreover, learning analytics can aid institutions in gathering information on courses and materials that attract students, planning course development, allocating resources, assessing performance, and identifying high- and low-performing students. In essence, learning analytics provides a comprehensive view of student performance, which can be used to make informed decisions and ultimately improve the overall quality of education.

In the realm of education, making informed decisions about student progress and potential success is crucial. Fortunately, advancements in technology have paved the way for new approaches to education decision-making, one of which is learning analytics. This method utilizes machine learning algorithms and logistic regression analyses to scrutinize data such as students' demographics, abilities, and use of virtual learning environments (Wong, 2017). By analyzing this information, educators can predict academic performance and provide support to students who need it most. Moreover, learning analytics enables teachers to identify students who may be at

risk of underperforming. For example, the Course Signal System utilizes a range of factors, such as students' demographics, past academic performance, and level of effort in studying, to predict potential academic struggles (Wong, 2017). This kind of preemptive approach to education decision-making can help students receive the support they need to succeed and prevent them from falling behind. Indeed, the use of learning analytics has the potential to revolutionize the way we approach education decision-making, ensuring that every student has the opportunity to thrive and reach their full potential.

To evaluate the effectiveness of learning analytics in higher education institutions, a benefit matrix can be employed. However, it is of utmost importance to ensure that the use of learning analytics complies with ethical regulations, maintaining confidentiality, and respecting personal privacy (García-Peñalvo, 2020). While the potential for improving decision-making in education through learning analytics is highly promising, further empirical research must be conducted to validate its advantages for teaching and learning. One major challenge in implementing learning analytics projects can be the lack of sufficient staff and technology, which can significantly hinder the efficacy of educational decision-making. Therefore, institutions must invest in the necessary resources to enable the effective utilization of learning analytics in education.

The proper utilization of learning analytics in the education sector can bring about significant improvements in decision-making processes and student success rates. In this regard, higher education institutions must prioritize the extensive implementation of learning analytics to personalize students' learning experiences and enhance their academic achievements. By leveraging data-driven insights and predictive analytics, educators can identify areas where students may require additional support and develop targeted interventions to help them overcome academic challenges. Moreover, learning analytics can also help institutions assess the effectiveness of their teaching strategies and adjust their approaches to better meet the needs of their students. Ultimately, the integration of learning analytics in education has the potential to revolutionize the way we approach teaching and learning, leading to better outcomes for students and greater success for institutions.

Challenges of Learning Analytics

The Challenges Associated with Learning Analytics

Over the last five years, there has been a surge of research in the field of learning analytics. However, this growth has brought about some difficulties. While it is crucial to focus on small-scale efforts and specific tools, a more holistic strategy is required to address the challenges that come with learning analytics. These challenges include ensuring adequate infrastructure and resources, establishing effective communication between stakeholders, addressing ethical and privacy concerns, and handling technical issues, such as data quality and accuracy (Ifenthaler & Schumacher, 2016).

One of the main challenges faced by learning analytics in higher education is the lack of a clear understanding of its purpose and potential (Tsai & Gasevic, 2017). This incomplete understanding can hinder the complete utilization of learning analytics. It is essential to collect data in an ethical manner that respects the privacy of students. Any incorrect data collection and analysis can lead to inaccuracies and unreliability, which is why it's

crucial to prioritize ethical data collection. Compatibility issues between learning management systems and analytical tools can also impact the quality and integrity of data (Ferguson & Shum, 2012). Therefore, it's important to ensure that these systems and tools work together seamlessly to provide accurate and reliable data for better decision-making in higher education.

Learning analytics presents several challenges, one of which is ensuring the privacy and security of personal data collected, stored, analyzed, and presented. To build student trust, it's crucial to use and protect learning analytics data ethically and responsibly. Compliance with privacy and security standards and taking appropriate precautions are essential. Another challenge is integrating learning analytics into existing corporate cultures and practices, as well as the lack of guidance to improve data literacy among end users. Thus, it's important to educate users in this area and support decision-making processes based on analytical results.

Addressing Privacy and Ethical Concerns through Learning Analytics

In recent times, there has been a growing focus on EP4LA, which stands for Ethics, Privacy, Policy, Legal, and Algorithmic aspects, within the learning analytics community. It is crucial to give attention to ethical and privacy matters to ensure the widespread adoption of learning analytics applications (Drachsler et al., 2015). To achieve this, it is imperative to establish policies and frameworks that address issues such as transparency, consent, security, and accountability (Khalil, M; Ebner, 2015). These measures are vital in protecting students' privacy and creating a secure environment for learning analytics to collect and analyze data. Additionally, it is crucial to involve all stakeholders in learning analytics, including students, educators, and institutions, in the development and implementation of policies and frameworks (Khalil, M; Ebner, 2015). The participation of all stakeholders will ensure that the policies and frameworks developed are effective and considerate of the needs of all parties involved. Ultimately, the implementation of such policies and frameworks will promote the responsible use of learning analytics, leading to better outcomes for all stakeholders.

When considering learning analytics, it is crucial to address challenges related to data privacy and security, as well as ensure the quality and accuracy of the data (Ferguson & Shum, 2012). Lack of standardization in data collection and analysis can negatively impact the effectiveness and accuracy of learning analytics. To mitigate data privacy risks, specialized tools can be utilized (Joksimović et al., 2022), providing reliable and consistent data privacy management. However, the use of open datasets in data analytics can pose privacy risks in learning analytics projects. Therefore, a careful and consistent approach should be taken when addressing privacy and ethical issues (Manca et al., 2016).

Through the European Learning Analytics Community Exchange (LACE) project and workshops, ethics and privacy concerns have been addressed and transformed (Ferguson et al., 2016). The 22 challenges that guide this work emphasize the importance of separately considering ethical, data protection, and privacy issues about learning analytics (Ferguson et al., 2016). To ensure the protection of student privacy, it is crucial to prioritize the transparent and secure use of student data when implementing learning analytics. By addressing ethical and privacy issues, learning analytics can facilitate data-driven transformation in education.

Exploring the Use of Learning Analytics for Resolving Data Quality Concerns

For learning analytics to have a positive impact, it is essential to address any potential issues with data quality. This requires a commitment to using reliable and accurate data, as well as ensuring that the sources and methods used to collect the data adhere to ethical and scientific principles. Additionally, it is crucial to carefully evaluate and interpret the data to ensure that learning analytics practices are used fairly and equitably across all student groups (Gašević et al., 2022). By taking these steps, we can ensure that learning analytics is a valuable tool for improving educational outcomes for all students.

When engaging in research related to learning analytics, it is of utmost importance to emphasize the quality of data. Failing to do so could have negative consequences on the dependability and efficacy of these initiatives. To ensure triumph, it is vital to prioritize data quality throughout the entire process, from the initial planning stages to the implementation phase. This can be accomplished by utilizing suitable evaluation techniques and instruments that promote effective and dependable learning analytics practices.

To achieve success in learning analytics, it is essential to prioritize the improvement of data quality. By doing so, we can guarantee that the results derived from learning analytics projects are reliable and effective, which will enable us to make informed decisions that enhance student learning and educational experience. It is crucial to address concerns related to data quality, as this will not only increase the reliability of learning analytics applications but also ensure that ethical standards are upheld throughout the process. Therefore, we must take proactive measures to ensure that data quality is continuously monitored and improved.

Applications of Learning Analytics

Exploring the Various Uses of Learning Analytics

The utilization of learning analytics has become an increasingly critical tool in achieving various educational objectives across diverse contexts. This method involves employing a range of technologies and techniques, including data mining, web analytics, and business intelligence, to process and present data that has been collected from interactions and navigations within educational content (Serrano-Laguna et al., 2014). In recent times, there has been a growing focus on the application of learning analytics in the context of high school education. The deployment of educational technology in high schools has opened up new possibilities for the implementation of learning analytics, which can potentially provide invaluable insights into student performance, engagement, and progress (Serrano-Laguna et al., 2014).

Learning analytics has multiple purposes and is crucial in various fields. Its applications range from customizing students' learning experiences to evaluating the efficiency of teaching methods, forecasting student performance, and guiding organizational decision-making. Moreover, learning analytics can promote learning at different levels and enhance academic achievements. However, in high school settings, learning analytics is not widely implemented and has primarily been utilized in smaller initiatives instead of being adopted institution-wide (Serrano-Laguna et al., 2014).

In the realm of high schools and education, there exists a wealth of potential techniques and research areas that can be employed to effectively leverage the power of learning analytics. One such method is the use of social network analysis, which can help to illuminate the social connections and relationships that exist between students and teachers, thereby providing valuable insights into how learning processes can be improved. Another tool that is commonly used in the application of learning analytics is epistemic network analysis, which focuses more specifically on the content and knowledge structures that underlie the learning process. By analyzing these structures and identifying their strengths and weaknesses, educators can gain a better understanding of how to optimize student learning and performance.

In addition to these methods, process mining is another valuable tool that can be used to study and analyze the various steps and stages involved in the learning process. By breaking down this process into its constituent parts and analyzing each one individually, educators can gain a more nuanced understanding of how to optimize student learning and performance. It is important to note, however, that machine learning algorithms alone cannot fully capture or study the complex and multifaceted nature of the learning process. To fully understand the methods, tools, and applications of learning analytics in high schools, it can be helpful to conduct a systematic literature review and analyze past models to improve student performance.

Dashboard applications are also an incredibly valuable tool in this domain, as they allow educators to visualize student and teacher learning traces and gain a better understanding of how to optimize the learning process (Verbert et al., 2013). By analyzing past models and identifying areas for improvement, educators can help to ensure that students are receiving the best possible education and are equipped with the skills and knowledge they need to succeed in their future endeavors. Overall, learning analytics is a powerful tool with a wide range of potential applications and benefits for students, teachers, and educational institutions. As this technology continues to evolve and become more widely adopted in the future, we will likely see even more innovative and effective applications of learning analytics in the realm of education.

Improving Student Engagement through Learning Analytics

The practice of utilizing learning analytics has proven to be an incredibly valuable tool for enhancing student engagement. Student engagement is a multifaceted concept that encompasses a wide range of observable behaviors, internal cognitions, emotions, and representations. By leveraging learning analytics, educators can gain a more holistic understanding of their students' perspectives and tailor their approach to better meet their needs. One of the primary benefits of using learning analytics is the ability to provide students with meaningful feedback. Feedback can empower students to make more informed decisions and track their academic progress more effectively. This type of feedback also promotes effective communication between students and institutions, heightens students' self-awareness, and offers support and assistance in challenging situations (Silvola et al., 2021).

Another significant advantage of using learning analytics as a feedback channel is the ability to create adaptive learning conditions tailored to students' needs. By leveraging data and analytics, educators can gain a deeper

understanding of how students learn and adapt their approach accordingly. This type of personalized learning can be incredibly effective in helping students reach their full potential. Overall, the use of learning analytics is a powerful tool for enhancing student engagement and improving academic outcomes. By providing students with meaningful feedback, promoting effective communication, and offering personalized learning opportunities, educators can help students achieve their goals and succeed in their academic careers.

The process of analyzing data to support student engagement in learning is a multifaceted and nuanced endeavor that requires alignment of student expectations with the information provided. To effectively leverage Learning Analytics to increase student engagement, it is crucial to prioritize the needs of the learner and consider their unique perspective (Gray et al., 2022). Social Learning Analytics has emerged as a powerful tool in this regard, offering valuable insights into student behavior and learning patterns. By identifying disinterested students and offering targeted interventions, Social Learning Analytics can help increase student engagement (Chen et al., 2018). Additionally, by providing instructors with data-driven insights, Learning Analytics can help them adjust their teaching strategies to further engage students. However, it is important to note that Learning Analytics alone cannot guarantee students' mastery of knowledge. As such, instructors should approach student analysis with caution, taking care to consider the context and limitations of the data at hand (Franzoni et al., 2020). Ultimately, a thoughtful and holistic approach to Learning Analytics can help support student engagement and success.

When it comes to Learning Analytics, it's crucial to offer frequent updates to students to help them make informed decisions about their academic and skills development. This can be achieved through providing feedback on their progress. By doing so, educational institutions can increase student engagement, leading to more effective learning experiences that foster motivation and a sense of connection. To fully harness the power of Learning Analytics, it's important to prioritize understanding student needs, ensuring that data is used ethically and safely, and tailoring teaching strategies to be student-centered. By doing this, we can create a learning environment that empowers students to reach their full potential.

Improving Instruction through Learning Analytics

Learning analytics is a powerful tool that has the potential to revolutionize the education sector. By collecting data from various sources, including student interactions with educational software, online platforms, and other digital tools, learning analytics can provide real-time feedback to both instructors and students. This feedback can be used to identify the strengths and weaknesses of both parties, allowing for the creation of tailored learning experiences that are optimized for specific goals.

One of the key benefits of learning analytics is that it can help to enhance the quality of learning. By identifying areas where students are struggling and providing targeted support, educational software can help to improve learning outcomes. Similarly, by analyzing the performance of instructors, learning analytics can help to identify areas where they could improve their teaching practices, ultimately leading to better learning experiences for students. Another important benefit of learning analytics is that it can offer insights into effective teaching and learning practices from a variety of perspectives. This includes both pedagogical and technological insights, which

can be used to inform instructional design, delivery, student mentoring, and assessment. By leveraging these insights, educators can create more engaging and effective learning experiences that are better suited to the needs of their students (Fiaidhi, 2014).

Overall, learning analytics has the potential to transform the education sector by providing educators with a powerful tool for improving teaching and learning outcomes. By leveraging data to provide real-time feedback and insights, educators can create more effective and engaging learning experiences that are tailored to the needs of their students. Learning analytics is a comprehensive process that involves using multiple data sources and techniques to evaluate the effectiveness of teaching and learning. This process entails developing criteria and predictive indicators that can capture the complexities of the learning process (Lee et al., 2020). Educational technologies play a crucial role in this process as they can be used to visualize and interpret collected data, correct errors, and guide corrective actions. By analyzing large amounts of data obtained from the teaching and learning process, decisions can be made at all levels of the education system, ranging from the classroom to the institutional level.

One of the challenges of learning analytics is handling unstructured text data, which is abundant in academic institutions. Text analytics can be used to address this challenge by leveraging natural language processing techniques to extract valuable insights from unstructured text data. Through this approach, educators can gain a better understanding of how students interact with the learning materials, identify patterns and trends in student behavior, and develop strategies to improve the learning experience. Another valuable source of data in learning analytics is clickstream data, which records every page, section, or tag that students request. This data can be used to gain insights into student behavior, such as how much time they spend on specific learning activities, what resources they utilize most frequently, and what topics they struggle with. By analyzing clickstream data, educators can gain a more nuanced understanding of student needs and develop personalized learning plans that cater to their unique strengths and weaknesses. Overall, learning analytics is a powerful tool for educators and institutions to improve teaching and learning outcomes. By leveraging multiple data sources and techniques, educators can gain insights into student behavior and develop strategies to improve the learning experience.

To summarize, learning analytics has emerged as a potent mechanism for improving the teaching and learning experience and promoting student achievement. By leveraging data analysis techniques and offering valuable insights, educators can better tailor their instructional strategies to align with the unique needs of individual students. Nevertheless, it is essential to consider data privacy and ethical concerns while implementing this technology to ensure that it is utilized appropriately and responsibly. If used widely and effectively, learning analytics can significantly enhance the quality and success rates of education.

Learning Analytics Tools and Technologies

Tools and Technologies for Learning Analytics

Learning analytics is a field that involves extensive research and development to gain a deeper understanding of the various tools and technologies that can be utilized in education. This area of study emphasizes the importance

of existing tools that offer valuable insights into different aspects of the learning process. Thanks to technology, learning analytics tools and visualization techniques have been greatly enhanced. Specifically, dashboards and feedback mechanisms are now designed based on learner performance indicators, which have proven instrumental in illuminating the complex relationships between educational sciences and dashboard design (Ali et al., 2013). These insights are valuable in helping educators make informed decisions about how to improve the learning experience for their students.

The trend of using learning analytics to explore student behavior has become more widespread. However, to effectively use learning analytics, it is important to develop different types of feedback for different people and goals. Feedback based on linkage mechanisms to support learning is also emphasized. Instead of relying on superficial feedback from external factors in online learning, it is essential to adopt more targeted and student-oriented analytical methods.

Social learning analytics is a valuable tool for personalized and effective learning experiences. Analyzing social interactions in the learning process helps educators better understand learning pathways and narratives (Ali et al., 2013). Social learning analytics can help improve educational institutions and increase student achievement. Visualizing social learning analytics can also aid in understanding visible and invisible interactions in distance education. By better understanding student interactions and communication with teachers, the learning experience can be made more effective.

In the field of learning analytics for higher education, a wide range of data mining and learning analytics tools are available to support educators and students in achieving their educational goals. Among these tools, Predictive Learning Analytics (PLA), Learning Management Systems (LMS), and social network analysis tools like Gephi and NodeXL are some of the most important ones. Other tools include data analysis and modeling tools such as R, Python, and RapidMiner (Salihoun, 2020). One example of a large-scale and long-term PLA system is OU Analyze (OUA), which has been utilized by 23,180 students in 231 undergraduate online courses and accessed by 1159 teachers (Ali et al., 2013). Through OUA, teachers are provided with predictive insights into students' chances of passing the course, thus supporting the teaching process and improving student outcomes.

The development of learning analytics involves the integration of various technologies and methodologies from different research fields. Predictive analytical models like logistic regression and decision trees are some of the methods used to better understand learning processes (Salihoun, 2020). However, it is crucial that the data collection process is structured correctly, and ethical concerns regarding student confidentiality are observed during the analyses. Institutions are investing in the development of learning analytics to enhance their analytics capabilities, and the research community is also playing an important role in supporting work around learning analytics (Siemens, 2013). By utilizing data analytics, educators can improve the quality of education and enhance student achievement, making it a powerful tool in the field of education.

Building Predictive Models with Learning Analytics

The use of Learning Analytics is becoming increasingly important in developing predictive models. While predictive analytics offers greater value, it can also produce black-box models lacking transparency, which undermines user trust. Therefore, creating accurate forecasting models requires technical expertise.

Machine learning algorithms generate classifiers to learn from historical data and make predictions about future outcomes. These predictions are presented to students, enhancing their understanding of predictive models. Dashboards regularly use these techniques to emphasize forecasts based on historical and current data. Ideally, generic predictive models should be used to predict student outcomes across different courses. However, customized models may be necessary for certain courses due to a lack of data, which can increase technical resource costs.

Learning analytics relies heavily on predictive modeling, which can help forecast outcomes based on human behavior. It is important for learning analytics tools to convey confidence to students regarding the accuracy of their predictive output, as this can support their learning experience and improve educational processes. However, accurately predicting outcomes is a challenge in learning analytics, and recent reports show the accuracy of predictive models. These models can be integrated into dashboards to show students their performance and probability of achieving certain grades. While these predictive boards can help motivated students maintain their level of motivation, there are still uncertainties in influencing final results.

To identify students at risk and offer personalized messages, an early warning system can be developed using notes. Prescriptive analytics is a complex yet insightful form of analytics that can simplify the decision-making process for learners. By providing advice on behavioral adjustments and learning strategies, prescriptive analytics can use predictive analytics to understand possible causal relationships and generate recommendations for users to achieve positive outcomes. Model reasoning can help learners understand which factors are important to the predictive model and communicate the underlying model's accuracy to increase user confidence. Additionally, model reasoning can suggest changes in learning behavior to support the learning experience of students and offer valuable insights to educational institutions, making educational processes more effective and efficient.

Visualizing Data Through Learning Analytics

It has been demonstrated through various studies that there are four main types of information available to students that can provide valuable insights into their learning processes. These types of information include frequency of access to course materials, time spent on course materials, timing of access, and frequency of posting to discussion forums. Visualization methods are effective in enabling students to better understand their learning progress and encourage reflection on their learning process.

Social media text mining analytics and visualization have also been found to be useful in facilitating corporate learning and improving public service quality. The ability to analyze large amounts of social media data and

extract meaningful insights has proven to be a valuable tool for organizations looking to improve their services and offerings. Additionally, several tools are available for students and teachers, such as control panels to visualize learning traces.

In terms of student assessment, social comparisons can be used to analyze students by comparing them to specially defined groups and making comparisons with past classes. Visualization techniques can also be used as supervised and unsupervised learning methods and can help students better understand their learning processes by providing real-time clickstream data.

Learning analytics tools are particularly useful in monitoring teaching and learning activities on a web-based learning platform. They can reveal the relationship between different dimensions of student engagement activities and demonstrate the impact of the instructor's lesson preparation. For example, LOCO-Analyst is a learning analytics tool that models learning contexts and leverages semantic annotations of various learning resources. Visualization techniques can be integrated to provide metacognitive support so that students can receive visual guidance to develop learning strategies. Analytical tools can also be used to better understand student engagement and performance by visualizing the impact of student engagement activities and monitoring activities on engagement activities.

Overall, visualization techniques and learning analytics play an important role in education, providing valuable information about student progress and learning strategies. The data presented to students and teachers can help them better understand their learning processes and develop more effective learning strategies. Likewise, social media text mining analytics and visualization can be used effectively to improve corporate learning and public service quality. Learning analytics tools can help teachers effectively assess lesson preparation and increase student engagement. All these methods are constantly being developed in the field of education and continue to positively affect the learning experience of students.

Conclusion

The concept of learning analytics is focused on using data to enhance the learning process of students. Educators can improve academic performance and streamline teaching methods by collecting, analyzing, and interpreting data. However, it's important to consider ethical and privacy concerns and to continue researching and developing this area. Learning analytics can shape future education policies and practices and unlock students' full potential.

Learning analytics is a data-driven approach that supports personalized learning and improves educational processes. This method enables educators to understand student needs better and make informed decisions based on data analysis. It's crucial to address ethical and confidentiality concerns and base decisions on research. This approach offers valuable insights to enhance academic achievement and optimize educational processes.

Unlike traditional data analysis, learning analytics focuses on understanding students' unique needs, and tailoring their learning experiences to match. By analyzing data in context and considering interactions, educators can use

ad hoc tools to process large amounts of data and create effective responses. This student-centered approach has the power to enhance data-driven decision-making processes in education.

The use of learning analytics, a data-driven approach, offers educational institutions insights into student learning and performance. This data can aid in providing personalized support and improving education programs. By understanding the needs of students, educators can optimize their teaching strategies and institutions can improve their services. Learning analytics is a valuable tool in education, highlighting the benefits of using data to enhance learning experiences.

Learning analytics can improve education experiences by predicting student performance, identifying learning characteristics, and providing personalized support. This data-driven approach allows educators to better understand student needs and optimize their teaching strategies. However, it is essential to use learning analytics with ethical and privacy considerations in mind. More research and technology support is needed to ensure the effective and efficient use of learning analytics in education.

Learning analytics provides valuable insights to higher education institutions, aiding in decision-making processes. It enables the prediction of student performance and the identification of students at risk. However, it is crucial to consider ethical and privacy issues when using learning analytics. Further research and technology support is needed to improve decision-making processes in education. The effective and efficient use of learning analytics is a crucial step in increasing student success and personalizing the learning experience.

When it comes to learning analytics, several challenges must be addressed. Technical issues, such as providing the necessary infrastructure and resources, ensuring data accuracy, and dealing with ethical and privacy concerns, are among the most important. Additionally, there is a lack of understanding about what learning analytics is and how it can be used, which makes it difficult to address privacy and security issues related to data collection.

To effectively use learning analytics, it is important to develop data literacy and support decision-making based on analytical results. Confidentiality and ethical concerns are also major issues, and it is necessary to establish ethical policies and frameworks, provide standards for data privacy and security, and promote transparency and accountability in data analytics. The use of open datasets and data collection processes in learning analytics projects must be approached with care and European Learning Analytics Community Exchange (LACE) project and workshops guide in this area.

Data quality is another critical concern. It is important to ensure that data used in learning analytics projects is reliable, confidential, and based on ethical and scientific standards. Fairness and impartiality should also be ensured among student groups. Planning and using data quality assessment methods and tools play a critical role in achieving reliable and effective results. Improvements in data quality will drive learning analytics achievements and enable better decisions about student learning and educational experience. Ultimately, addressing these challenges will enable learning analytics to effectively drive data-driven transformation in education.

The use of learning analytics is becoming increasingly popular in high schools as it offers an effective solution for personalizing student experiences, guiding assessments, and informing decision-making processes. This tool processes and visualizes data collected from educational content.

Learning analytics can be an effective tool for increasing student engagement by providing actionable feedback that allows students to make more active choices and monitor their study progress more institutionally. It can also mediate information between the student and the institution, increase students' self-awareness, and function as a feedback channel to adapt learning conditions to their needs. However, it is important to understand student needs, use data ethically and safely, and adapt teaching strategies in a student-centered manner.

Real-time feedback from learning analytics has the potential to improve teaching and learning processes. The data collected can help evaluate the performance of instructors and students and improve the quality of educational content. It also enables better fitting student needs and instructional strategies by using a variety of data analysis techniques. However, it is important to consider data privacy and ethical issues when using learning analytics.

In the field of education, learning analytics involves the use of various tools and technologies such as data analysis tools, dashboards, social learning analytics, and predictive analytical models. These tools help to better understand student behavior and learning processes, ultimately improving teaching methods. However, it's crucial to consider ethical issues around the data collection process structure and student confidentiality. Both educational institutions and the research community contribute to the development of learning analytics.

Learning analytics plays a vital role in building predictive models that learn from historical data using machine learning algorithms. This helps to predict possible future outcomes and can be used in applications such as early warning systems and personalized messages, by predicting student performance. It also provides students with advice and recommendations that offer insights to improve their learning behavior. By making educational processes more effective and efficient, learning analytics supports the student experience and provides valuable information to educational institutions.

Students benefit from learning analytics by having access to visualization methods that provide valuable insights into their learning processes. These insights include frequency of access to course materials, time spent, timing of access, and frequency of posting to discussion forums. Visualization techniques such as social comparisons and clickstream data can be used to understand student progress and learning strategies. These tools can be used effectively to increase student engagement and evaluate teachers' lesson preparation. Continuously developed within the field of education, learning analytics continues to improve the learning experience of students.

References

Agudo-Peregrina, Á. F., Iglesias-Pradas, S., Conde-González, M. Á., & Hernández-García, Á. (2014). Can we predict success from log data in VLEs? Classification of interactions for learning analytics and their relation with performance in VLE-supported F2F and online learning. *Computers in Human Behavior*,

31(1), 542–550. https://doi.org/10.1016/J.CHB.2013.05.031

Ali, L., Asadi, M., Gašević, D., Jovanović, J., & Hatala, M. (2013). Factors influencing beliefs for the adoption of a learning analytics tool: An empirical study. *Computers & Education*, *62*, 130–148. https://doi.org/10.1016/J.COMPEDU.2012.10.023

Chen, B., Chang, Y. H., Ouyang, F., & Zhou, W. (2018). Fostering student engagement in online discussion through social learning analytics. *The Internet and Higher Education*, *37*, 21–30. https://doi.org/10.1016/J.IHEDUC.2017.12.002

Drachsler, H., Kismihók, G., Chen, W., Hoel, T., Berg, A., Cooper, A., Scheffel, M., Ferguson, R., & Manderveld, J. (2015). Ethical and privacy issues in the application of learning analytics. *ACM International Conference Proceeding Series*, *16-20-March-2015*, 390–391. https://doi.org/10.1145/2723576.2723642

El Alfy, S., Marx Gómez, J., & Dani, A. (2019). Exploring the benefits and challenges of learning analytics in higher education institutions: a systematic literature review. *Information Discovery and Delivery*, *47*(1), 25–34. https://doi.org/10.1108/IDD-06-2018-0018/FULL/PDF

Ferguson, R., Hoel, T., Scheffel, M., & Drachsler, H. (2016). Guest editorial: Ethics and privacy in learning analytics. *Journal of Learning Analytics*, *3*(1). https://doi.org/10.18608/jla.2016.31.2

Ferguson, R., & Shum, S. B. (2012). Social learning analytics: Five approaches. *ACM International Conference Proceeding Series*, 23–33. https://doi.org/10.1145/2330601.2330616

Fiaidhi, J. (2014). The next step for learning analytics. *IT Professional*, *16*(5), 4–8. https://doi.org/10.1109/MITP.2014.78

Franzoni, V., Milani, A., Mengoni, P., & Piccinato, F. (2020). Artificial intelligence visual metaphors in e-learning interfaces for learning analytics. *Applied Sciences 2020, Vol. 10, Page 7195*, *10*(20), 7195. https://doi.org/10.3390/APP10207195

García-Peñalvo, F. J. (2020). Learning analytics as a breakthrough in educational improvement. *Lecture Notes in Educational Technology*, 1–15. https://doi.org/10.1007/978-981-15-4526-9_1/COVER

Gašević, D., Greiff, S., & Shaffer, D. W. (2022). Towards strengthening links between learning analytics and assessment: Challenges and potentials of a promising new bond. *Computers in Human Behavior*, *134*, 107304. https://doi.org/10.1016/J.CHB.2022.107304

Gray, G., Cooke, G., Murnion, P., Rooney, P., & O'Rourke, K. C. (2022). Stakeholders' insights on learning analytics: Perspectives of students and staff. *Computers & Education*, *187*, 104550. https://doi.org/10.1016/J.COMPEDU.2022.104550

Guzmán-Valenzuela, C., Gómez-González, C., Rojas-Murphy Tagle, A., & Lorca-Vyhmeister, A. (2021). Learning analytics in higher education: a preponderance of analytics but very little learning? *International Journal of Educational Technology in Higher Education*, *18*(1). https://doi.org/10.1186/s41239-021-00258-x

Ifenthaler, D. (2017). Are higher education institutions prepared for learning analytics? *TechTrends*, *61*(4), 366–371. https://doi.org/10.1007/S11528-016-0154-0/TABLES/3

Ifenthaler, D., & Schumacher, C. (2016). Student perceptions of privacy principles for learning analytics. *Educational Technology Research and Development*, *64*(5), 923–938. https://doi.org/10.1007/S11423-016-9477-Y/FIGURES/2

Joksimović, S., Marshall, R., Rakotoarivelo, T., Ladjal, D., Zhan, C., & Pardo, A. (2022). Privacy-Driven

Learning Analytics. *Smart Innovation, Systems and Technologies*, *261*, 1–22. https://doi.org/10.1007/978-3-030-86316-6_1/COVER

Khalil, M; Ebner, M. (2015). Learning analytics: principles and constraints. *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, *2015*(JUNE), 1326–1336. http://www.editlib.org/p/151324

Lee, L. K., Cheung, S. K. S., & Kwok, L. F. (2020). Learning analytics: current trends and innovative practices. *Journal of Computers in Education*, *7*(1), 1–6. https://doi.org/10.1007/S40692-020-00155-8/FIGURES/3

Leitner, P., Khalil, M., & Ebner, M. (2017). Learning analytics in higher education—a literature review. *Studies in Systems, Decision and Control*, *94*, 1–23. https://doi.org/10.1007/978-3-319-52977-6_1/COVER

Manca, S., Manca, S., Caviglione, L., & Raffaghelli, J. (2016). Big data for social media learning analytics: potentials and challenges. *Journal of E-Learning and Knowledge Society*, *12*(2).

Quadri, A. T., & Shukor, N. A. (2021). The benefits of learning analytics to higher education institutions: A scoping review. *International Journal of Emerging Technologies in Learning*, *16*(23), 4–15. https://doi.org/10.3991/ijet.v16i23.27471

Roberts, L. D., Chang, V., & Gibson, D. (2016). Ethical considerations in adopting a university- and system-wide approach to data and learning analytics. *Big Data and Learning Analytics in Higher Education: Current Theory and Practice*, 89–108. https://doi.org/10.1007/978-3-319-06520-5_7/COVER

Salihoun, M. (2020). State of art of data mining and learning analytics tools in higher education. *International Journal of Emerging Technologies in Learning*, *15*(21), 58–76. https://doi.org/10.3991/ijet.v15i21.16435

Schumacher, C., & Ifenthaler, D. (2018). Features students really expect from learning analytics. *Computers in Human Behavior*, *78*, 397–407. https://doi.org/10.1016/J.CHB.2017.06.030

Serrano-Laguna, Á., Torrente, J., Moreno-Ger, P., & Fernández-Manjón, B. (2014). Application of Learning Analytics in educational videogames. *Entertainment Computing*, *5*(4), 313–322. https://doi.org/10.1016/J.ENTCOM.2014.02.003

Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist*, *57*(10), 1380–1400. https://doi.org/10.1177/0002764213498851

Silvola, A., Näykki, P., Kaveri, A., & Muukkonen, H. (2021). Expectations for supporting student engagement with learning analytics: An academic path perspective. *Computers & Education*, *168*, 104192. https://doi.org/10.1016/J.COMPEDU.2021.104192

Slade, S., & Prinsloo, P. (2013). Learning analytics: Ethical issues and dilemmas. *American Behavioral Scientist*, *57*(10), 1510–1529. https://doi.org/10.1177/0002764213479366

Taş, N. (2021). Artificial Intelligence in Education: Literature Review. *International Conference on Studies in Education and Social Sciences (ICSES).* Antalya: ISTES .

Taş, N., & Gülcü, A. (2019). *Bilgisayar Destekli Öğretimin Temelleri.* Erzurum: Ertual Akademi.

Troussas, C., Krouska, A., & Virvou, M. (2020). Using a multi module model for learning analytics to predict learners' cognitive states and provide tailored learning pathways and assessment. *Intelligent Systems Reference Library*, *158*, 9–22. https://doi.org/10.1007/978-3-030-13743-4_2/COVER

Tsai, Y. S., & Gasevic, D. (2017). Learning analytics in higher education - Challenges and policies: A review of eight learning analytics policies. *ACM International Conference Proceeding Series*, 233–242. https://doi.org/10.1145/3027385.3027400

Verbert, K., Duval, E., Klerkx, J., Govaerts, S., & Santos, J. L. (2013). Learning analytics dashboard applications. *American Behavioral Scientist*, *57*(10), 1500–1509. https://doi.org/10.1177/0002764213479363

Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. *Computers in Human Behavior*, *89*, 98–110. https://doi.org/10.1016/J.CHB.2018.07.027

Wong, B. T. M. (2017). Learning analytics in higher education: an analysis of case studies. *Asian Association of Open Universities Journal*, *12*(1), 21–40. https://doi.org/10.1108/AAOUJ-01-2017-0009

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Citation

Kaban, A. (2023). From data to insights: The power of learning analytics. In A. Kaban & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 101-120). ISTES Organization.

Chapter 8 - Application of Artificial Intelligence in Teachers' Performance Management: A Mini-Review and Research Opportunities

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Chapter Highlights

- This study argues that advances in artificial intelligence (AI) are a new focus of global competition and a new possibility for organizational progress. In doing so, it highlights the potential of AI in education and specifically addresses its applications in improving teachers' performance and evaluation.
- Successful organizations are using AI in their performance management systems to monitor and guide employee performance. Performance management is defined as a strategic managerial process of monitoring an organization's performance in terms of effectiveness, efficiency, and impact through frequent planning, regular measurement, and evaluation techniques and tools.
- Teachers' performance is managed through performance appraisal, a process of continuous evaluation to help educational institutions achieve their goals. Performance appraisal helps teachers identify and improve their strengths and weaknesses, while at the same time increasing student achievement.
- AI is used in teacher performance evaluation processes, ensuring objective results. This technology helps teachers identify their strengths and weaknesses, improve their teaching strategies, and better serve students. AI also improves the quality of education by providing teachers with fast and effective feedback.
- Teachers' work efficiency plays a strategic role in ensuring the quality of education. Technologies such as AI and machine learning are being used to measure and improve teachers' productivity. The use of AI allows us to evaluate teachers' performance more objectively and increase productivity.

Abstract

Global attention has been drawn to recent advances in artificial intelligence (AI), as it is evolving into a new area of concentration for global competition and a new possibility for human and organizational progress. As AI technology has flourished, so have its applications in education, with tremendous potential to deliver dynamic assessments and enhance teachers' performance. Performance management processes are extensive and stretched out throughout the year, leaving evaluators to record and grade teachers based on their recent accomplishments. Furthermore, since evaluators are always preoccupied, they simply record this action as completed with a tick mark, obscuring or skewing the results, thus, making it impossible to grasp the individual's potential in the process. These drawbacks have necessitated the implementation of AI methodologies and tools in the performance management systems of educational institutions. AI in performance management systems creates a data-driven appraisal system that helps maintain transparency and avoids misapprehension, distrust, and biases. In this study, we looked at the introduction of AI in education by assessing the impact of AI on performance management. The study adopted the PRISMA framework to conduct a systematic literature review on the subject of interest. Laying its foundation on the PRISMA framework, the methodology comprises the search strategy, the selection criteria, quality assessment, and data extraction. The study shows that using AI in performance management as a means for teacher evaluation and assessment can serve as a decision-making guide for the administration of institutions. It helps to reveal teachers' true abilities, helps teachers focus on teaching challenges and key issues, highlights the shortcomings in their teaching activities, and enhances the essential assurance and support for teachers to make genuine progress.

Introduction

Global attention has been drawn to recent advances in artificial intelligence (AI), as it is evolving into a new area of concentration for global competition and a new possibility for human and organizational progress. Most countries have begun to pay attention to the changes AI can offer to the growth of organizations (Yang, 2019). As AI technology has flourished, so have its applications in education, with tremendous potential to deliver dynamic assessments and enhance teachers' performance (Zhang, Xiao, Li, Hou, et al., 2021). AI is improving education efficiency by helping with academic and administrative tasks (Ahmad et al., 2022). Well-organized staff performance is one of the components of any organizational progress, and good performance is demonstrated by factors like dependability, affordability, efficacy, and client focus. Therefore, to identify and manage the factors that affect employee performance and behavior, successful organizations worldwide have implemented artificial intelligence (AI), in Performance Management Systems (PMS). A performance management system is defined as a strategic managerial process that gives managers, leaders, employees, and interested parties at different levels a set of techniques and tools to monitor and maintain, frequently plan, irregularly measure, and assess the performance of the organization in terms of efficiency, effectiveness, and impact. The purpose of performance management is to align an employee's performance with the organization's ultimate success (Rath, 2018).

In the education sector, the performance management system is been implemented through performance appraisal which is a continuous evaluation procedure and a goal-oriented process used by educational institutions to achieve

their objectives by constantly measuring and providing feedback to teachers to improve their performance and help them achieve better results (Yambi & Yambi, 2020; Zhou et al., 2022). Through routine performance appraisals (PA), which include continuing assessments of each teacher's performance, these institutions gauge and raise the value of their teaching force (Sułkowski et al., 2020). Teachers' performance appraisal offers a systematic framework to construct and guarantee a culture of professionals dedicated to catering to educational requirements, such as increasing teachers' effectiveness and students' achievement. Thus, the appraisal of teachers is critical in the study of performance management because it also makes extensive use of goal-setting and metrics to identify progress and areas of individual strength. This offers many additional advantages not provided by the yearly traditional assessment process (Sánchez-Prieto et al., 2020).

However, despite these benefits, performance management systems present some drawbacks, such as a lack of automation and the potential for human errors. In addition, the performance management processes are extensive and stretched out throughout the year, leaving evaluators to record and grade teachers based on just their recent accomplishments. Furthermore, since evaluators are always preoccupied, they simply record this action as completed with a tick mark, obscuring or skewing the results, thus, making it impossible to grasp the individual's potential in the process. These drawbacks have necessitated the implementation of AI methodologies and tools in the performance management systems of educational institutions (Sánchez-Prieto et al., 2020). AI in performance management systems creates a data-driven appraisal system that helps maintain transparency and avoids misapprehension, distrust, and biases. Their applications in educational evaluation and appraisal are increasing and have attracted much attention in recent years (Zawacki-Richter et al., 2019). Applications of AI in performance appraisal open new possibilities for digital education, from automating and augmenting teaching and evaluation in the classroom to enabling the next generation of digital education enhanced by AI (Popenici & Kerr, 2017; Vanleeuwen et al., 2020). This review seeks to examine the effectiveness of AI in teacher performance evaluation, feedback, and productivity of higher education teachers.

Literature Review

Performance Management System in Education

Educating a population is argued by several economics studies to be a key to its development and prosperity. The human capital concept, upon which these studies are based, states that monetary investments in a person's education and professional development pay off in the form of increased productivity (Carneiro et al., 2010). Further research, according to Benlhabib (2019), has demonstrated a strong positive correlation between development and high-quality education rather than quantity. From their findings they go on to explain, that countries are under increasing pressure to implement performance management measures and accountability in their educational systems, as well as to make substantial financial investments to boost education quality. They argued that advocates of New Public Managerialism believe that schools may be made more efficient and productive if they treat education like a commodity on the market rather than a public good or social service (Benlhabib, 2019). Page (2016) argues that there has been a dearth of studies into the Performance Management System (PMS) at academic institutions and that the studies that have been conducted have been framed in terms of managerialism, performativity, and marketization. Instead of being bound by the constraints of the professional

concept, PMS adopts the framework of the labor process theory and is consistent with the management concept. Page continued by arguing that PMS has gained influence among teachers due to the ethical obligation of teaching since it is generally believed that improved teacher performance translates into more positive learning outcomes for students. From this point of view, school administrators have an ethical obligation to get rid of the "bad teachers", (Page, 2016) who are seen as the "problem" (Chiang et al., 2020) and are actively working against the best interests of their students by avoiding their responsibilities and causing harm to their education.

Likewise, performance management's incorporation into the educational system can be traced back to laws that have been required or other forms of coercion imposed by the government. This is closely related to New Public Management, a set of reforms made in the public sector. This reform in the form of a performance-oriented approach has emerged as a critical competency for school administrators due to a direct result of the severe budget constraints and the growth in expectations to improve the government's efficacy, effectiveness, and transparency. By law, principals must provide feedback on their teachers' work and keep records of their evaluations. For this requirement to be met, school administrators must first delegate tasks that contribute to the school's overall mission. In addition, they must provide regular opportunities for professional development and evaluation for teachers. This puts many teachers in what is called a "performative condition" at work (Naidu, 2011). Schools are expected to have a strategic plan in place to offer the necessary direction, and performance management as a tool helps with this. This means that educational institutions should develop a long-term strategy outlining how they intend to achieve their goals. Employees are also held accountable through performance management systems. In other words, performance management is an effective means by which educational institutions can incorporate additional opportunities for professional development and, thus, contribute to increased workplace performance. This suggests that upper-level administration values professional development and thinks performance management will increase opportunities for it in schools (Bulawa, 2012).

Artificial Intelligence in Education

The introduction of Artificial Intelligence (AI) into the educational contexts can be traced to the 1970s. At that time, researchers were interested in seeing how computers might substitute for one-to-one human tutoring, which is thought to be the most effective approach to teaching but was unavailable to most people (Bloom, 1984). Today, AI technologies are increasingly being used to facilitate the management and delivery of education. Rather than supporting teaching or learning directly, these system-facing applications are designed to automate aspects of school administration, building on Education Management Information Systems. Also, the rise of big data, artificial neural networks, cloud computing, and machine learning have all contributed to the development of a computer capable of mimicking human intellect (Zhai et al., 2021). The term "artificial intelligence" (AI) refers to a group of technologies that produce absolute magical results when combined with data, algorithms, and processing power. AI can also be referred to as a software system, perhaps integrated into hardware built by humans, capable of making a decision based on interpretation, perception, and reasoning using facts gathered from the environment and applied to solve a difficult problem. AI is autonomous, i.e., it can make decisions without requiring human intervention to accomplish a task- or purpose-related objective. It also possesses adaptability, indicating that the system can perceive its surroundings and modify its behavior in response to environmental shifts (Dignum, 2021).

Furthermore, AI in the educational system is due to the increasing workload of teachers and the need to increase teachers' productivity. Artificial Intelligence in Education (AIED) helps identify the gaps in teaching and learning and increases proficiency in education (van der Vorst & Jelicic, 2019). AIED helps the education system in evaluation, assessment, prediction, personification, intelligent tutoring, and adaptive systems. It also has the potential to address some of the biggest challenges in education today, innovate teaching and learning practices, and ultimately accelerate progress toward SDG 4 (Robertson, 1976). Administrative tasks, such as student monitoring, are made easier through automated systems, and the desktop computer has been joined in the classroom by an increasing number of gadgets (Johnson et al., 2016). A huge rise in data generation and computational power has occurred in tandem with the development of digital technologies and their growing interconnectedness. This leads to the widespread use of intelligent systems that can learn from themselves, reason like humans, and generalize from massive datasets (Xu et al., 2021).

Likewise, new AI-based teaching and learning solutions are being developed and tested in areas like performance management (Bates et al., 2020; Roll & Wylie, 2016). Performance management necessitates school administrators to participate in various activities with their respective teachers, such as evaluating the teachers' performance (Wiener & Jacobs, 2011). Successful performance appraisal and management implementation contribute to teachers' efficient and effective teaching performance. Recent advances in artificial intelligence are causing a revolution in the educational system by opening the door to individualized learning, improved teacher evaluation and administration, and many other benefits. AI technologies are helping to determine the performance levels of teaching professionals while simultaneously improving individual students' curriculum and skill levels (Kinshuk et al., 2016; Popenici & Kerr, 2017; Tuomi, 2018).

However, these rapid technological developments inevitably bring multiple risks and challenges, which have outpaced policy debates and regulatory frameworks (Pedro et al., 2019). Irrespective of the glaring benefits of AI in education, there is a potential risk concerning the fundamental human rights of both learners and teachers and relationship building between teachers and students and among students. Berendt et al. (2020) argue that fundamental human rights should be a priority and the starting point for the application of AI in educational systems by considering how AI in education affects individual fundamental human rights and freedom. Students and teachers, rather than AI tools, corporate organizations should be the main beneficiaries of the development, marketing, and integration of AI in education. Guilherme (2019) indicates that the relationship between teachers and students in the classroom should not be undervalued. Policymakers should be intentionally aware of the necessity to balance the 'technologicalisation' of education and the creation of the ideal conditions since, according to (Berendt et al., 2020), beyond data privacy, AI in education has an impact on basic human rights.

The Role of AI in Performance management

A Performance Management System is a method of recording and analyzing data on the accomplishments of groups, individuals, and organizations. The purpose of performance management is to foster the growth of employees' capabilities so that they can fulfill and even exceed their employers' expectations and realize their full potential for the good of both themselves and the organization. It is preferable to carry out performance

management in a manner that is supported by data, such as completion times for jobs or other performance indicators. Artificial intelligence (AI) systems might make this data collection more efficient, making it possible for administrators to obtain the appropriate data at the appropriate time (Stroet, 2020). Artificial intelligence has provided considerably smarter, quicker, and better platforms than ever before, which has completely revolutionized the method by which daily tasks are carried out. Also, the ability of AI to handle massive amounts of information at breakneck speeds, accurately interpret that information, and eliminate human bias has led to extraordinary gains (Pothen, 2022).

Furthermore, the approach to providing evaluations and feedback to workers is an essential component of every organization. Its efficient management can contribute to increased levels of productivity among its workforce. However the traditional performance evaluation method is rife with various flaws when put into reality. These inaccuracies significantly impact how objective the evaluation can be considered. Hence, incorporating AI and other scientific evaluation techniques into the appraisal process has helped simplify the procedure. Behavioral tests that are trustworthy and were built using scientific principles have helped executives understand what motivates and encourages their staff (Kumari et al., 2021). Artificial intelligence (AI) has enabled administrators to more accurately evaluate their staff members' work toward achieving predetermined goals. AI not only helps to ensure that performance evaluations are carried out, but it also enables a documentation system that stores the results of various performance management tasks. Again, AI enables administrators to check their judgments and ensure that their feedback is accurate by providing a second opinion. It assists the administrators in getting better and offers them access to more data and information about the employees they are evaluating (Stroet, 2020). Likewise, AI can assist administrators in better-identifying gaps in the talent pool and in providing targeted training ideas to employees by assessing a person's career progression using data from previous performance assessments, skills, and hobbies. This data can be gleaned from an individual's digital profile (Nantham, 2021).

However, utilizing AI provides many advantages and has numerous downsides that prevent it from replacing people in performance management. This is because a significant financial cost is associated with incorporating AI into the performance review process. If the software or the system's hardware becomes dysfunctional, it might need a lot of effort and money to repair (Lucas, 2022). AI lacks a human aspect in that when AI is utilized, the function of the manager shifts from being the individual accountable for conducting performance reviews to that of a facilitator. Also, artificial intelligence can only learn and do tasks per how it was programmed. AI's lack of human intelligence might have a detrimental effect on employees (Nantham, 2021)(*Use of Artificial Intelligence in Performance Reviews | Profit. Co*, n.d.). AI may not be able to perform precisely well in every circumstance. There will be situations in which performance evaluations based on AI won't be able to take certain aspects into account. In states like this, the judgments that need to be made require the wisdom of humans. Therefore, over-reliance on artificial intelligence (AI) and connected technologies can limit human potential and the ability to make sound decisions (Chernov & Chernova, 2019).

Again, the most significant drawback of AI is that it has ethical norms that are open to interpretation. When businesses want more and more data, including personal data, artificial intelligence programs designed to acquire personal data can become very intrusive. Also, employees' reputations may suffer due to the performance reviews related to the data. This might lead to a decline in the level of trust that employees have in the organization. It is

of the utmost importance for organizations to seriously consider how and the specific areas in which they plan to implement AI in the performance evaluation process. They need to carefully draw a boundary where artificial intelligence merely supplements human intellect and assists managers in performing their jobs more effectively and making better judgments, rather than taking over their duties and being intrusive while collecting data (Nantham, 2021)(*Use of Artificial Intelligence in Performance Reviews | Profit.Co*, n.d.).

Method

The introduction of Artificial Intelligence (AI) is changing the face of many sectors. We looked at the introduction of AI in education by assessing the impact of AI on performance management. The current study adopted the PRISMA framework to conduct a systematic literature review on the subject of interest. Laying its foundation on the PRISMA framework, the methodology comprises the search strategy, the selection criteria, quality assessment, and data extraction, as explained below.

The Search Strategy

To identify the relevant literature for the review, the researchers developed objectives that were used for literature identification. We used the Scopus and Web of Science databases and conducted a literature search on August 20, 2022. We developed key works in the first stage to search for the literature. The keywords include “artificial intelligence and performance management.” In the second stage, we used a combination of words in the existing literature to conduct another search for the articles. The combined words used are given in Table 1.

Table 1. The combined keywords

Performance Management	"performance management” OR “performance system" OR “teacher performance evaluation" OR "performance appraisal*" OR “teacher productivity" OR "teacher assessment" OR "teacher evaluation" OR "teacher outcome" OR "teacher feedback"
	AND
Artificial Intelligence	"artificial intelligence" OR "machine intelligence" OR "intelligent support" OR "deep learning" OR "machine learning" OR "automated assessor*" OR "intelligent agent*" OR "expert system" OR "neural network" OR "natural language processing" OR "data mining"

Selecting Criteria

We constricted our search to works of literature that have been published in the fields of education alone as our selection criteria. During the evaluation process, we did not include articles unrelated to the study’s scope and those falling out of the defined period (i.e., 2000-2022). The researchers also considered only articles in English, and finally, articles that did not address the study’s objective were excluded from the evaluation. Below are the summary points;

- Full articles in English only
- Objectives of the articles identified should fall within the themes of the study
- Articles directly related to the research objective

- Published between 2000 and 2022

Quality Assessment

Following the objective set out for the review, we obtained a search result of 285 papers—232 from Scopus and 53 from Web of Science. In the next stage, we filtered out all duplicated articles, which resulted in 280 papers. The third round of screening resulted in the researchers removing 254 more publications because they were not relevant to the study's objective. Eleven (11) more papers were removed due to the methodologies used. Finally, a total of 15 papers were used for this review. The framework in Figure 1 below shows the process of quality assurance.

Data Extraction

We used the Microsoft Excel application to extract relevant information from the papers selected for the review. The Excel sheet contained essential characteristics such as the paper's title, publication date, authors' details, DOI, methodology used, and area of AI.

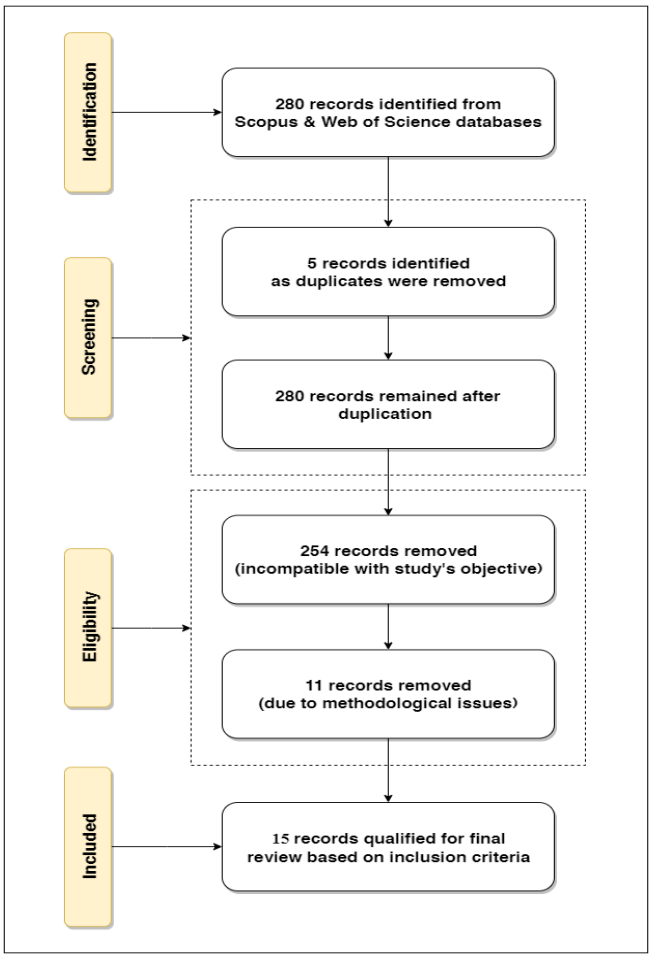

Figure 1. The search, screening, eligibility, and inclusion processes diagram at each stage based on the PRISMA guidelines

Results

The Distribution of Articles by Journals

We analyzed the number of papers published by each journal in this field (see Table 2). The overall analysis from Table 2 shows that the Journal of Mobile Information Systems and the Journal of Wireless Communications and Mobile Computing have published two papers each, representing 13.33%. The rest of the journals have published one article each. The journals published in this field include the Indian Journal of Science and Technology, the International Journal of Innovation and Learning, Frontiers in Psychology, Computer Applications in Engineering Education, etc. This implies that only a few journals significantly influence the publications done in this field.

Table 2. The distribution of articles by journal, percentage, year, and number of publications

The Distribution of Articles by Journals

Name of Journal	Year	Number of Publication	Percentage
International Journal of Intelligent Engineering & Systems	2018	1	6.67
Journal of Innovation and Knowledge	2022	1	6.67
Mobile Information Systems	2022	2	13.33
International Journal of System Assurance Engineering and Management	2021	1	6.67
Indian Journal of Science and Technology	2016	1	6.67
International Journal of Innovation and Learning	2020	1	6.67
Frontiers in Psychology	2022	1	6.67
Computer Applications in Engineering Education	2016	1	6.67
Journal of Intelligent & Fuzzy Systems	2020	1	6.67
Mathematical Problems in Engineering	2022	1	6.67
Journal Of Institutional Research (South East Asia)	2020	1	6.67
Wireless Communications and Mobile Computing	2021 2022	2	13.33
Wireless Personal Communications	2021	1	6.67

Note: The two articles from Mobile Information Systems were published in the same year (2022)

The Distribution of Papers Published Over Time

To understand the publication trend in this field, we analyzed the number of papers published over time (see Figure 1). The result shows that publication has been inconsistent for the past years. The highest number of publications is seen in 2022, with six papers. The early 2000s (i.e., 2000 -2015) saw no work done in this field. Two papers were published in 2016, with one published in 2018. Both 2017 and 2019 did not record any publications. However, the number of publications sharply increased to three for 2020 and 2021. The sharp increase in the publication in 2022 suggests a strong interest in this field among researchers.

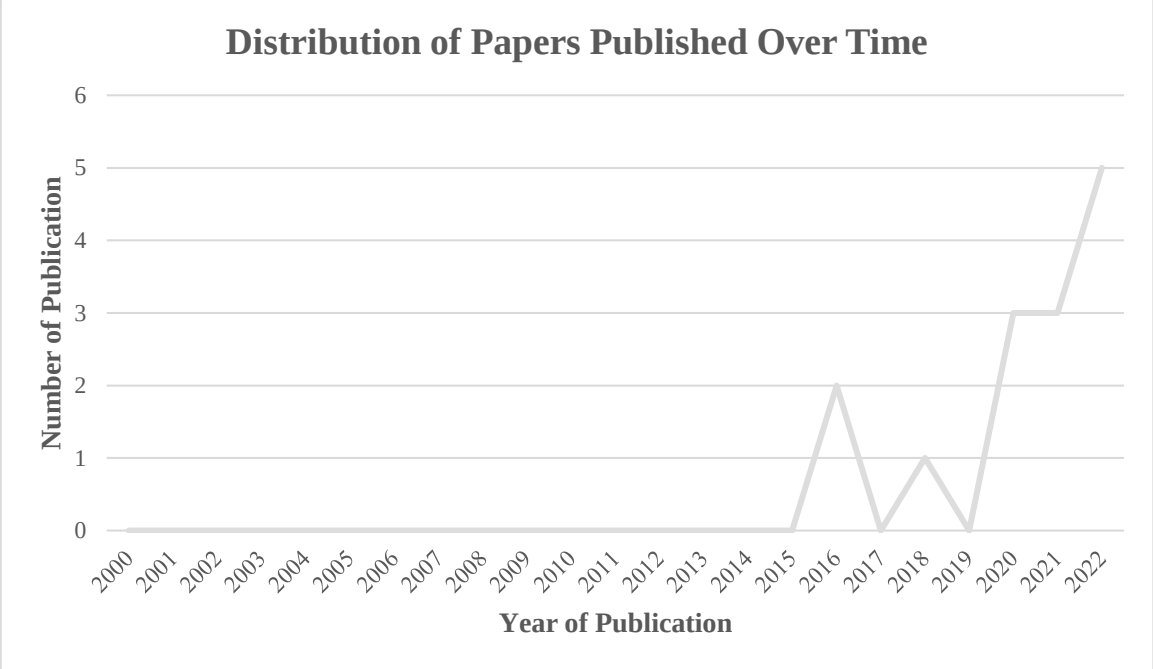

Figure 2. Distribution of papers published over time

Analysis of Author and Co-Authorship

Within this section of the article, we conducted an author and co-authorship analysis to demonstrate the cooperation and mutual understanding that has developed among scholars working within this area. According to the findings, 80% of the articles were co-authored, while 20% were single-authored. In addition, we did not observe any group of writers publishing more than one paper. This can point to the fact that there is less effort in collaboration within this research field.

Discussion

AI in Teacher Performance Evaluation and Assessment

Raising educational standards requires improving the overall quality of instruction, and one of the most essential tools for accomplishing this goal is teacher evaluation. The purpose of evaluating the quality of teaching is to provide support to educational reform, offer learners assistance in problem-solving, lessen the amount of pressure placed on pupils, enhance standards, and encourage intellectual development. As part of educational management, a system for evaluating the quality of instruction needs to be developed and continuously enhanced. Evaluating teaching quality is difficult because of the inherent limitations in the traditional methodologies used to assess the quality of instruction. As a result, the development and improvement of a method for evaluating the effectiveness of teachers are essential for educational management (Zhang, Xiao, Li, Hou, et al., 2021). Zhou et al. (2022) indicate that AI in teacher evaluation not only helps in considering many factors in the evaluation of teachers but also improves teaching quality. This can be attributed to the validity and reliability of AI employed in teacher evaluation which can serve as a decision-making guide for the administration of teaching authority since it can reveal teachers' genuine abilities, help teachers focus on teaching challenges and key issues, highlight the

shortcomings in their teaching activities, and enhance the essential assurance and support for teachers to accomplish genuine progress (Gao et al., 2020).

Similarly, the assessment process is essential to the teaching and learning processes. Instead of serving as a tool for measurement, assessments are now used to help teachers improve their teaching (Ng et al., 2020). Even though implementing performance assessment in education has moved at a snail's pace, this aspect of corporate applications is seeing fast development. Implementing performance assessment in schools helps students learn more practical skills since the practice is centered on enhancing teachers' performance (Meng et al., 2022). Performance assessment is a highly important and delicate process, especially regarding assessing teachers working in educational institutions. With performance assessment, teachers can improve their weaknesses and the quality of teaching at institutions if their weak points are located through a system that provides an early warning to notifications and rewards (Rashid & Ahmad, 2016). In addition, teachers' capability, performance, knowledge, and assessment significantly impact the standard of students' education. These methods enable educational institutions to assess teachers' performance and choose the most qualified candidates for teaching positions. Employing an Artificial Intelligence (AI) based cloud computing system fast-tracks teachers' assessments and helps school administrators conduct efficient recruitments (Kavitha, 2021).

Kavitha (2021) also provided evidence that Cloud Computing based on Data Mining can help educational institutions evaluate and decide the classification rule to determine and hire the most suitable teacher based on knowledge by utilizing a cloud database. This was demonstrated by the research that was conducted by Kavitha. Through the use of the cloud computing platform, one can have access to the various resources that are now available on the World Wide Web in an efficient and scalable manner. With the assistance of data mining, the company can ensure the safety and dependability of the software management as well as the data storage. Zhang, Xiao, Li, Hou, et al. (2021), and Cheng et al. (2020) likewise presented a unique model for evaluating the quality of classroom instruction in higher education institutions based on improved genetic algorithms and neural networks in their research. Their findings demonstrated that improving the neural network's prediction accuracy and convergence speed led to enhanced teaching quality evaluation findings, which in turn led to a more practical framework for evaluating the teaching quality of professors at colleges and universities. AI in evaluating teachers' performance is a suitable technique to evaluate their work since computer intelligence can adapt to various indicators and influencing elements in the assessment.

AI-based evaluation tools enable administrators to fast-track assessment processes without external influences on the assessment outcomes (Ng et al., 2020; Rashid & Ahmad, 2016; Samuel et al., 2014; Yang et al., 2022). Again, using AI in teacher assessment is acceptable to users, especially when the system has been certified and helps better predict teachers' performance (Chen et al., 2021; Lamarca & Ambat, 2018; Samuel et al., 2014). The application of AI in assessing teacher performance is a reasonable way based on the ability of machine learning to different proportion indicators and influencing factors in assessment (Yang et al., 2022). There are many more researchers who have used artificial intelligence in their studies to improve teaching quality, teacher performance, and evaluation; examples are; C5 data mining (Cheng et al., 2020), Decision Tree Algorithm (Yan & Jan, 2022), Convolutional Neural Network (Zhou et al., 2022), Clementine data mining (Gao et al., 2020), etc. By enhancing AI prediction accuracy and convergence speed, teaching quality evaluation is enhanced, leading to a more useful

methodology for assessment (Zhang, Xiao, Li, Hou, et al., 2021). Hence, scientific means of teacher evaluation can be deployed with the use of AI, which will mitigate challenges in the current teaching evaluation system, which is based on indicators of teaching quality achievements or subjective judgments of experts and subject groups that cannot be comprehensive, systematic, and scientific (Yang et al., 2022).

Feedback on Teachers' Performance

Feedback on teaching performance is the communication between teaching managers and teachers about teaching performance. Teacher feedback is important to let the teacher know whether the teaching effectiveness has met the set teaching objectives. Feedback is also one of the mainstreams of evaluation and is the key to the effectiveness of teaching performance management. Simultaneously, schools should develop teaching performance management systems based on big data to support teaching performance at all stages, including feedback. When teachers are being evaluated, there is always a need to provide timely feedback to teachers in other for them to facilitate the judgment of teaching strategies, ensure that the problems reflected in the evaluation are also addressed, and also improve their teaching quality (Xin et al., 2022). Also, through timely feedback, the evaluation result is tailed, classified, summarized, and analyzed through the web terminal. Most teaching performance feedback summarizes the past performance and looks at the new evaluation cycle. Therefore, the feedback process should focus on the performance indicators' content.

The use of AI in teacher performance evaluation has the added advantage of close to accurately predicting the expected performance of teachers based on available data. This enables the provision of corrective measures before the occurrence of such outcomes in the future (Chen et al., 2021). Hence as opposed to the traditional evaluation by subject experts, which cannot accurately provide feedback to mitigate the occurrence of a future happening, the use of AI in evaluation solves that issue. In the field of education, artificial intelligence has the potential to enhance the way administrators and students interact with the evaluation and feedback of teachers. Automating assessment aims to reduce the amount of labor involved in marking and providing feedback. Automation in teachers' assessment and feedback can be enhanced by heavily relying on technology such as natural language processing and artificial intelligence to give alternative assessment forms. Instead of the traditional method of evaluation, which involves subject specialists who cannot offer accurate feedback to prevent the occurrence of future unfair practices, AI automation pushes the education sector towards a more continuous assessment cycle, improving the outcomes and experience of teachers (Chen et al., 2021; Zhou et al., 2022). Providing feedback to educators can assist educators in gaining a better understanding of their capabilities, which can be a vital first step toward improving procedures in the classroom. Recognizing such strengths and shortcomings, providing information to inform decisions regarding resource allocation, and inspiring actors to improve performance are all key elements that can promote policy goals such as school improvement, accountability, and choice. Teachers' professional development as educators, as well as their job security and job satisfaction, are all significantly boosted due to the major impact that feedback has on both the teachers themselves and the work they do (OECD, 2009).

Work Productivity

Work productivity on the part of teachers plays an essential and strategic role in the provision of quality education. This role can, for example, play a role in determining the progression of education quality through direct encounters with students to provide them with skills and competencies. Because they are directly involved in school pedagogical activities, teachers and educators play an extremely important part in achieving the national education goal. As teachers need to organize, carry out, and supervise every educational activity to benefit the school's goal accomplishment, their productivity becomes a significant component of institutional aspects. These aspects also entail teachers' personalities and physical abilities, especially in the amount of work they do during school hours. As already mentioned above, these productivity matrices can only be accurately measured and improved with the application of automation processes such as AI and machine learning. The application of these techniques for gauging teachers' productivity is gaining significant attention, as seen in (Kavitha, 2021; Meng et al., 2022; Zhang, Xiao, Li, Hou, et al., 2021; Zhou et al., 2022), etc.

Without AI in teacher performance evaluation, some teachers who work hard by combining teaching and administrative work would not be seen as being the product for promotion since they cannot produce research papers like other teachers in other fields such as Science, technology & engineering. Cheng et al. (2020) argue that teachers who fall in the teaching cluster of universities are not seen as efficient and thus do not usually get promoted since they cannot churn out research publications like those in the research clusters in the university environment. The use of AI could improve teaching management quality hence increasing productivity. Meng et al. (2022) demonstrate how using big educational data and benchmarking analysis could yield more insightful results and new information for raising the caliber of teaching management quality and improving teaching performance evaluation.

Conclusion

Since the 1970s, artificial intelligence has been employed in education, and in the present day, AI technologies are being used more often to make educational administration and delivery more efficient. Using AI in performance management as a means for teacher evaluation and assessment can serve as a decision-making guide for the administration of institutions. It helps to reveal teachers' true abilities, helps teachers focus on teaching challenges and key issues, highlights the shortcomings in their teaching activities, and enhances the essential assurance and support for teachers to make genuine progress. Advanced tools such as machine learning and cloud computing present ways to evaluate the quality of classroom instruction in higher education institutions. Additionally, using cloud computing platforms allows efficient access to a wide variety of resources now available on the World Wide Web. In this mini-review, we have explored and summarized the currently available scientific discussions on the use of AI in performance evaluation, particularly in the higher education sector. We analyzed the number of papers published by each journal in this field between 2000 and 2022. A significant finding from the analysis shows that adopting AI tools and processes in performance management in educational institutions is beginning to gain widespread recognition among researchers.

Further analysis of author, co-authorship, and publication revealed that 80% of the articles were co-authored,

while 20% were single-authored. No group of writers was found to have published more than one paper, highlighting less effort in collaboration within this research field. Moreover, the Journal of Mobile Information Systems and the Journal of Wireless Communications and Mobile Computing were found to have published the highest with two papers each, implying only a few journals have influenced publications in this field. One important finding from the review highlights the significance of implementing AI in teacher evaluation to address problems with the current teacher evaluation system, which is largely based on indicators of teaching quality accomplishments or subjective judgments of experts in a subject area and therefore lacks the capability of being comprehensive, systematic, and scientific. This is of the utmost significance since performance management is undergoing a fundamental shift from the outdated practices of the past (performance appraisal) to contemporary practices that are more efficient, transparent, criteria-based, and feedback-oriented.

Older assessment methods have been shown ineffectual, and educational institutions are coming under increasing pressure to bring their systems and capabilities up to speed with the latest trends in technological advancement. Performance evaluations in educational institutions need to be more future-oriented, emphasizing development, coaching, and assessment using innovative software and tools for performance management. These technologies are critical for embracing innovative classroom performance management methods that encourage regular dialogues about students' and instructors' successes, tailored growth, and increased visibility of those accomplishments. In addition, they contribute to the motivation of the teaching staff, which is beneficial given that most educators are driven by appreciation rather than financial compensation. On the other hand, educational institutions must understand the advantages of implementing current performance management trends and endeavor to meet set goals by satisfying their teaching workforce.

The results of this study offer readers, policymakers, and school administrators the most up-to-date information available on the usefulness of AI in assessing, providing feedback on, and increasing the productivity of higher education instructors. This research provides a systematic understanding of how AI-based teacher evaluation can be used to evaluate and enhance teachers' work output, aid in the evaluation of instructional strategies, guarantee that issues highlighted in evaluations are resolved, and ultimately boost the quality of instruction. Incorporating AI into teacher performance evaluations can also ensure effective and constructive feedback to teachers which can boost accountability, transparency, and productivity.

Future Research Opportunities

The review found only two papers using hybrid nature-inspired algorithmic approaches with neural networks (Rashid & Ahmad, 2016; Zhang, Xiao, Li, & Hou, 2021). Nature-inspired algorithms (NIAs) are a group of innovative problem-solving methodologies and approaches derived from natural processes. These algorithms are extremely effective at finding solutions to multi-dimensional and multi-modal problems, as found in neural networks. Popular NIAs such as genetic algorithm (GA) and particle swarm optimization (PSO) have widespread usage in the literature. However, there are some limitations—they are parameter-based algorithms (leading to some biases), longer computational time, and finding the optimum values and solutions is difficult. Thus, to achieve better results in these AI-PM models, future researchers are encouraged to introduce other NIAs, such as

the Jaya algorithm, without parameters algorithm recently developed by (Venkata Rao, 2016).

Future researchers are also encouraged to place more emphasis on the development of AI-PM-based parameters as universal systems to achieve more fruitful outcomes in measuring performance management. These parameters could play the role of a benchmark system, which is vitally important for the continuous monitoring and evaluation of teachers to keep pace with the fast changes in education and the teaching profession.

Future research could be geared toward the use of big data in teacher evaluation. The use of big data in education has received little attention in the literature. Unlike the other aspects of technology use in education, the use of big data which has greater variety, arriving in greater volumes and at an increasing velocity, could help in really understanding the efficiency and productivity of the teacher.

Reference

Ahmad, S. F., Alam, M. M., Rahmat, M. K., Mubarik, M. S., & Hyder, S. I. (2022). Academic and Administrative Role of Artificial Intelligence in Education. *Sustainability*, *14*(3), 1101. https://doi.org/10.3390/su14031101

Bates, T., Cobo, C., Mariño, O., & Wheeler, S. (2020). Can artificial intelligence transform higher education? *International Journal of Educational Technology in Higher Education*, *17*(1), 42. https://doi.org/10.1186/s41239-020-00218-x

Benlhabib, H. (2019). A Review about Performance Management in Education Systems: Case of Morocco. Proceedings of the International Conference on Industrial Engineering and Operations Management, Morocco.

Berendt, B., Littlejohn, A., & Blakemore, M. (2020). AI in education: learner choice and fundamental rights. *Learning, Media and Technology*, *45*(3), 312-324. https://doi.org/10.1080/17439884.2020.1786399

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational researcher*, *13*(6), 4-16. https://files.ascd.org/staticfiles/ascd/pdf/journals/ed_lead/el_198405_bloom.pdf

Bulawa, P. (2012). Implementation of the Performance Management System (PMS) in Senior Secondary Schools in Botswana: An İnvestigation of Senior Management Team's Expected Benefits of the PMS. *European Journal of Educational Research*, *1*, 321-337. https://doi.org/10.12973/eu-jer.1.4.321

Carneiro, P., Dearden, L., & Vignoles, A. (2010). The Economics of Vocational Education and Training. *International Encyclopedia of Education*, 255-261. https://doi.org/10.1016/B978-0-08-044894-7.01737-1

Chen, L., Jagota, V., & Kumar, A. (2021). Research on optimization of scientific research performance management based on BP neural network. *International Journal of System Assurance Engineering and Management*. https://doi.org/10.1007/s13198-021-01263-z

Cheng, T.-M., Hou, H.-Y., Agrawal, D. C., Hsu, S.-C., & Wu, H.-T. (2020). Data Mining The Categories Of Teachers And Offering Promotion Strategies For The Mainstream - Case Of A Technology University In Taiwan. *JIRSEA*, *18*(2), 51-88.

Chernov, A., & Chernova, V. (2019). Artificial Intelligence In Management: Challenges And Opportunities. 38th International Scientific Conference on Economic and Social Development, Rabat, Morocco.

Chiang, T.-H., Thurston, A., & Lee, J. C.-K. (2020). The birth of neoprofessionalism in the context of neoliberal governmentality: The case of productive university teachers. *International Journal of Educational Research*, *103*, 101582. https://doi.org/https://doi.org/10.1016/j.ijer.2020.101582

Dignum, V. (2021). The role and challenges of education for responsible AI. *London Review of Education*, *19*(1). https://doi.org/10.14324/LRE.19.1.01

Gao, F., Isaeva, E., & Rocha, Á. (2020). Establishment of college English teachers' teaching ability evaluation based on Clementine data mining. *Journal of Intelligent & Fuzzy Systems*, *38*(6), 6833-6841. https://doi.org/10.3233/jifs-179761

Guilherme, A. (2019). AI and education: the importance of teacher and student relations. *AI & SOCIETY*, *34*(1), 47-54. https://doi.org/10.1007/s00146-017-0693-8

Johnson, A. M., Jacovina, M. E., Russell, D. G., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. In *Adaptive educational technologies for literacy instruction* (pp. 13-30). Routledge.

Kavitha, K. (2021). Assessing Teacher's Performance Evaluation and Prediction Model Using Cloud Computing Over Multi-dimensional Dataset. *Wireless Personal Communications*, *119*(4), 3207-3221. https://doi.org/10.1007/s11277-021-08394-3

Kinshuk, Chen, N.-S., Cheng, I. L., & Chew, S. W. (2016). Evolution Is not enough: Revolutionizing Current Learning Environments to Smart Learning Environments. *International Journal of Artificial Intelligence in Education*, *26*(2), 561-581. https://doi.org/10.1007/s40593-016-0108-x

Kumari, K., Ali, S., Khan, N., & Abbas, J. (2021). Examining the Role of Motivation and Reward in Employees' Job Performance through Mediating Effect of Job Satisfaction: An Empirical Evidence. *International Journal of Organizational Leadership*, *10*, 401-420. https://doi.org/10.33844/ijol.2021.60606

Lamarca, B., & Ambat, S. (2018). The Development of a Performance Appraisal System Using Decision Tree Analysis and Fuzzy Logic. *International Journal of Intelligent Engineering and Systems*, *11*(4), 11-19. https://doi.org/10.22266/ijies2018.0831.02

Lucas, O. (2022). The Role of Artificial Intelligence in Performance Management. *eLeaP*. https://performance.eleapsoftware.com/the-role-of-artificial-intelligence-in-performance-management/

Meng, L., Zhu, J., Wang, L., & Ning, X. (2022). Classroom Teaching Performance Evaluation Model Guided by Big Data and Mobile Computing. *Wireless Communications and Mobile Computing*, *2022*, 1-9. https://doi.org/10.1155/2022/2084423

Naidu, S. (2011). Performance Management as a Means of Teacher Evaluation: A South Australian Perspective. *Online submission*. https://files.eric.ed.gov/fulltext/ED525413.pdf

Nantham, S. (2021). Use of Artificial Intelligence in Performance Reviews. *Best OKR Software by Profit.co*. https://www.profit.co/blog/performance-management/use-of-artificial-intelligence-in-performance-reviews/

Ng, W. S., Xie, H., Wang, F. L., & Li, T. (2020). Peer assessment of peer assessment plan a deep learning approach of teacher assessment literacy. *Int. J. Innovation and Learning*, *27*(4).

OECD. (2009). *Creating Effective Teaching and Learning Environments: First Results from TALIS*. OECD. https://doi.org/10.1787/9789264068780-en

Page, D. (2016). Understanding performance management in schools: a dialectical approach. *International*

Journal of Educational Management, *30*, 166-176. https://doi.org/10.1108/IJEM-06-2014-0087

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). Artificial intelligence in education: challenges and opportunities for sustainable development. (no 07), 46 p. https://unesdoc.unesco.org/ark:/48223/pf0000366994?posInSet=22&queryId=9d8ca6cf-6a26-4f09-9b10-5e339c0e75da (UNESCO working papers on education policy, no. 07)

Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning*, *12*(1), 22. https://doi.org/10.1186/s41039-017-0062-8

Pothen, A. S. (2022). Artificial Intelligence and its Increasing Importance. In (pp. 74-81). https://www.researchgate.net/profile/Ashlyn-S-Pothen/publication/358058444_Artificial_Intelligence_and_its_Increasing_Importance/inline/jsViewer/61eeb1138d338833e390dda6?inViewer=1&pdfJsDownload=1&origin=publication_detail&previewAsPdf=false

Rashid, T. A., & Ahmad, H. A. (2016). Lecturer performance system using neural network with Particle Swarm Optimization. *Computer Applications in Engineering Education*, *24*(4), 629-638. https://doi.org/10.1002/cae.21737

Rath, A. (2018). Evolution of Performance Management System: A Review of Literature. *International Journal of Creative Research Thoughts (IJCRT)*, *6*(2), 874-884. https://www.ijcrt.org/papers/IJCRT1813200.pdf

Robertson, M. (1976). Artificial intelligence in education. *Nature*, *262*(5568), 435-437. https://doi.org/10.1038/262435a0

Roll, I., & Wylie, R. (2016). Evolution and Revolution in Artificial Intelligence in Education. *International Journal of Artificial Intelligence in Education*, *26*(2), 582-599. https://doi.org/10.1007/s40593-016-0110-3

Samuel, O. W., Omisore, M. O., & Atajeromavwo, E. J. (2014). Online fuzzy based decision support system for human resource performance appraisal. *Measurement*, *55*, 452-461. https://doi.org/10.1016/j.measurement.2014.05.024

Sánchez-Prieto, J., Cruz-Benito, J., Therón, R., & García-Peñalvo, F. (2020). Assessed by Machines: Development of a TAM-Based Tool to Measure AI-based Assessment Acceptance Among Students. *International Journal of Interactive Multimedia and Artificial Intelligence*, *6*, 80-86. https://doi.org/10.9781/ijimai.2020.11.009

Stroet, H. P. (2020). *AI in performance management: what are the effects for line managers?* University of Twente]. https://purl.utwente.nl/essays/77429

Sułkowski, Ł., Przytuła, S., Borg, C., & Kulikowski, K. (2020). Performance Appraisal in Universities—Assessing the Tension in Public Service Motivation (PSM). *Education Sciences*, *10*, 174. https://doi.org/10.3390/educsci10070174

Tuomi, I. (2018). *The impact of Artificial Intelligence on learning, teaching, and education*. Publications Office. https://doi.org/10.2760/12297

van der Vorst, T., & Jelicic, N. (2019). Artificial Intelligence in Education: Can AI bring the full potential of personalized learning to education? https://www.econstor.eu/bitstream/10419/205222/1/van-der-Vorst-Jelicic.pdf

Vanleeuwen, C., Veletsianos, G., Belikov, O., & Johnson, N. (2020). Institutional Perspectives on Faculty Development for Digital Education in Canada. *Canadian Journal of Learning and Technology*, *46*. https://doi.org/10.21432/cjlt27944

Venkata Rao, R. (2016). Jaya: A simple and new optimization algorithm for solving constrained and unconstrained optimization problems. *International Journal of Industrial Engineering Computations*, 19-34. https://doi.org/10.5267/j.ijiec.2015.8.004

Wiener, R., & Jacobs, A. (2011). Designing and Implementing Teacher Performance Management Systems: Pitfalls and Possibilities. *Aspen Institute*. https://files.eric.ed.gov/fulltext/ED521073.pdf

Xin, X., Shu-Jiang, Y., Nan, P., ChenXu, D., & Dan, L. (2022). Review on A big data-based innovative knowledge teaching evaluation system in universities. *Journal of Innovation & Knowledge*, *7*(3). https://doi.org/10.1016/j.jik.2022.100197

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C.-W., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M., . . . Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4), 100179. https://doi.org/https://doi.org/10.1016/j.xinn.2021.100179

Yambi, T., & Yambi, C. (2020). Assessment And Evaluation In Education. https://www.researchgate.net/profile/Tomas-Yambi/publication/342918149_ASSESSMENT_AND_EVALUATION_IN_EDUCATION/inline/jsViewer/5f0d737aa6fdcc547aee9fb3?inViewer=1&pdfJsDownload=1&origin=publication_detail&previewAsPdf=false

Yan, Y., & Jan, N. (2022). Decision Tree Algorithm in the Performance Evaluation of School-Enterprise Cooperation for Higher Vocational Education. *Mathematical Problems in Engineering*, *2022*, 1-9. https://doi.org/10.1155/2022/4151168

Yang, A., Yu, S., & Khattak, H. A. (2022). Research on Teaching Evaluation System Based on Machine Learning. *Mobile Information Systems*, *2022*, 1-10. https://doi.org/10.1155/2022/9255064

Yang, X. (2019). Accelerated Move for AI Education in China. *ECNU Review of Education*, *2*(3), 347-352. https://doi.org/10.1177/2096531119878590

Zawacki-Richter, O., Marín, V., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education -where are the educators? *International Journal of Educational Technology in Higher Education*, *16*, 1-27. https://doi.org/10.1186/s41239-019-0171-0

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., Liu, J.-B., Yuan, J., & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complexity*, *2021*, 8812542. https://doi.org/10.1155/2021/8812542

Zhang, H., Xiao, B., Li, J., & Hou, M. (2021). An Improved Genetic Algorithm and Neural Network-Based Evaluation Model of Classroom Teaching Quality in Colleges and Universities. *Wireless Communications and Mobile Computing*, *2021*, 1-7. https://doi.org/10.1155/2021/2602385

Zhang, H., Xiao, B., Li, J., Hou, M., & Zhong, S. (2021). An Improved Genetic Algorithm and Neural Network-Based Evaluation Model of Classroom Teaching Quality in Colleges and Universities. *Wireless Communications and Mobile Computing*, *2021*, 1-7. https://doi.org/10.1155/2021/2602385

Zhou, D., He, S., & Khattak, H. A. (2022). Performance Management of Education and Teaching Reform Based

on Convolutional Neural Network. *Mobile Information Systems, 2022*, 1-9. https://doi.org/10.1155/2022/5321629

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Citation

Achaa, L., O., Sumo, P., D., Arhin, I., Danquah, R., Nweze, C., N., & Nelson, S., K. (2023). Application of artificial intelligence in teachers' performance management: A mini-review and research opportunities. In A. Kaban & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 121-139). ISTES Organization.

Chapter 9 - Artificial Intelligence (AI) in Teaching and Learning: A Comprehensive Review

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Chapter Highlights

- Artificial intelligence has entered the field of teaching and education and has improved education by providing teachers with practical teaching tools. AI applications such as virtual reality, simulations, and providing students with practical skills are noteworthy.
- AI guides teachers by providing students with pedagogical tools such as customized teaching and language learning tools. It also improves the work of teachers and trainers, increasing efficiency, effectiveness, and quality.
- AI can increase the speed at which students learn and help instructors by identifying gaps. With the ability to deliver customized content to students, it provides teaching that suits students' needs, abilities, and skills.
- AI is used in administrative tasks, especially grading, plagiarism checking, and commenting on student work. In this way, it helps teachers spend more time speeding up their administrative work.
- AI applications in education are an important tool to make the educational process more efficient and effective. Future studies should delve even deeper into the role of AI in education and conduct more research to understand the potential of this technology better.

Abstract

The study aims to determine how AI may affect education. The research only examines how AI affects administration, education, and learning. A preliminary inquiry that established a narrative and framework for AI research determined this. The data show that educational institutions have widely adopted and used artificial intelligence (AI). Computing and associated technologies created artificial intelligence (AI). It now includes web-based and online intelligent education solutions. AI has also been used with embedded computer systems, humanoid robots, and web-based chatbots to conduct teacher jobs alone or with human instructors. Teachers have efficiently assessed and evaluated students' work and improved their instruction using these platforms. Due to machine learning and flexibility, educational systems may modify curriculum and materials to meet student needs; this improves learning outcomes by increasing adoption and retention.

Introduction

As a result of technological developments, many sectors are evolving to serve a wide range of fields, including civil and military uses (Rodriguez-Andina et al., 2010). Cell phones and the internet are interconnected technologies that significantly affect our daily lives (Huba & Kozák, 2016). There is a contentious debate about how much screen time children should have among psychologists, educators, and parents. Another rapidly expanding innovation can transform the educational system fundamentally.

Artificial Intelligence (AI) is a familiar technology or topic. Several novelists in the past, as well as science fiction movies, predicted its rise to fame. While things have yet to go as planned, technology is here to stay and is causing changes across the board. It is uncommon for technology to be created that has a broad impact across many industries, including education (Nguyen et al., 2020; Minh T. Nguyen et al., 2021).

According to current estimates, experts believe that between 2017 and 2021, the United States will see a 47.5 percent growth in the use of artificial intelligence in education (Lobera et al., 2020). According to a survey on the artificial intelligence market in the US education sector, this is true. Although many education experts believe technology will not replace teachers' necessities, they acknowledge that it will impact how they carry out their duties and the recommended instructional practices.

It's not just about altering the way instructors carry out their duties. Additionally, it is changing how students learn. This growth is occurring in more than just the US. The use of AI in education is anticipated to grow globally at a rate of 45% annually, reaching $5.80 billion by 2025, according to the market research engine (Berendt et al., 2020).

The study explored how AI has changed education's administrative, instructional, and learning components. AI in education started with computers and computer systems and evolved into online learning platforms. Embedded technologies allow cobots and humanoid robots to function as teacher colleagues, autonomous educators, and chatbots. Robots on various platforms and technologies have enhanced instructors' efficacy and efficiency,

improving educational quality. AI has enhanced students' learning experiences by customizing and personalizing learning materials based on their needs and skills. AI has greatly influenced education, notably in administration, instruction, and learning in the educational system or individual educational institutions.

The paper's organization continues: Section 2 covers recent AI education applications. Section 3 discusses AI background and technical features in education to demonstrate technological applications. In parts 4, 5, and 6, AI techniques in teaching, learning, and educational management are discussed, along with their effects. Section 7 concludes and plans future work.

2. Recent Applications of AI in Education

The educational system is very dependent on outdated practices. Although there are knowledge gaps in the current grading systems, a dose of AI tools and technology can usher in a new era of automation. According to estimates, the market for AI in education will grow to $3.68 billion by 2023, according to marketsandmarkets.com, with a CAGR of 47 percent from 2018 to 2023 (Subrahmanyam & Swathi, 2018). Educators should consider designing a digital transformation inside their area to include the relevant AI technologies that generate the intended outcomes. Let's look at some of the most important AI uses in education (Vincent-Lancrin & van der Vlies, 2020).

2.1. Universal Access to Education

Providing high-quality education to all students, regardless of region or race, is difficult. However, AI can dramatically improve student-teacher and peer-educator interactions. AI technologies provide intelligent data collection, tailored timetables, unique occupations, and 24/7 education. They can also build language translations, subtitles, and regional plug-and-play applications to promote universal learning and eliminate outmoded or inefficient instructional methods (Guilherme, 2019). AI-powered systems can analyze enormous volumes of data in real-time and integrate the cloud, allowing businesses with global branches to do short administrative, testing, and instructional duties identically.

2.2. Admin Tasks

In schools, colleges, and institutions, automate scheduling, rescheduling, attendance, grading, financing, bookkeeping, and record-keeping (Sharma et al., 2021). This simplifies the routine, removing boring tasks the employee no longer does. AI can aid in many jobs, including:

- Eliminating truancy warnings
- Automatically send report cards and other correspondence to parents.
- Schedule and plan meetings.
- Send normal student forms, enrollments, and other documentation to the appropriate department via automation.

- Reduce the amount of time spent on progress reports.
- Make any other record-keeping chores more efficient.

It may allow professors and teachers to concentrate on increasing educational quality rather than laborious paperwork and lowering work strain.

2.3. Assessment Programs

After collecting measurements for scoring assignments from teachers or professors, AI-powered grading software employs machine learning to develop calculating methods (Alam, 2021). The tools mimic how teachers grade pupils. Teachers' input and AI can swiftly evaluate essays, papers, and tests in several languages. They may swiftly incorporate them into a virtual environment or cloud platform. It helps instructors focus on other activities when there are numerous papers to grade.

2.4. Voice-activated Tools

Voice assistants are a fun and practical method to help users and bring learning into the home. The following are some of the advantages of voice assistants in education:

- Efficient time saving for students and teachers
- Community learning opportunities
- Personalized instruction in seconds

Even if they don't have smart speakers, these AI-powered voice assistants can be used in smartphone apps.

2.5. Personalized Education

AI technologies help students learn by creating tailored study programs and tailoring lessons. They discover knowledge gaps and provide instructional resources, evaluation tools, and feedback for preschool through college students. AI-powered software, games, and applications may help students learn at their own pace, time, and repetition needs. This machine-assisted classroom helps teachers tailor lessons to students. It may greatly improve flexible learning and give all learners a firm foundation (Rad et al., 2018).

2.6. Smart Content

Smart content can range from digital textbooks, manuals, instructional snippets, and videos to AI systems that create individualized educational environments depending on tactics and goals. Find ways to use AI to personalize education, a worldwide trend. Using web-based curricula, schools can create AR and VR learning environments

(Elkoubaiti & Mrabet, 2018). AI monitoring and assessment systems can simplify content for different learning types and varying learning speeds. AI and machine learning algorithms may discover curricular gaps and help teachers address them when many pupils give erroneous answers.

2.7. Intelligent Tutoring

Intelligent tutoring systems (ITS) can provide personalized feedback and teaching (Mousavinasab et al., 2021). They cannot replace instructors since they are not mature enough to learn. They can help when human instructors cannot teach and assess small online classes. E-learning platforms may teach languages, geography, circuits, medical diagnostics, computer programming, mathematics, physics, genetics, chemistry, and other disciplines. Engagement, grading, and comprehension guide their design.

2.8. Virtual Learning Environment

VR technology lets students engage with information on their mobile devices or laptops. Virtual learning environments can promote immersion, group learning, and student counseling. Virtual reality headsets can help ADD/ADHD kids focus by blocking distractions (Huda et al., 2018). Interactive virtual simulations offer students soft skill coaching, life skills, and self-development.

3. AI Background and Technical Aspects in Education

3.1. The Background of AI and Approaches in Education

Artificial intelligence (AI) is often used to describe computers. Computers may have been the foundation of artificial intelligence, but a review of various articles shows a shift away from computers, hardware, and software. Thanks to embedded computers, sensors, and other technologies, AI can now be integrated into robots, buildings, and other devices (Do et al., 2021). In reality, the research defines and accounts for AI twice. They call AI a theory and a field. AI is an area of computer science that addresses several cognitive tasks related to human intelligence, including learning, comprehending problems, identifying patterns, and adapting (Hwang et al., 2020). The paper defined AI as a theoretical framework for designing and applying computer systems with intelligence and the ability to perform human-like tasks like speech recognition, visual perception, language translation, and decision-making.

Many academic definitions and studies of AI highlight similar elements or qualities. Sharma et al. call AI "devices that can approximate human reasoning" (Verma et al., 2021). Like this, AI requires decades of study and development. System designers, data scientists, product designers, statisticians, linguists, cognitive scientists, psychologists, education experts, and others collaborated to create intelligent education systems that could support teachers and students (Nagao, 2019). AI is founded on enhanced software and program skills, such as algorithmic machine learning, which allows computers to do activities that require human intelligence and environmental adaptability (Nguyen et al., 2021). Artificial intelligence—a machine's or computer's ability to replicate human intelligence and behavior—was also seen (Cabezas-González & Casillas-Martín, 2021).

Artificial intelligence is the development of computers with some intelligence and the capacity to do human-like tasks, including cognition, learning, decision-making, and environmental adaptation. Therefore, some qualities and concepts are essential for AI. This definition and discussion of AI conclude that intelligence, a machine's ability to do activities that require human-like abilities, is a significant component.

New applications, including face unlocking, speech recognition, natural language translation, virtual reality, AI, and machine learning, have gained interest in mobile device usage to improve computing quality. Machine learning demands a lot of computational power for complicated training and learning. Computationally efficient systems have solved this challenge. Qualcomm launched the Snapdragon Neural Processing Engine in 2016 to accelerate GPU neural network operations. HiSilicon offered HiAI for neural network operations. The Android Neural Networks API was designed to run machine learning models quickly on mobile devices (Hojjatinia et al., 2020). This API benefits mobile users by reducing network latency and complexity. SqueezeNet, MobileNet, and Shufflenet are well-developed mobile phone AI learning networks (Zhou et al., 2021). AI on mobile devices makes learning faster, more engaging, and more personalized, elevating mobile education. Because AI can connect students to virtual classrooms, virtual reality helps build a worldwide classroom. AI-powered chatbots customize online learning and transform instructor interactions into chats. Students' understanding may be assessed using this technique.

3.2. Technical Aspects in Education

As shown in Table 1, AI approaches can benefit the educational sector in various circumstances. Examples of AI-assisted education include innovative virtual learning, intelligent teaching, and data analysis and prediction. Table 1 lists the main applications of AI in education along with the key technologies that underpin them. It's important to note that as learning requirements rise, AI-enabled education is becoming increasingly important (Pokrivčáková, 2019). Intelligent education systems provide timely, personalized training and feedback to both teachers and students. They mostly use machine learning-related technologies (Perrotta & Selwyn, 2020), which are strongly related to statistics models and cognitive learning theory, to increase the value and effectiveness of learning.

Table 1. AI techniques with scenarios in teaching and learning.

No	AI education scenarios	AI possible techniques
1	Intelligent schools	Virtual labs; A/R; V/R; hearing and sensing technologies;
2	Online and mobility of remote education	Virtual personalized assistants; Edge computing; Real-time analysis;
3	Personalized intelligent teaching	Intelligent teaching systems; Data mining or Bayesian knowledge interference; Learning analytics;
4	Grading and evaluation	Computer vision; Image recognition; Prediction systems;

5	Students and Schools' assessment	Academic analytics; Adaptive learning methods; Personalized learning approaches;
6	Building curriculums	Big data data analysis; Clustering algorithms; Machine Learning or Deep Learning technology;

AI systems use machine learning, data mining, and knowledge model methodologies for learning analysis, recommendation, comprehension, and acquisition (Chen et al., 2022). Teaching materials, data, and intelligent algorithms comprise an AI education system with two parts: the system model (which contains the learner, teaching, and knowledge models) and the intelligent technology (Kim et al., 2020). Figure 1 shows that a model's contribution to a data map, which builds structures and association rules for education data (Romero & Ventura, 2020), is crucial to learning. The model is an artificial intelligence system's brain.

The learner model improves AI learning systems' autonomy. Information from students' behavior while learning determines it. Students' ideas and talents are examined to determine their learning capacity. The learners' knowledge mastery is assessed by mapping the knowledge analysis's findings—learner modeling links learning objectives, resources, tools, and instructional techniques (Chassignol et al., 2018). The knowledge model produces a knowledge structure map with learning components, sometimes adding specialized information and instructions to avoid typical mistakes and misconceptions (Yang & Zhang, 2019). The teaching model established the knowledge field's norms, which combined the learner and knowledge field models, allowing instructors to personalize instruction.

Students are more inclined to conduct themselves well, act well, or ask for help as they learn. AI systems can always use the tutoring model's teaching theories. The user interface displays learners' performance through speech, typing, and clicking and outputs words, figures, cartoons, and agencies. The sophisticated HMI performs AI functions, including speech recognition, emotion detection, and natural language interaction.

a- Machine Learning

The core of machine learning is the process of parsing, which produces meaningful patterns and organized information based on a sampling data set known as "training data. For instance, machine learning can help students choose classes and even universities by providing recommendations. It "matches" students with institutions where they can grow the most by using data on student success, aspirations, and preferences. Additionally, this technology can help teachers better understand how students absorb each concept (Goksel & Bozkurt, 2019). To help students grasp the course material better, instructors can modify their teaching strategies in response to cumulative student performance data. For instance, photo recognition and machine learning predictions can be used to assess tests and homework for students, yielding results more quickly and reliably than humans. Deep learning, a branch of machine learning, has received much media attention lately. The most commonly used methods are decision tree learning, inductive logic programming, clustering, reinforcement learning, and Bayesian networks. From a technical perspective, deep learning emphasizes the learning of successive layers that produce increasingly meaningful representations. These layer features, arranged in literal layers stacked on top of one

another, are extracted using neural networks.

b- Learning Analytics

Learning analytics uses student characteristics and knowledge objects from learner and knowledge field models. Learning analytics applies machine learning to education. Intervening with at-risk pupils or offering feedback and instructional content is one way to tailor education to specific students (Balica, 2018). Machine learning, data visualization, learning sciences, and semantics are used. AI-based competency learning may uncover student insights and predict their fundamental abilities, allowing institutions to respond proactively. AI's broad learning capabilities and competency-based learning power learning analytics. AI can identify prospective dropouts based on multiple characteristics, providing schools with early warning systems and actionable data. Learning analytics should expand to encompass interpersonal skills, the arts, and literature, which complicate evaluating competencies and learning outcomes. Learning analytics must be specialized enough for individual learning environments and wide enough for numerous institutions and courses. Innovative learning analytics will help students, instructors, administrators, and institutions learn.

c- Data Mining

Educational data mining provides automatic, methodical answers. AI-based educational data mining creates intrinsic association rules and customizes information for students. A few writing exercises can assess student demographics and grade information (Chien & Chen, 2008). This is done via machine learning regression, which may also predict student achievement. Data mining improves knowledge acquisition and learning by understanding learning situations and students.

Data mining extracts hidden information through pattern recognition and predictive modeling, allowing educators to alter curriculum development. Data mining-based AI can help students study at their own speed and choose their learning technique from knowledge field data, which is one of its most important uses. In customized learning, students choose topics that interest them, and teachers modify their teaching methods (Walkington & Bernacki, 2020). Data mining helps AI develop more accurate and reliable intelligence (e.g., via machine learning).

Figure 1 shows how AI education's technological framework develops a data map with structures and association rules for educational data.

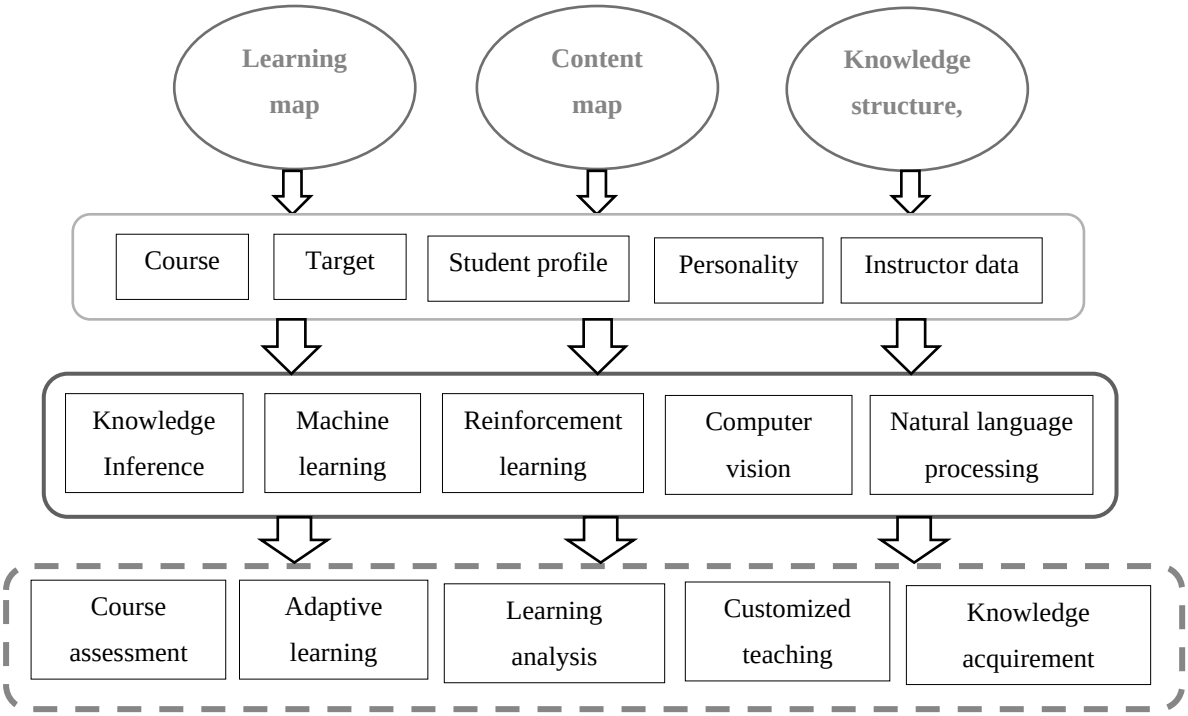

Figure 1. An illustration of the AI education technological structure

4. AI in Teaching

The papers discovered and analyzed show that AI systems have invaded teaching and education. AI helped create and execute effective instructional tools. These tools have improved education, as seen in Figure 2. The graphic displays AI applications for instructors. AI platforms and instructional aids are highlighted in several publications. In (Felix, 2020), virtual reality is used to teach pupils or demonstrate knowledge. Pedagogical tools and platforms include AI applications like simulation-based education. Other projects have considered using virtual reality as an AI component in education. Virtual reality, 3-D technologies, and highly interactive simulations have been shown to assist pupils in learning concepts (Ahmad, 2018). Through virtual reality and simulation, AI guides medical students through practical topics like procedures and human anatomy.

Other research has focused on integrating AI into machines or robots, developing strong instructional tools, and improving pedagogical approaches. According to some research, integrating AI principles into robots and developing and using cobots as teacher assistants and colleagues can help students learn to read and pronounce words (Eguchi, 2021). The study found that using AI in education, especially as instructional tools and with other technologies, has spurred the development of better teaching tools (Desyandri et al., 2019). Pokrivcakova, on the other hand, promotes chatbots and AI integration in computer applications. Chatbots can answer student questions and offer instructional information (Kristanto & Mariono, 2017). AI lets humanoids and robots think, decide, communicate, and converse, making them useful educational aids.

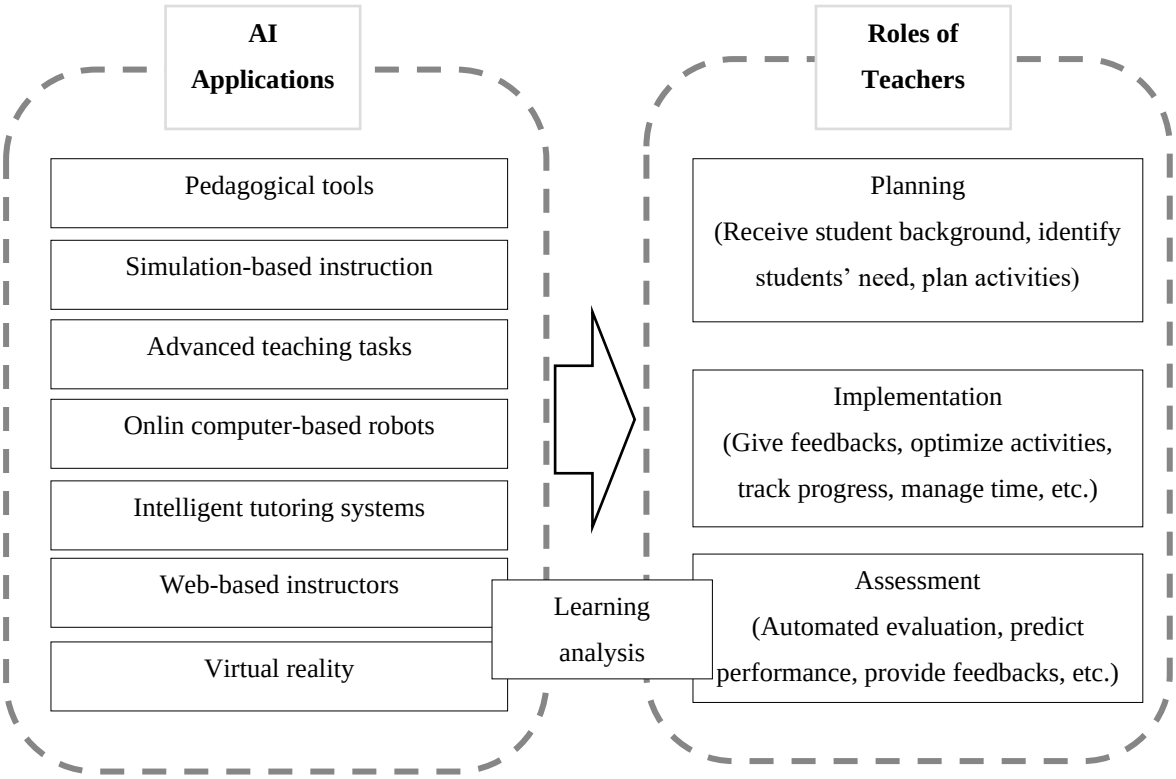

Figure 2. Contents of AI technologies to support teaching roles in educational areas

Due to the article's analysis, several AI education applications were found. Studies examine intelligent tutoring systems in various ways. Rus et al. state that animated conversational agents like chatbots or robots and intelligent tutoring systems (ITS) that communicate and hold dialogues have improved teaching (Chen et al., 2016; Nino, 2020). Pokrivcakova's AI education apps, like CALL, which gives pupils personalized teaching and language learning writing and translation tools (Nino, 2020), focus on the same themes. AI is also used in education to give teachers or instructors directions. AI in web-based education, notably AIWBES, has made teaching and adding teacher-like capabilities important tools for instructors. The use of AIWBES in teaching and the incorporation of teacher-like functionalities make the platform a strong tool for instructors (Koh, 2019).

IWBE, or intelligent and adaptive web-based systems, in which teachers are studied and presented as social agents, are more likely to be discussed to ensure that web-based education is an effective and organized way to enhance the learner experience. The technology then understands and supports teachers in instructing pupils (Pardo, 2018). It supports instructors' instruction as a standalone educational tool. Several technologies and methods use AI.

Discussion of the impacts

Figure 2 shows how teachers used AI in instruction in this research. Numerous studies show that educators readily adapt and use AI as a teaching aid or educational tool. AI in instruction and pedagogy has greatly affected this part of education. Numerous studies have shown that it improves instructors' productivity, efficiency, and quality. Delivering relevant material according to the curriculum and the learner's needs and skills determines effectiveness. Assimilation and retention of knowledge by students or learners assess efficiency and quality. Given

these operational definitions and descriptions of efficiency, quality, and effectiveness, the study's findings suggest that AI has helped education achieve quality, effectiveness, and efficiency.

AI boosts instructional efficiency. Rus and his colleagues (Chen et al., 2016) claim that employing evidence-based or empirically supported strategies, such as widespread usage of cognition and learning models (Huang & Rust, 2018), has helped pupils learn and remember the most. As Rus et al. noted, learner-centered systems like DeepTutor and AutoTutor enable customization and tailored information based on the learner's skills and needs, improving the learner's experience and encouraging learning objectives. AI has increased instructional quality and efficacy since current technology-based adaptive systems tailor materials and information to learners' requirements, delivering an ideal learning experience (Alammary et al., 2014). AI improves course content distribution, especially on online and web-based learning platforms, from curriculum development through delivery.

AI, especially its incorporation into online and web-based learning platforms, has improved education since it allows these platforms to generate and utilize outstanding teaching materials (Kahraman et al., 2010). The same learning benefits were seen in other investigations. Estevez et al. (2019), emphasize the importance of adaptable IWEBS and instructions based on observed and learned learner behavior. These characteristics improve learning and instructional efficacy by allowing platforms to personalize pedagogical strategies. CAL and CBT use a "put it all on the web" approach and may not meet students' learning needs, while ITS customizes, individualizes, and personalizes learning (Lambropoulos et al., 2015). AI has improved education, notably in terms of efficacy and efficiency. AI tutoring systems were created to overcome the problems of one-on-one teacher-student tutoring, improving instructors' jobs (Darling-Hammond, 2017).

The investigation revealed several major themes or ways AI has affected instructors' jobs. Technology, particularly artificial intelligence (AI), can promote academic integrity through plagiarism checks, proctoring, and online student monitoring on Grammarly, Turnitin, and White Smoke (Alam, 2021; Fazlollahi et al., 2022; Maxim et al., 2016). In other research (Hite et al., 2019; Schelly et al., 2015), gamification, which leverages AI for education, improved instruction. Virtual reality and 3-D technology are also part of gamification. These studies also discussed the benefits of VR and 3-D simulation, team-viewer tools, and gamification to improve education. Another study found that expressive humanoid robots with dialogue and conversational skills can improve educational quality by encouraging student involvement (Kaendler et al., 2015; Masika & Jones, 2016; Scull et al., 2020; Strauß & Rummel, 2020) due to their expanded capabilities and human-like looks.

5. AI in Learning

Learning, a crucial part of education, is also studied. With good learning resources and instruction, artificial intelligence may help students learn faster. AI can also help students catch up faster by alerting professors to concerns the human eye misses. Figure 3 shows how AI has been embraced, employed, or abused to help students' learning in the study's many papers. Software that uses AI to enhance student learning has also been found. AI has greatly improved student learning by tailoring curriculum and content to students' needs, talents, and abilities

(Xie et al., 2021). Adaptive learning software uses AI or machine learning to "adapt" a student's learning route in real-time. Teaching pupils to acquire and retain information can be done in numerous ways (Chee et al., 2015; Holmes et al., 2021). AI in education has erased national and international barriers, enabling global online and web-based learning (Kumar & Sharma, 2016; Tekin et al., 2015).

Publications identified platforms and applications. Some systems allow content customization and personalization, which improves learning and retention. Knewton uses machine learning algorithms to make real-time recommendations to students based on their learning preferences. It then tailors course content to their needs (Williamson, 2016). Other systems with comparable characteristics, such as Cerego, Immersive Reader, and CALL, can improve students' educational experiences from pre-kindergarten through university bachelor and graduate programs (Schonert-Reichl, 2017; Williamson, 2016). The authors also showed that AI and chatbots improve students' learning experiences by employing machine learning algorithms to personalize information to their needs and competencies (Benešová & Tupa, 2017). The author also discusses how machine translation, adaptive educational systems, and intelligent tutoring systems use AI to help students. AI customizes and personalizes content to meet learners' skills and needs.

However, past research has demonstrated that AI applications dramatically impact learners' experiences. Intelligent tutoring systems (ITS) and simulation-based learning enhance deep learning, which improves student learning (Hwang et al., 2016). Mikropoulos argues that simulation and virtual reality improve student learning (Ahmadi & Reza, 2018). Simulation, virtual reality, and other AI-based learning technologies assist students in becoming future-ready and able to keep up with AI in industry (Galloway & Swiatek, 2018). Another example of AI helping kids study is AIWBES. AIWBES generates learned material more adaptively. Kahraman et al. says AIWBES' interactive problem-solving will help students complete these tasks by providing qualified assistance at each level (Cantabella et al., 2019). The same AI capabilities are mentioned in online learning. IWBE, or intelligent and adaptive web-based systems, especially multi-agent systems (MAS), treat learners as social agents, analyze their behavior, and adjust by providing relevant information (Ikedinachi et al., 2019; Sharma et al., 2019). AI's integration, acceptance, and use in education have focused on enhancing students' experiences despite its significant influence on other parts of education.

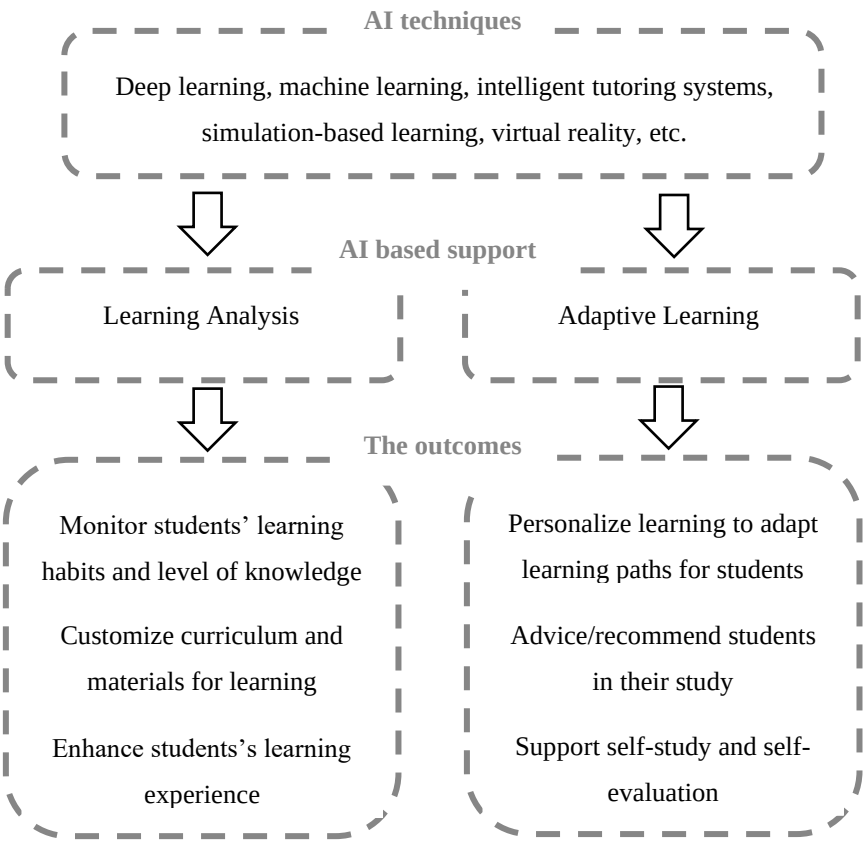

Figure 3. Contents of AI techniques to support learners

Discussion of the impacts

This research also investigates how AI has affected student learning. AI's conversational agents question and prod pupils until they can explain themselves and their logic, boosting information intake and retention, according to Rus et al. (Salem, 2019).

Some research suggests AI can help students learn. AI may assess learning progress, including knowledge and understanding, and utilize the results to improve the system's capacity to personalize content to students' needs and abilities, encouraging them and exploiting their unique skills to promote retention (Pinchbeck & Heaney, 2022; Salimon et al., 2021). AI allows Pokrivcakova to build and employ intelligent learning systems and adaptive material customized to each student's learning requirements and skills, such as intelligent virtual reality and simulation teaching and learning, which increases learning (Villegas-Ch et al., 2020). Simulation and other similar technologies aid education. Simulation and other technology increase learning by giving students hands-on experience. The researchers reviewed studies showing VR and 3-D technologies boost learning usability, enjoyment, excitement, motivation, and engagement (Raja & Priya, 2021).

Later research on web-based systems demonstrated significant AI and learning quality gains. According to Kahraman, adaptive hypermedia, information filtering, class monitoring, and collaborative learning improve student engagement, interactions, and learning (Kabudi et al., 2021). Peredo et al. connected AIWBE to better

learning and noted that web-based systems tailor instructions and materials to discover and evaluate learner activities. StudentTracker middleware tailors AIWBE pedagogy using online learner data, including completed tasks, learning tracking, time, and others (Davies et al., 2021). Web-based platforms encourage learning through cost and global availability (Coma-Tatay et al., 2019). Platforms boosted learning overall.

More research showed AI's learning benefits and influence. TurnItIn and Pearson's Write-to-Learn have increased learning using AI for writing and editing (Crossman, 2019; Haldorai et al., 2021; Mehtab & Mahmud, 2022). However, several studies have shown AI may harm learning. Pangrazio et al. (2022), say AI may make paper mills and paper-churning platforms easier for students to use, encouraging dishonesty and undermining academic integrity. According to research, AI for learning offers more benefits than drawbacks (Kassymova et al., 2020; Sadeghi, 2019).

6. AI in Educational Management

This chapter discusses AI research in education, focusing on administrative duties. AI is expected to impact administrative jobs, including grading, reviewing, and giving comments on students' work. Sharma et al. assert that AI has boosted institutional and administrative productivity, particularly for distance and online learning (Gandedkar et al., 2021). Some systems, like Knewton, help professors provide students with feedback based on how they utilize them. Other research on administrative support systems takes similar views.

For example, intelligent tutoring systems (ITSs) may grade and comment on student work (Al-Hanjori et al., 2017). Instructors who use ITS are more efficient at administrative activities in addition to their main duty of guiding students to success. Mikropoulos and Natsis' study validates these conclusions: AI has made administrative chores like grading student work more efficient (Hanewicz et al., 2017). In today's online learning environment, tools like Turnitin and Ecree give suggested grading, check for plagiarism, and let teachers perform various administrative tasks. AI speeds up administrative tasks that would take a long time without it.

Discussion of the impacts

AI has greatly influenced education administration and management in many forms and for varied purposes. It has helped professors grade and provide students with feedback. Instructors may easily grade and comment on students' work with AIWBE systems (Reis et al., 2019). Websites like Knewton help teachers grade student work and provide comments on learning progress (Alnahdi, 2019). AI has simplified administrative tasks and enhanced teachers' instruction. With intelligent tutoring systems' various features, teachers may grade and give comments (Goralski & Tan, 2020).

Other AI-powered apps help professors identify plagiarism, grade, and offer students feedback on their work. Grammarly, Ecree, PaperRater, and TurnItIn are examples. AI has greatly reduced instructors' paperwork and administrative tasks, allowing them to focus on teaching and disseminating information according to the institution's or nation's curriculum (Chamunyonga et al., 2020; Paek & Kim, 2021). Even though many of the

articles evaluated focused on other areas of education, there was an improvement in the quality of administrative tasks and processes and the efficiency and productivity of instructors or educators in completing them.

7. Conclusions and Future Work

This research sought to determine how AI will impact schooling. A qualitative literature review was the research strategy and approach. The study analyzed professional journal articles, publications, and conference reports to reach its purpose. Computers and computer technology have enabled the development and usage of artificial intelligence (AI) in numerous sectors. AI, which has a major influence on its industries, was made feasible by introducing personal computers and subsequent processing and computing advances. The educational institutions studied in this research have widely embraced and deployed AI.

AI has various educational and technological uses. Some professions use AI to examine comprehension issues, instructor backgrounds, and school infrastructures to build curriculums. AI helps instructors, students, and administrators arrange for study or instruction. Opening concerns and adding challenges might cause field researchers considerable problems.

Acknowledgements:

The author would like to thank the support of the Thai Nguyen University of Technology (TNUT), Viet Nam.

References

Ahmad, Y. B. (2018). Teaching English pronunciation of suprasegmental features on students of English education". *SHS Web of Conferences. EDP Sciences*.

Ahmadi, D., & Reza, M. (2018). The use of technology in English language learning: A literature review". *International Journal of Research in English Education*, *3*, 115–125.

Alam, A. (2021, December 3). Should robots replace teachers? Mobilisation of AI and learning analytics in education. *2021 International Conference on Advances in Computing, Communication, and Control (ICAC3)*. Presented at the 2021 International Conference on Advances in Computing, Communication, and Control (ICAC3), Mumbai, India. doi:10.1109/icac353642.2021.9697300

Alam, A. (2021, November 26). Possibilities and apprehensions in the landscape of artificial intelligence in education. *2021 International Conference on Computational Intelligence and Computing Applications (ICCICA)*. Presented at the 2021 International Conference on Computational Intelligence and Computing Applications (ICCICA), Nagpur, India. doi:10.1109/iccica52458.2021.9697272

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches". *Australasian Journal of Educational Technology*, 30–34.

Al-Hanjori, M. M., Shaath, M. Z., & Naser, S. S. A. (2001). Learning computer networks using intelligent tutoring system". *International Journal of Advanced Research and Development*.

Alnahdi, A. (2019). The impact of the use of artificial intelligence in the education sector. In *International Journal*

of Artificial Intelligence and Machine Learning.

Balica, R. (2018). Big data learning analytics and algorithmic decision-making in digital education governance. *Analysis and Metaphysics*, *17*, 128–133.

Benešová, A., & Tupa, J. (2017). Requirements for education and qualification of people in Industry 4.0". *Procedia Manufacturing*, *11*, 2195–2202.

Berendt, B., Littlejohn, A., & Blakemore, M. (2020). AI in education: learner choice and fundamental rights. *Learning, Media and Technology, 45*(3), 312-324.

Cabezas-González, M., & Casillas-Martín, S. (2021). Artificial intelligence in the DigiCraft educational program. In *Information Technology Trends for a Global and Interdisciplinary Research Community* (pp. 88–110). doi:10.4018/978-1-7998-4156-2.ch005

Cantabella, M., Martínez-España, R., Ayuso, B., Yáñez, J. A., & Muñoz, A. (2019). Analysis of student behavior in learning management systems through a Big Data framework". *Future Generation Computer Systems*, *90*, 262–272.

Chamunyonga, C., Edwards, C., Caldwell, P., Rutledge, P., & Burbery, J. (2020). The impact of artificial intelligence and machine learning in radiation therapy: considerations for future curriculum enhancement". *Journal of Medical Imaging and Radiation Sciences*, *2*, 214–220.

Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. (2018). Artificial Intelligence trends in education: a narrative overview. *Procedia Computer Science*, *136*, 16–24. doi:10.1016/j.procs.2018.08.233

Chee, Y. S., Mehrotra, S., & Ong, J. C. (2015). Professional development for scaling pedagogical innovation in the context of game-based learning: Teacher identity as cornerstone in "shifting" practice". *Asia-Pacific Journal of Teacher Education*, *5*, 423–437.

Chen, M., Bell, R. A., & Taylor, L. D. (2016). Narrator point of view and persuasion in health narratives: the role of protagonist-reader similarity, identification, and self-referencing". *Journal of Health Communication*, *8*, 908–918.

Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022). Two Decades of Artificial Intelligence in Education. *Educational Technology & Society*, *25*(1), 28–47.

Chien, C., F. (2008). Data mining to improve personnel selection and enhance human capital: A case study in high-technology industry". *Expert Systems with Applications*, *34*, 280–290.

Coma-Tatay, I., Casas-Yrurzum, S., Casanova-Salas, P., & Fernández-Marín, M. (2019). *Multimedia Tools and Applications*. *5*, 6093–6118.

Crossman, K. (2019). Is this in my contract?: How part-time contract faculty face barriers to reporting academic integrity breaches". *Canadian Perspectives on Academic Integrity*, *2*(1), 32–39.

Darling-Hammond, L. (2017). Teacher education around the world: What can we learn from international practice?". *European Journal of Teacher Education*, *3*, 291–309.

Davies, H. C., Eynon, R., & Salveson, C. (2021). The mobilisation of AI in education: A Bourdieusean field analysis". *Sociology*, *3*, 539–560.

Desyandri, D., Muhammadi, M., Mansurdin, M., & Fahmi, R. (2019). Development of integrated thematic teaching material used discovery learning model in grade V elementary school". *Jurnal Konseling Dan Pendidikan*, *7*(1), 16–22.

Do, H. T., Truong, L. H., Nguyen, M. T., Chien, C.-F., Tran, H. T., Hua, H. T., … Nguyen, N. T. T. (2021). Energy-efficient unmanned aerial vehicle (UAV) surveillance utilizing artificial intelligence (AI). *Wireless Communications and Mobile Computing, 2021*, 1–11. doi:10.1155/2021/8615367

Eguchi, A. (2021). AI-Powered Educational Robotics as a Learning Tool to Promote Artificial Intelligence and Computer Science Education". In *International Conference on Robotics in Education (RiE)* (pp. 279–287). Cham: Springer.

Elkoubaiti, H., & Mrabet, R. (2018). A Survey of Pedagogical Affordances of Augmented and Virtual Realities Technologies in IoT-Based Classroom. In *IEEE 5th International Congress on Information Science and Technology (CiSt)* (pp. 334–341).

Estevez, J., Garate, G., & Grana, M. (2019). Gentle introduction to artificial intelligence for high-school students using scratch. *IEEE Access: Practical Innovations, Open Solutions*, *7*, 179027–179036. doi:10.1109/access.2019.2956136

Fazlollahi, A. M., Bakhaidar, M., Alsayegh, A., Yilmaz, R., Winkler-Schwartz, A., Mirchi, N., & Del Maestro. (2022). Effect of Artificial Intelligence Tutoring vs Expert Instruction on Learning Simulated Surgical Skills Among Medical Students: A Randomized Clinical Trial". *JAMA Network Open*, *5*, e2149008–e2149008.

Felix, C. V. (2020). *International perspectives on the role of technology in humanizing higher education*. Emerald Publishing Limited.

Galloway, C., & Swiatek, L. (2018). Public relations and artificial intelligence: It's not (just) about robots". *Public Relations Review*, *5*, 734–740.

Gandedkar, N. H., Wong, M. T., & Darendeliler, M. A. (2021). Role of virtual reality (VR), augmented reality (AR) and artificial intelligence (AI) in tertiary education and research of orthodontics: An insight". *Seminars in Orthodontics. WB Saunders*, 69–77.

Goksel, N., & Bozkurt, A. (2019). Artificial intelligence in education: Current insights and future perspectives. In *Handbook of Research on Learning in the Age of Transhumanism* (pp. 224–236).

Goralski, M. A., & Tan, T. K. (2020). Artificial intelligence and sustainable development". *The International Journal of Management Education*, *18*(1).

Guilherme, A. (2019). AI and education: the importance of teacher and student relations. *AI & Society*, *34*(1), 47-54.

Haldorai, A., Murugan, S., & Ramu, A. (2021). Evolution, challenges, and application of intelligent ICT education: An overview". *Computer Applications in Engineering Education*, *29*, 562–571.

Hanewicz, C., Platt, A., & Arendt, A. (2017). Creating a learner-centered teaching environment using student choice in assignments". *Distance Education*, *38*, 273–287.

Hite, R., Jones, M. G., Childers, G., Chesnutt, K., Corin, E., & Pereyra, M. (2019). Pre-Service and In-Service Science Teachers' Technological Acceptance of 3-D, Haptic-Enabled Virtual Reality Instructional Technology". *The Electronic Journal for Research in Science & Mathematics Education*, 23–24.

Hojjatinia, S., Hamzenejadi, S., & Mohseni, H. (2020). *Android Botnet Detection using Convolutional Neural Networks. 2020 28th Iranian Conference on Electrical Engineering (ICEE)*. 1–6.

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., & Koedinger. (n.d.). Ethics of AI in education: Towards a community-wide framework". *International Journal of Artificial*

Intelligence in Education, *2021*, 1–23.

Huang, M.-H., Rust, & Roland, T. (2018). Artificial intelligence in service". *Journal of Service Research*, *21*, 155–172.

Huba, M., & Kozak, S. (2016, November). From e-learning to industry 4.0. *2016 International Conference on Emerging eLearning Technologies and Applications (ICETA)*. Presented at the 2016 International Conference on Emerging eLearning Technologies and Applications (ICETA), Starý Smokovec, High Tatras, Slovakia. doi:10.1109/iceta.2016.7802083

Huda, M., Maseleno, A., Atmotiyoso, P., Siregar, M., Ahmad, R., Jasmi, K. A., & Muhamad, N. H. N. (2018). Big Data emerging technology: Insights into innovative environment for online learning resources. *International Journal of Emerging Technologies in Learning (iJET)*, *13*(01), 23. doi:10.3991/ijet.v13i01.6990

Hwang, G. J., Wu, P. H., Chen, C. C., & Tu, N. (2016). Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations". *Interactive Learning Environments*, *8*, 1895–1906.

Hwang, G.-J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence*, *1*(100001), 100001. doi:10.1016/j.caeai.2020.100001

Ikedinachi, A. P., Misra, S., Assibong, P. A., Olu-Owolabi, E. F., Maskeliūnas, R., & Damasevicius, R. (2019). Artificial intelligence, smart classrooms and online education in the 21st century: implications for human development". *Journal of Cases on Information Technology (JCIT)*, *3*, 66–79.

Kabudi, T., Pappas, I., & Olsen, D. H. (n.d.). AI-enabled adaptive learning systems: A systematic mapping of the literature". *Computers and Education: Artificial Intelligence*, *2021*.

Kaendler, C., Wiedmann, M., Rummel, N., & Spada, H. (2015). Teacher competencies for the implementation of collaborative learning in the classroom: A framework and research review". *Educational Psychology Review*, *3*, 505–536.

Kahraman, H. T., Sagiroglu, S., & Colak, I. (2010, October). Development of adaptive and intelligent web-based educational systems. *2010 4th International Conference on Application of Information and Communication Technologies*. Presented at the 2010 4th International Conference on Application of Information and Communication Technologies (AICT), Tashkent, Uzbekistan. doi:10.1109/icaict.2010.5612054

Kassymova, G., Akhmetova, A., Baibekova, M., Kalniyazova, A., Mazhinov, B., & Mussina, S. (2020). E-Learning environments and problem-based learning". *International Journal of Advanced Science and Technology*, *7*, 346–356.

Kim, M. K., Gaul, C. J., Kim, S. M., & Madathany, R. J. (2019). Advance in detecting key concepts as an expert model: Using student mental model analyzer for research and teaching (SMART). *Technology Knowledge and Learning*. doi:10.1007/s10758-019-09418-5

Koh, J. H. (2019). TPACK design scaffolds for supporting teacher pedagogical change". *Educational Technology Research and Development*, *3*, 577–595.

Kristanto, A., & Mariono, A. (2017). The Development of Instructional Materials E-Learning Based on Blended Learning". *International Education Studies*, *7*, 10–17.

Kumar, V., & Sharma, D. (2016). Creating collaborative and convenient learning environment using cloud-based moodle LMS: an instructor and administrator perspective". *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT), 1*, 35–50.

Lambropoulos, N., Mporas, I., Fardoun, H. M., & Katib, I. (2015). Ontological design to support cognitive plasticity for creative immersive experience in computer aided learning". In *International Conference on Learning and Collaboration Technologies* (pp. 261–270). Cham: Springer.

Lobera, J., Fernández Rodríguez, C. J., & Torres-Albero, C. (2020). Privacy, values and machines: Predicting opposition to artificial intelligence. *Communication Studies*, *71*(3), 448–465. doi:10.1080/10510974.2020.1736114

Masika, R., & Jones, J. (2016). Building student belonging and engagement: Insights into higher education students' experiences of participating and learning together". *Teaching in Higher Education*, *21*, 138–150.

Maxim, B. R., Kaur, R., Apzynski, C., Edwards, D., & Evans, E. (2016, October). An agile software engineering process improvement game. *2016 IEEE Frontiers in Education Conference (FIE)*. Presented at the 2016 IEEE Frontiers in Education Conference (FIE), Erie, PA, USA. doi:10.1109/fie.2016.7757682

Mehtab, F. H., & Mahmud, A. (2022). Robots in the Neighborhood: Application and Criminalization of the Artificial Intelligence in Education". In *Technologies, Artificial Intelligence and the Future of Learning Post-COVID-19* (pp. 393–410). Cham: Springer.

Mousavinasab, E., Zarifsanaiey, N., R. Niakan Kalhori, S., Rakhshan, M., Keikha, L., & Ghazi Saeedi, M. (2021). Intelligent tutoring systems: a systematic review of characteristics, applications, and evaluation methods. *Interactive Learning Environments*, *29*(1), 142–163. doi:10.1080/10494820.2018.1558257

Nagao, K. (2019). Artificial Intelligence in Education. In *Artificial Intelligence Accelerates Human Learning* (pp. 1–17). doi:10.1007/978-981-13-6175-3_1

Nguyen, H. T. T., Nguyen, M. T., Do, H. T., Hua, H. T., & Nguyen, C. V. (2021). DRL-based intelligent resource allocation for diverse QoS in 5G and toward 6G vehicular networks: A comprehensive survey. *Wireless Communications and Mobile Computing*, *2021*, 1–21. doi:10.1155/2021/5051328

Nguyen, M. T., Truong Trang, L. H., & Le, T. H. (2021). Video surveillance processing algorithms utilizing artificial intelligent (AI) for unmanned autonomous vehicles (UAVs)". *MethodsX*, *8*.

Nguyen, M. T., Truong, L. H., Tran, T. T., & Chien, C.-F. (2020). Artificial intelligence based data processing algorithm for video surveillance to empower industry 3.5. *Computers & Industrial Engineering*, *148*(106671), 106671. doi:10.1016/j.cie.2020.106671

Nino, A. (2020). Exploring the use of online machine translation for independent language learning". *Research in Learning Technology*.

Paek, S., & Kim, N. (2021). Analysis of worldwide research trends on the impact of artificial intelligence in education. *Sustainability*, *13*(14), 7941.

Pangrazio, L., Selwyn, N., & Cumbo, B. (2022). A patchwork of platforms: mapping data infrastructures in schools. *Learning, Media and Technology*, 1-16.

Pardo, A. (2018). A feedback model for data-rich learning experiences. *Assessment and Evaluation in Higher Education*, *43*(3), 428–438. doi:10.1080/02602938.2017.1356905

Perrotta, C., & Selwyn, N. (2020). Deep learning goes to school: toward a relational understanding of AI in education. *Learning, Media and Technology*, *45*(3), 251–269. doi:10.1080/17439884.2020.1686017

Pinchbeck, J., & Heaney, C. (n.d.). The impact of Online Forum Use on Student Retention in a Level 1 Distance Learning Module". *Athens Journal of Education*, *2022*, 103–118.

Pokrivcakova, S. (2019). Preparing teachers for the application of AI-powered technologies in foreign language education. *Journal of Language and Cultural Education*, *7*(3), 135–153. doi:10.2478/jolace-2019-0025

Rad, P., Roopaei, M., Beebe, N., Shadaram, M., & Au, Y. (2018). AI thinking for cloud education platform with personalized learning. *Proceedings of the 51st Hawaii International Conference on System Sciences*. Presented at the Hawaii International Conference on System Sciences. doi:10.24251/hicss.2018.003

Raja, M., & Priya, G. G. (2021). "Conceptual Origins, Technological Advancements, and Impacts of Using Virtual Reality Technology in Education. *Webology*, *18*(2).

Reis, J., Santo, P. E., & Melao, N. (2019, June). Impacts of artificial intelligence on public administration: A systematic literature review. *2019 14th Iberian Conference on Information Systems and Technologies (CISTI)*. Presented at the 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), Coimbra, Portugal. doi:10.23919/cisti.2019.8760893

Rodriguez-Andina, J. J., Gomes, L., & Bogosyan, S. (2010). Current trends in industrial electronics education. *IEEE Transactions on Industrial Electronics (1982)*, *57*(10), 3245–3252. doi:10.1109/tie.2010.2057235

Romero, C., & Ventura, S. (2020). Educational data mining and learning analytics: An updated survey. *Wiley Interdisciplinary Reviews. Data Mining and Knowledge Discovery*, *10*(3). doi:10.1002/widm.1355

Sadeghi, M. (2019). A shift from classroom to distance learning: Advantages and limitations. *International Journal of Research in English Education*, *4*, 80–88.

Salem, A. A. (2019). A Sage on a Stage, to Express and Impress: TED Talks for Improving Oral Presentation Skills, Vocabulary Retention and Its Impact on Reducing Speaking Anxiety in ESP Settings". *ESP Settings". English Language Teaching*, *6*, 146–160.

Salimon, M. G., Sanuri, S. M. M., Aliyu, O. A., Perumal, S., & Yusr, M. (2021). E-learning satisfaction and retention: A concurrent perspective of cognitive absorption, perceived social presence and technology acceptance model". *Journal of Systems and Information Technology*.

Schelly, C., Anzalone, G., Wijnen, B., & Pearce, J. (2015). Open-source 3-D printing technologies for education: Bringing additive manufacturing to the classroom". *Journal of Visual Languages & Computing*, *28*, 226–237.

Schonert-Reichl, K. A. (2017). Social and emotional learning and teachers". *The Future of Children*, 137–155.

Scull, J., Phillips, M., Sharma, U., & Garnier, K. (2020). Innovations in teacher education at the time of COVID19: an Australian perspective". *Journal of Education for Teaching*, *46*, 497–506.

Sharma, K., Papamitsiou, Z., & Giannakos, M. (2019). Building pipelines for educational data using AI and multimodal analytics: A "grey-box" approach. *British Journal of Educational Technology: Journal of the Council for Educational Technology*, *50*(6), 3004–3031. doi:10.1111/bjet.12854

Sharma, U., Tomar, P., Bhardwaj, H., & Sakalle, A. (2021). Artificial intelligence and its implications in education. In *Impact of AI Technologies on Teaching, Learning, and Research in Higher Education* (pp. 222–235). doi:10.4018/978-1-7998-4763-2.ch014

Strauß, S., & Rummel, N. (2020). Promoting interaction in online distance education: designing, implementing and supporting collaborative learning". *Information and Learning Sciences*.

Subrahmanyam, V. V., & Swathi, K. (2018). Artificial intelligence and its implications in education. In *International Conference on Improving Access to Higher Education for Underserved Communities in Uncovered Regions* (pp. 1–11).

Tekin, C., Braun, J., & van der Schaar, M. (2015, April). eTutor: Online learning for personalized education. *2015 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. Presented at the ICASSP 2015 - 2015 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), South Brisbane, Queensland, Australia. doi:10.1109/icassp.2015.7179032

Verma, S., Sharma, R., Deb, S., & Maitra, D. (2021). Artificial intelligence in marketing: Systematic review and future research direction. *International Journal of Information Management Data Insights*, *1*(1), 100002. doi:10.1016/j.jjimei.2020.100002

Villegas-Ch, W., Román-Cañizares, M., & Palacios-Pacheco, X. (2020). Improvement of an online education model with the integration of machine learning and data analysis in an LMS". *Applied Sciences*, *15*.

Vincent-Lancrin, S., & Vlies, R. (2020). *Trustworthy artificial intelligence (AI) in education: Promises and challenges*. Paris: OECD Publishing.

Walkington, C., & Bernacki, M. L. (2020). Appraising research on personalized learning: Definitions, theoretical alignment, advancements, and future directions". *Journal of Research on Technology in Education, 52*, 235–252.

Williamson, B. (2016). Digital education governance: data visualization, predictive analytics, and 'real-time'policy instruments". *Journal of Education Policy*, *2*, 123–141.

Xie, H., Hwang, G. J., & Wong, T. L. (2021). Editorial Note: From Conventional AI to Modern AI in Education: Reexamining AI and Analytic Techniques for Teaching and Learning". *Journal of Educational Technology & Society*, 24–27.

Yang, J., & Zhang, B. (2019). Artificial intelligence in intelligent tutoring robots: A systematic review and design guidelines. *Applied Sciences (Basel, Switzerland)*, *9*(10), 2078. doi:10.3390/app9102078

Zhou, S. K., Greenspan, H., Davatzikos, C., Duncan, J. S., Van Ginneken, B., Madabhushi, A., … Summers, R. M. (2021). A review of deep learning in medical imaging: Imaging traits, technology trends, case studies with progress highlights, and future promises. *Proceedings of the IEEE. Institute of Electrical and Electronics Engineers*, *109*(5), 820–838. doi:10.1109/jproc.2021.3054390

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Citation

Nguyen, T., TK., Thuan, H. T., & Nguyen, M., T. (2023). Artificial Intelligence (AI) in teaching and learning: A comprehensive review. In A. Kaban, & A. Stachowicz-Stanusch (Eds.), *Empowering Education: Exploring the Potential of Artificial Intelligence* (pp. 140-161). ISTES Organization.

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ISBN: 978-1-952092-57-2