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Artificial Intelligence in Education: a Systematic Review

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Abstract

This systematic review presents a comprehensive synthesis of recent scientific findings concerning the disruptive effects of artificial intelligence on the educational sector. In light of the rapid expansion of AI integration in education over the past three years, this study draws upon a sample of 17 scholarly outputs from the post-pandemic era to derive meaningful insights. Although previous studies have shown that AI can generate positive outcomes for both teachers and students, there is a lack of knowledge on how AI is used in the educational process. Hence, this research article aims to investigate not only the benefits and risks emerging from the implementation of AI technologies in education but also the educational level at which AI instruments are mostly integrated into teaching and learning and the characteristics of AI-based models currently used. While few studies have been found on this critical topic, the current references offer up-to-date information on various dimensions of AI systems in education (knowledge, instruments, activities, and consequences). The findings reveal that AI tools have greatly improved students' conceptual understanding related to artificial intelligence, algorithmic thinking, robotics, artificial neural networks, and computer science, as well as the acquisition of other valuable competencies like creativeness, literacy, cooperative research, and emotion control. Finally, future directions for exploring AI in education are presented.

Keywords: artificial intelligence, AI tools, education, educational technology, human-machine.

JEL Classification: I21, I24, I28.

1. Introduction

Over the past decade, digital technology has not only been the driving force behind the current transition to the era of advanced manufacturing but has also

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spurred the rise of the Industrial Internet of Things, signifying the convergence of cyber-physical systems and the integration of digital technologies in industrial processes. As predicted by Moore's law (Moore, 1998) for more than a half century, the development of digital technologies not only exponentially increased the efficiency and performance of various devices and gadgets, but also improved their operational capabilities (Jiahong, Weipeng, 2022).

Consequently, technology plays a pivotal role in transforming human perspectives and actions toward sustainability through its ability to educate and inform individuals about their carbon footprint, thereby influencing their attitudes and behaviours (George et al., 2021; Schroder et al., 2021; Dwivedi et al., 2022). In contrast, the notable deficiency in awareness about climate change concerns and their interconnection with digitalisation and technological innovation necessitates the implementation of a green IT curriculum at the secondary school and higher education levels to effectively address this issue (Perkins et al., 2018; Marques et al., 2019; Miller, 2020).

Nevertheless, the COVID-19 pandemic has impeded the pace of digital transformation, as evidenced by its adverse effects on economic growth irrespective of a nation's level of development (Habibi, Zabardast, 2020; Corejova, Chinoracky, 2021). On the one hand, among various factors, including macroeconomic stability, foreign direct investment, and trade openness, the level of digitalisation emerges as one of the significant determinants of competitiveness, exerting a substantial influence on a nation's economic growth (Boikova et al., 2021). On the other hand, this factor must be addressed by highly educated labour in order to make a positive impact on economic development (Volchik et al., 2018; Kolade, Owoseni, 2022; Werfhorst et al., 2022).

Furthermore, the global impact of COVID-19 has compelled educational institutions to swiftly explore inventive remedies within a compressed time frame (Tam, El-Azar, 2020), while all learning was diverted online due to the self-isolation period (Sloan, 2020). Given the limited time available for contemplating educational intricacies, the closure of schools and universities worldwide in response to the pandemic has resulted in the disruption of learning for nearly one billion students (UNESCO, 2020). The paradigm shift in education, triggered by the sudden shift from traditional schooling to the online environment, has propelled the embrace of open innovation and Education 4.0 (Akimov et al., 2023).

Consequently, in the context of infrastructure, Education 4.0 encompasses the provision of cutting-edge educational platforms, software, and applications, facilitating a novel educational paradigm characterised by human-machine interaction (Gennari et al., 2023). In view of this, artificial intelligence (AI) in education has become an intriguing topic of increasing interest for educators and researchers, as it has the ability to personalise learning experiences (Tahiru, 2021; Lee, Yeo, 2022; Liu et al., 2022; Mizumoto, Eguchi, 2023; Ray, 2023; Wand et al., 2023).

1.1 Justification, Aims, and Research Questions

The field of education is undergoing a profound transformation through the deliberate integration of novel technologies and paradigms into its processes, driven by the objective of addressing the evolving needs and demands of students in a proactive manner (UNESCO, 2020; Sipică, Toma, 2022). Moreover, the COVID-19 pandemic has underscored the significance of incorporating innovative technologies, implementing novel educational methodologies, and reconfiguring conventional learning settings and practices (Sloan, 2020; Tam, El-Azar, 2020; Fahey, Hino, 2020; De' et al., 2020). The synergistic utilisation of augmented reality and artificial intelligence holds the potential to facilitate this transition, thereby presenting a multitude of educational advantages and avenues (Ceobanu et al., 2022; Akimov et al., 2023).

While numerous studies (Cropley, 2019; Jiahong, Weipeng, 2022; Lee, Yeo, 2022; Liu et al., 2022; Denes, 2023; Chiu et al., 2023; Akimov et al., 2023; Iku-Silan et al., 2023; Jiahong, Weipeng, 2023; Mizumoto, Eguchi, 2023) have explored the implications of artificial intelligence (AI) for future education, there is a dearth of evidence related to the implementation of AI in education through public policies. Accordingly, the objective of this study was to conduct a systematic literature review to critically examine the existing body of knowledge and research on the utilisation of augmented reality and AI in education within the framework of public policy regulations. In addition, this systematic review examines the ramifications of the COVID-19 crisis on the expeditious uptake of educational policies concerning the incorporation of artificial intelligence into the pedagogical process, thereby elucidating the effects and consequences of the pandemic on the educational domain. The following research questions (RQs) were designed to guide the investigation:

Research Question 1 (RQ1): What are the advantages derived from the amalgamation and integration of artificial intelligence into the educational process?

Research Question 2 (RQ2): What are the main threats and risks associated with the integration of AI into the educational process?

Research Question 3 (RQ3): Which countries have yielded the most substantial body of research on this subject matter?

Research Question 4 (RQ4): In which educational phase is the application of artificial intelligence in education more commonly observed?

1.2 AI in Education

As the utilisation of AI technologies in education continues to grow, there has been a corresponding increase in the volume of published research on this subject. For example, Chiu et al. (2023) identified four prominent functions performed by AI in the educational context, enhancing the overall value of learning, training, assessment, and management processes. They revealed that AI can: (1) delegate assignments tailored to individual aptitudes; (2) facilitate human-machine dialogues; (3) assess student artefacts for constructive critique; (4) improve adaptability and interactivity in the digital world; (5) provide adaptive teaching strategies;

(6) improve teachers' instructional competencies; (7) support teachers' professional development; (8) provide automatic assessment; (9) predict student performance; (10) improve the performance of the educational unit management platform; (11) provide convenient and personalised service; (12) and support fact-based educational decision making.

Additionally, Tahiru (2021) revealed through their research that AI tools had already been adopted and employed within educational institutions in advanced nations such as the United States of America, Japan, as well as other developed countries including South Korea, Hong Kong, Estonia, among others, before the occurrence of the pandemic.

Earlier studies have also made a partial contribution towards comprehending the attributes and constituents of AI within the framework of Education 4.0 and open innovation competencies. Mollick and Mollick (2023), for example, emphasised the importance of AI tools for advancing teaching and learning practices provided that they are used carefully and thoughtfully in the classroom, as well-designed AI applications can expand teachers' capabilities, enhance learning, and support evidence-based teaching practices. Likewise, AI-based chatbots present many opportunities for preservice teachers to develop their pedagogical competencies by providing personalised interaction on a meaningful task (Lee, Yeo, 2022).

Furthermore, a comprehensive review conducted by Jiahong and Weipeng (2022) investigated the influence of artificial intelligence on early childhood education (ECE). Their results revealed a significant enhancement in children's conceptual comprehension of AI, automated learning systems, informatics, and robotics, along with notable improvements in complementary proficiencies such as inventiveness, emotion regulation, collaboration, reading ability, and computational problem solving. These findings align with recent research conducted by Iku-Silan et al. (2023), which similarly demonstrated that the intelligent conversational agent, according to their model, confers significant advantages in terms of students' learning outcomes, commitment levels, mental workload, and confidence and self-assurance.

In addition, the utilisation of a chatbot employing AI techniques has the capacity to foster a favorable reading experience while capturing students' attention and cultivating their interest in the learning process (Liu et al., 2022). Current investigations primarily center on assessing the impacts of ChatGPT, an AI-based chatbot devised by OpenAI and introduced in November 2022. ChatGPT builds upon OpenAI's foundational models, namely GPT-3.5 and GPT-4, and has undergone refinement via the utilisation of superintended and underpinning learning techniques.

Within the realm of education and training, ChatGPT holds potential for various applications including: (1) tailoring education materials and lesson plans to align with individual learners' requirements and preferences; (2) providing learners with timely feedback and guidance throughout their educational journey; (3) developing captivating educational materials such as quizzes, tests, collaborative exercises, and multimedia productions; (4) supporting instructors with rating tasks, automated essay scoring, and productive feedback to pupils; and (5) creating flexible learning

contexts adequate for each learner's performance and progress (Mizumoto, Eguchi, 2023; Ray, 2023).

2. Methodology

This section elucidates the research approach by offering a discerning viewpoint on the selection of the present systematic literature review approach, along with the meticulous process that underlies the emergence of the conclusions and inputs presented in this research article.

2.1 Methodological Framework

In order to address the aforementioned research inquiries and accomplish the established objectives, a systematic exploration of the literature was carried out according to the guidelines outlined in the Statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Given the diverse range of experimental studies, reports, assessments, suggestions, and hypothetical investigations encompassing the domain of AI in education, a meta-synthesis was deemed the appropriate approach. The adoption of the PRISMA statement was motivated not only by its rigorous criteria and principles, but also by its well-established reputation as a method widely employed in various subject areas, including education, to provide comprehensive insights.

To conduct a scientifically rigorous study, a comprehensive search strategy was employed, involving an in-depth combination of keywords across three prominent databases: Web of Science (WoS), SCOPUS, and Google Scholar. Notably, the utilisation of the WoS and SCOPUS databases yielded the retrieval of the most relevant and accurate documents, in line with their recognised status as high-impact scientific databases.

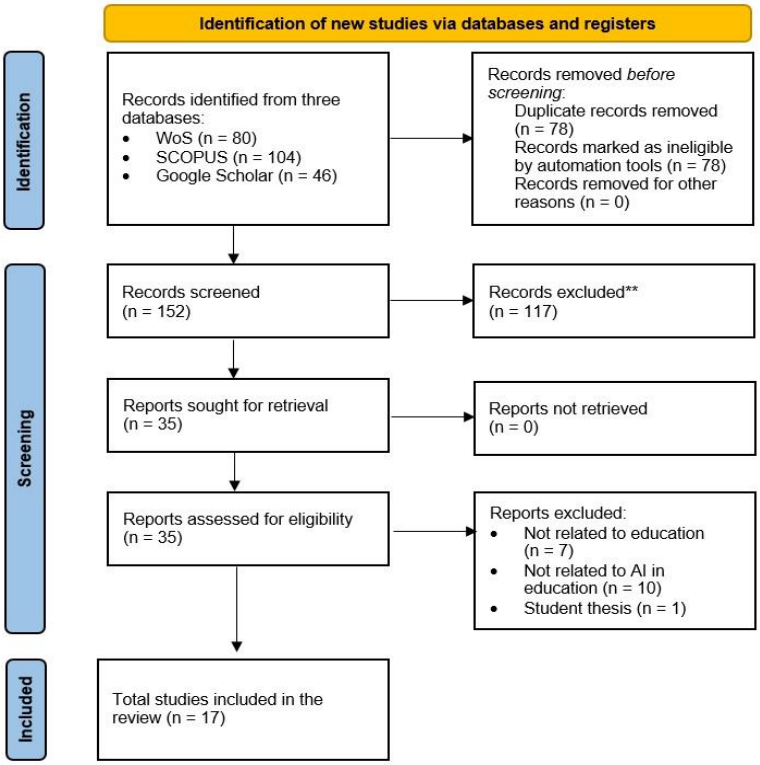
2.2 Meta-analysis Process

Data were collected from the period spanning 2021 to May 2023, with the objective of encompassing public policies pertaining to the integration of AI technologies in the educational domain, both prior to and in the aftermath of the pandemic crisis. A relevant and comprehensive search equation was employed to survey the literature concerning AI in education, encompassing a wide range of educational levels and topics. Considering the multidisciplinary character of the subject, the subsequent search string was utilised: "('artificial intelligence') AND ('AI') AND ('education' OR 'school' OR 'teach' OR 'college' OR 'student' OR 'learn' OR 'policy')".

The entire process of identifying scholarly literature through database searches is presented in Figure 1, adhering to the comprehensive steps and guidelines outlined in the PRISMA 2020 Checklist. In the beginning, a total of 230 studies were retrieved from the three databases (104 from SCOPUS, 80 from WoS, and 46 from Google Scholar). Among these documents, 78 were identified as copies and excluded from the analysis, resulting in a pool of 152 articles for screening. The primary

addition criteria encompassed the combined utilisation of artificial intelligence applications and tools, direct relevance to the scholastic process, and the inclusion of empirical studies, educational AI tools development, research syntheses, or theoretic contributions. Of the 152 documents, 117 did not meet the predetermined research criteria and were subsequently excluded from the study. The remaining 35 documents were successfully obtained for further examination. Supplementary evaluation led to the exclusion of 18 additional studies that did not satisfy the established research criteria. As a result, a total of 17 studies were included in the review and subjected to detailed analysis.

Figure 1. PRISMA flow diagram



Source: Authors' own contribution.

The 17 identified documents were categorised into three distinct groups: empirical studies, proposal and prototype papers, and theoretical papers. The appraisal and abstract papers underwent comprehensive scrutiny to identify their primary findings. Similarly, the proposal and prototype articles were scanned and analysed to determine their findings and recommendations. As for the experimental studies, a systematic analysis was conducted based on several variables including the state where the study was piloted, educational phase, application area, development category, sample size, main objective, research methodology, primary variables of interest, research mechanisms and tools utilised, AI instrument's name,

software development approach, programming tools employed, computing platform, devices employed in the experimental setup, key AI characteristics, and the focal findings derived from the study.

3. Findings

Table 1 presents a comprehensive overview of the 17 studies included in this research, providing details on the author(s), authors' country, publication year and title, investigation objectives, design of study, participants, AI applications utilised, and key conclusions. The table presents a detailed description and characteristics of each study, enabling a comprehensive understanding of their key aspects and outcomes.

Next, a comprehensive analysis was conducted using a combination of qualitative and quantitative methods to examine the data. Through a rigorous examination of the articles and their respective variables, the outcomes obtained are presented in the following section.

First, the countries (RQ3) that exhibited a substantial presence in conducting pragmatic research on the incorporation of artificial intelligence into the educational process are the United States, Taiwan, Japan, China, Singapore, the UK, Sweden, and Italy. Countries such as China, Germany, Hong Kong, Australia, the United Kingdom, Vietnam, India, and Ghana have actively engaged in the implementation of systematic reviews and conceptual papers within the realm of artificial intelligence in education.

Secondly, the majority of studies focused on the implementation of AI at all levels of education (freq. = 9, pct. = 52 %); followed by the assimilation of AI technologies in early childhood education (freq. = 2, pct. = 12 %), secondary school (freq. = 2, pct. = 12 %), and high-school (freq. = 2, pct. = 12 %); and primary school (freq .= 1, pct. = 6 %) and university (freq. = 1, pct. = 6 %) (RQ4). The majority of papers focused on understanding the opportunities and provocations of AI in education for both educators and students, as well as for the management of their educational units (52 %).

Notwithstanding the varied objectives of the articles, a considerable portion of them predominantly focuses on examining the influence of AI, particularly the effects of transformer-based language models, on learning outcomes, classroom effectiveness, and student engagement. Additionally, attention is paid to addressing the potential ethical implications arising from the use of AI in educational contexts.

Moreover, it is worth noting that the empirical studies encompassed a diverse range of research methods, including survey-based questionnaires, quasi-experiments, and experiments, thus providing a comprehensive examination of the topic at hand. In contrast, the conceptual papers used a mix of qualitative and quantitative approaches.

However, the primary variables employed in the studies were directly linked to crucial aspects of students' educational journey, encompassing their learning achievements, drive levels, engagement levels, cognitive load experienced, and digital social well-being. A limited portion of the papers (30 %) concentrated on a

comprehensive examination of teachers' variables pertaining to AI, encompassing their preparedness for integrating AI in their instructional practices and their capacity to create educational content using AI guidance.

Table 1. Descriptive data of the incorporated articles

Author(s)/ Year/ Country	Article title	Research Aims	Research Design	Participant(s)	AI tools	Main findings
Chiu et al. (2023), Hong Kong	Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education	Understand the opportunities and challenges of AIEd by examining the literature from the last 10 years (2012–2021)	Systematic review study	N=92 studies	Assessment System, Prediction Model, Robotic language tutor, Automatic scoring tool, Chatbot, Teaching System, Braille tutor	AI technologies play numerous roles in the key educational domains. Also, they provide 7 learning aftermaths of AIEd, and 10 major provocations.
Denes (2023), UK	A case study of using AI for General Certificate of Secondary Education (GCSE) grade prediction in a selective independent school in England	AI models as assessment tools	Ofqual algorythm model, Questionnaire	N=180 students (secondary school)	Machine learning model	Numerical models alone are not yet suitable to replace public exams.
Gennari et al. (2023), Italy	Design for social digital well-being with young generations: Engage them and make them reflect	Promote education to responsible design as a key for digital social well-being	Questionnaire, interviews	N=24 students (17-18 year-olds, second-last year of high-school)	IoTgo phygital toolkit	Teens were also able to critically replicate in design for societal digital well-being.
Iku-Silan et al. (2023), Taiwan	Decision-guided chatbots and cognitive styles in interdisciplinary learning	To scrutinise the impact of this AI-based learning model on learning outcomes, enthusiasm, collective efficacy, classroom engagement, satisfaction with the learning tactic, and mental workload of learners with diverse reasoning styles.	Quasi-experiment method	N=71 students, junior high school	Decision-guided chatbot	The advantage of the contingency-based guided-exploratory learning mode to multimodal learning, which could be a good approach for cultivating students' learning achievements in multimedia learning.
Jiahong and Weipeng (2022), China	Artificial intelligence in early childhood education: A scoping review	To evaluate, synthesize and display the latest literature on AI in early childhood education.	Scoping review	N=17 articles	Zhorai, WeChat remote control, Teachable Machine, PopBots, Cognimates AI platform, and PlushPal	AI educational robots can integrate different disciplines of knowledge and multiple technologies simultaneously to greatly enrich children's learning experiences.
Jiahong and Weipeng (2023), China	A systematic review of integrating computational thinking in early childhood education	How to effectively teach and learn computational thinking in early childhood education.	Systematic review study	N=26 studies (2010-2022)	Bee-Bots, Daisy the Dinosaur, Kodable, Coding bots, Aphid's Toys, Matatalab, CHERP, and Cubetto	With age-appropriate instructional design, children could develop early concepts and skills of computational thinking, as well as other related skills such as communication, collaboration, and problem solving.

Author(s)/ Year/ Country	Article title	Research Aims	Research Design	Participant(s)	AI tools	Main findings
Joksimovic et al. (2023), Australia & Germany	Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review	Investigate the opportunities of AI for supporting complex problem-solving.	Scoping review	N=38 studies (2018-2023)	Social robots, Chatbots	The collaborative interaction between humans and machines in complex problem-solving tasks exhibits promising potential for enhancing the efficiency and effectiveness of problem-solving across diverse practical domains.
Kasneci et al. (2023), Germany	ChatGPT for good? On opportunities and challenges of large language models for education	Investigate how these models can be used to create educational material, enhance student commitment and communication, and personalize education experiences.	Scoping review	N=23 studies (2018-2023)	Large language models: GPT-3, BERT, BLOOM, T5, RoBERTa	The utilisation of large language models in the field of education necessitates the cultivation of competencies and literacies by educators and learners alike, encompassing a comprehensive understanding of the technology itself, as well as its limitations and potential vulnerabilities.
Kolade and Owoseni (2022), UK	Employment 5.0: The work of the future and the future of work	To highlight often conflicting views about technology ownership, work-less utopia, education reforms and the imperative of human centricity in appropriation of technology.	Systematic review study	N=68 studies (2011-2022)	Collaborative robots, Digital twins, Cyber-physical systems, Chatbots	In addition to embedding digital skills throughout the training curricula in the formal training courses, more resources in funding and time allocation need to be injected into the programmes for continuing staff development.
Liu et al. (2022), Taiwan	An analysis of children' interaction with an AI chatbot and its impact on their interest in reading	To understand the features of a chatbot built with artificial intelligence technologies as a book talk companion, and to survey the role of the interaction in students' commitment and attention in reading.	Experiment	N=68 students (11-12 year-olds; 6 weeks)	Chatbot including 157 books (based on the Google Actions Console framework)	The engagement of students in conversational interactions with the chatbot resulted in a sustained level of situational interest pertaining to the value dimension. In contrast, students who did not engage in the book talk with the chatbot experienced a substantial decline in their level of interest.
Mizumoto and Eguchi (2023), Japan & USA	Exploring the potential of using an AI language model for automated essay scoring	To evaluate ChatGPT's reliability and accuracy in performing automated essay scoring (AES).	Experiment	N=12,100 English essays (TOEFL11)	AI language model ChatGPT	Automated essay scoring (AES) systems can leverage artificial intelligence (AI) language models, such as ChatGPT, to enhance their validity and reliability in assessing and providing feedback on written texts across various domains and contexts.
McGrath et al. (2023), Sweden	University teachers' perceptions of responsibility and artificial intelligence in higher education - An experimental philosophical study	To investigate university teachers' relationships with emerging technologies by focusing on the uptake of artificial intelligence in higher education practices.	Online survey	N=194 university teachers	Learning analytics systems, AI-driven assessment tools, Automated short-answer grading systems	AI literacy was reported to be low among the university faculty, yet a considerable proportion of them perceived AI as a potential facilitator of more inclusive student support systems. Faculty development programs may be required to enhance their awareness and understanding of the implications of AI technologies for their pedagogy, and to equip them with the skills and competencies to effectively utilise the emerging technologies in their practice.

Author(s)/ Year/ Country	Article title	Research Aims	Research Design	Participant(s)	AI tools	Main findings
Mollick and Mollick (2023), USA	Using AI to Implement Effective Teaching Strategies in Classrooms: Five Strategies, Including Prompts	To show how teachers can create educational material using AI guidance.	Experiment	Bing AI (online) vs. GPT-4 (offline)	Large language models (LLMs)	AI can produce explanations, examples, practice problems, and diagnostic questions to support instructors, helping them spend less time on developing materials and more time focusing on students. While AI will not replace instructors, thoughtfully developed AI tools show promise in augmenting instructor capacity, improving learning, and supporting evidence-based teaching practices at scale.
Perkins (2023), Vietnam	Academic Integrity considerations of AI Large Language Models in the post-pandemic era: ChatGPT and beyond	To describe and demonstrate the potential that LLMs have in creating original, coherent text that can avoid detection by existing methods.	Scoping review	Chatbots	Large language models (LLMs)	LLMs have the ability to produce creative and articulate text that could be potentially utilised by students in academic examination, and we contend that LLMs have achieved a degree of complexity that makes it challenging for both human specialists and high-tech gears to invariably differentiate between LLM-generated and human-generated text.
Ray (2023), India	ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope	To provide an in-depth exploration of ChatGPT's role in advancing traditional bullnecks.	Scoping review	GPT-2, GPT-3, Bing Chat, BERT, T5, XLNet, RoBERTa, Transformer-based models from Hugging Face, SpaCy, BARD, NLTK, CTRL	Large language models (LLMs)	ChatGPT has facilitated the progress of generative AI in various dimensions, such as, (i) amended circumstantial interpretation, (ii) refined language construction, (iii) task versatility, (iv) polyglot know-how.
Tahiru (2021), Ghana	AI in Education: A Systematic Literature Review	To analyze the opportunities, benefits, and challenges of AI in education.	Systematic review study	N=23 articles (2010-2019)	AIED (AI in Education)	Ethical dilemmas arising from an AI system should be resolved by adhering to the established policies and standards, which specify the accountability for the information utilised by the system. A strategy to integrate responsibility in the application of AI in educational area would be an initial step to address the ethical challenges in AI.
Wand et al. (2023), China & Singapore	Preparing for AI-enhanced education: Conceptualizing and empirically examining teachers' AI readiness	To conceptualize and examine teachers'AI readiness.	Cluster analysis	N=3164 primary school teachers	AIED (AI in Education)	This paper investigated the notion of AI promptness for educators from four dimensions, namely reasoning, aptitude, perspective, and morals, and empirically confirmed that professors with different levels of AI promptness incline to differ in their perceptions of AI and invention and their work fulfillment.

Source: Authors' own contribution.

Thirdly, most of the studies highlighted the benefits of combining and integrating AI in education (freq. 11, pct. = 65 %), while the rest of the articles pointed out the main threats and risks associated with the implementation of AI in education (freq. 6, pct. = 35 %). On the one hand, most authors concentrated on determining the main advantageous functions of AI equipment in essential educational areas

(learning, teaching, assessment, and administration) (RQ1). For example, the contingency-driven guided-inquiry learning mode represents an effective approach for improving students' learning outcomes in multimedia learning (Iku-Silan et al., 2023), while the human-machine collaborative approach in elaborate problem solving has demonstrated to significantly increase the productivity and helpfulness of problem solving in a broad variety of concrete applications (Joksimovic et al., 2023). In terms of digital competencies, AI tools have the potential to develop students' computational thinking skills and noncognitive abilities such as analytical thinking, hand-eye coordination, and body-matter interaction (Jiahong, Weipeng, 2023; Gennari et al., 2023).

Additionally, cautiously developed AI applications present the potential for increasing instructor capacity, improving learning outcomes, and supporting evidence-based teaching practices while helping teachers spend less time on creating educational content and more time focusing on their students (Mollick, Mollick, 2023). Specifically, big linguistic systems like ChatGPT can be effectively applied as automatic essay grading instruments (Mizumoto, Eguchi, 2023) or as a tool for personalised learning materials development and real-time feedback to students during the educational process (Ray, 2023).

On the other hand, to maximise the potential of large language models for educational context, it is very important to address the usage of these AI tools with vigilance and judgmentally assess their restrictions, risks, and possible prejudices (Kasneci et al., 2023) (RQ2). The study of Denes (2023) assessed whether AI tools can substitute for the formal GCSE exam taken by 10th-grade students in the UK and concluded that human monitoring is still needed while using numerical models for assessment. At the same time, Kasneci et al. (2023) highlighted the importance of acquiring the competencies and literacies needed to understand and integrate AI technologies in teaching and learning. Other than including digital competencies all through the curriculum in the formal education area, authors also emphasise the importance of investments in terms of funding and time allocation for teacher training and formation (Kolade, Owoseni, 2022). Likewise, university teachers need support and training for a better understanding of the implications of AI techniques for their teaching practice (McGrath et al., 2023). Finally, policy makers should address the ethical issues determined by AI systems by incorporating accountability into the use of AI in education (Tahiru, 2021).

4. Discussion

This research article offers a systematic review of 17 WoS and Scopus articles conducted in different countries from 2021 to 2023, which allowed us to determine not only whether AI technologies have negative effects on educational outcomes, but also how these malicious consequences can be addressed. Generally, the studied papers present successful integration of various AI tools into the educational practices, as well as a rigorous description of the components and characteristics of their AI-based decision-guided chatbots. Papers apply different methodical

approaches in order to investigate the impact of large language models, especially chatbots, for both students and teachers.

The limitations of this current study must also be acknowledged. First, due to the relatively limited sample size of documents included in this analysis, there may be deficiencies in the research results. Second, our synthesis of previous studies only addressed documents written in English and might have omitted important publications from other scientific languages.

5. Conclusions

The post-COVID era has underlined the critical importance for both students and teachers to be equipped with AI readiness in order to make well-versed decisions about the utilisation and choice of AI tools (McGrath et al., 2023; Perkins, 2023; Wand et al., 2023). While the digital revolution in education created new issues such as the digital divide, lack of skills, or even misuse of AI instruments (Hatos, 2019; Werfhorst et al., 2022), education systems around the world must facilitate their transition to Industry 5.0 by developing 21st century competencies like resourcefulness and logical thinking, curiosity and resilience, affective and interpersonal skills, and metacognitive skills (Ceobanu et al., 2022; Sipică, Toma, 2022; Akimov et al., 2023).

Taking into consideration the social and ethnic obstacles underpinned by paucity and a deficiency of education for many people living in developing countries (Barnes, 2020; Fahey, Hino, 2020; De' et al., 2020), digital exclusion could only be overcome by the thoughtful adoption of educational policies that regulate the integration of AI technologies in education (Sipică, Toma, 2022). Therefore, the instruction of digital capabilities in a holistic way has the potential to improve teacher skills in terms of classroom organisation, cognitive stimulation and positive environment (Lee, Yeo, 2022; Runge et al., 2023; Mizumoto, Eguchi, 2023; Wand et al., 2023). Moreover, the direct involvement of teachers in educational activities in the field of digital media appears to allow a deeper engagement of students in the educational process (Gui et al., 2023; Iku-Silan et al., 2023; Mollick, Mollick, 2023; Jiahong, Weipeng, 2023; Mizumoto, Eguchi, 2023; Ray, 2023; Joksimovic et al., 2023).

Based on this systematic review, we can summarise that there are at least three methods to AI incorporation in education. First, AI-based e-learning systems (for example, large language models) can ensure a supportive environment for students' personalised learning activities, as well as enhance their interest and motivation (Jiahong, Weipeng, 2022; Liu et al., 2022). Second, AI technologies can also provide personalised lesson plans and diagnostic questions to support teachers in spending less time creating educational content and more time on focusing on students (Tahiru, 2021; Mollick, Mollick, 2023; Mizumoto, Eguchi, 2023). Third, AI educational robots can offer an interdisciplinary approach to learning and help improve children's learning experiences and skills, more specifically critical thinking, computational thinking, human-machine interaction, and complex problem

solving (Jiahong, Weipeng, 2022; Iku-Silan et al., 2023; Jiahong, Weipeng, 2023; Joksimovic et al., 2023).

Therefore, further research should be piloted to assess the assimilation of AI tools at all educational levels since AI-based large language models are more rapidly evolving and learning than the education field has the capacity to keep up with their pace.

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