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Integrating Large Language Models into Education: Revolutionising Teaching and Learning

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ABSTRACT Education sector is currently standing at the precipice of possibilities with the advent of Large Language Models (LLMs) and Artificial Intelligence (AI) technologies. AI has recently infiltrated educational processes to improve students' learning outcomes with the help of fluent chat bots such as ChatGPT, based on LLMs. This study explores the applications of LLMs in education shedding light on classroom support, flexible teaching and educational technology. This study employed descriptive review of existing literature focusing key trends on AI-driven pedagogy. The study identified both applications and potential risks involved such as data privacy, high dependency and ethical implications due to AI implementation in educational practices. The study presents practical recommendations of LLMs. The study concludes that LLM integration in education aids the educators, researchers and policymakers to transform the pedagogy and teaching methods to foster an effective, individualised learning environment for the students in future.

INTRODUCTION

From birth, humans acquire the ability to speak and utilise language in a variety of contexts throughout their lives. It is a vital instrument for communication and human expression. Nevertheless, machines are incapable of understanding and speaking human language without highly developed Artificial Intelligence (AI) (Hohenstein et al. 2023). In the past several years, AI has gained a lot of attention and been used in a variety of educational settings (Hohenstein et al. 2023). The term Artificial Intelligence (AI) describes a class of recently created algorithms that simulate specific features of human behaviour or thought processes. More precisely, they define generative AI algorithms, which are capable of creating new media like text or graphics.

Large language models (LLMs) are a type of deep learning neural networks with huge volumes of training data, and easy access to massive computing power. These networks were trained using a self-supervised learning process on enormous volumes of unlabelled text data (Wang et al. 2024). Specifically, methods including learning analysis, cognitive diagnostics, knowledge tracing, and content suggestions have widely adopted educational data mining approaches. Contemporary LLMs, like ChatGPT, combine enormous text databases with artificial neural networks with billions of parameters to parse and generate text. The user can provide arbitrary prompts and receive conversational, human-like responses with chat-like interfaces.

Earlier language models like Wordtune and Paperpal permitted users to paraphrase the sentence structure with certain limitations (Jeong and Jeong 2022). Nonetheless, latest AI tools are able to edit entire manuscripts and understand the fundamental concepts, as the result of user input from the large volume of training data. The accessibility of recently created chatbots, such OpenAI's ChatGPT, Google's Bard, and Microsoft's BingChat, creates new potential and problems for education. These technologies, which are built using LLMs, help educators to create scalable, customised learning resources for their students (Sanchez-Diaz et al. 2018; Awada et al. 2019). Professional expertise is required to evaluate and revise the LLM based learning. However, the path towards game-based learning may ultimately lead to the development of a new AI pedagogy that fully utilises the potential of balanced human-machine intelligence. Numerous studies focus on the LLM capabilities in the field of AI by shedding light on their remarkable ad-

vancements, large applications outweighing its risks, and its dynamic ability like text generation, critical thinking and reasoning. Game based learning is affected by wide range of factors, including sociocultural dimension, frequency of the usage of learning games in classroom settings, financial constraints, and restricted access to educational games (Shen et al. 2023).

Generative AI tools and LLM models are primarily used to develop game-based learning systems. Initially, generative AI was used to create educational games, allowing students to quickly design games based on lessons. Using AI tools, educators and teachers can develop a comprehensive learning game as a second strategy. A new phrase, "prompting pedagogy", describes the instructional strategies used in game creation with the aid of LLMs. To critically assess the produced outputs in game creation, subject matter experts' help is also necessary. Generative AI technology has amazing characteristics that allow it to generate a wide variety of data types, including text, code, images, videos, movies, and 3D models. Following a thorough examination of generative AI and LLM models (Chen et al. 2020; Batool et al. 2023), the generative AI models and applications are shown in Figure 1.

Images, videos, music and natural language are among the subfields of generative AI. By implementing generative AI technology across a range of industries, including gaming, art, and advertising, it has the potential to transform many sectors. For instance, a model can be trained to produce new paintings based on a large collection of unique and original paintings that are comparable to each other in the dataset. The applications of generative AI are provided in Figure 2 showing its capabilities throughout various time periods. In May, Google launched PaLM2, while in March, OpenAI released GPT-4. Both improved versions are largely trained on almost five times as much token (text data) as their earlier models, and they perform better in real-world scenarios (Cui et al. 2024; Li et al. 2024).

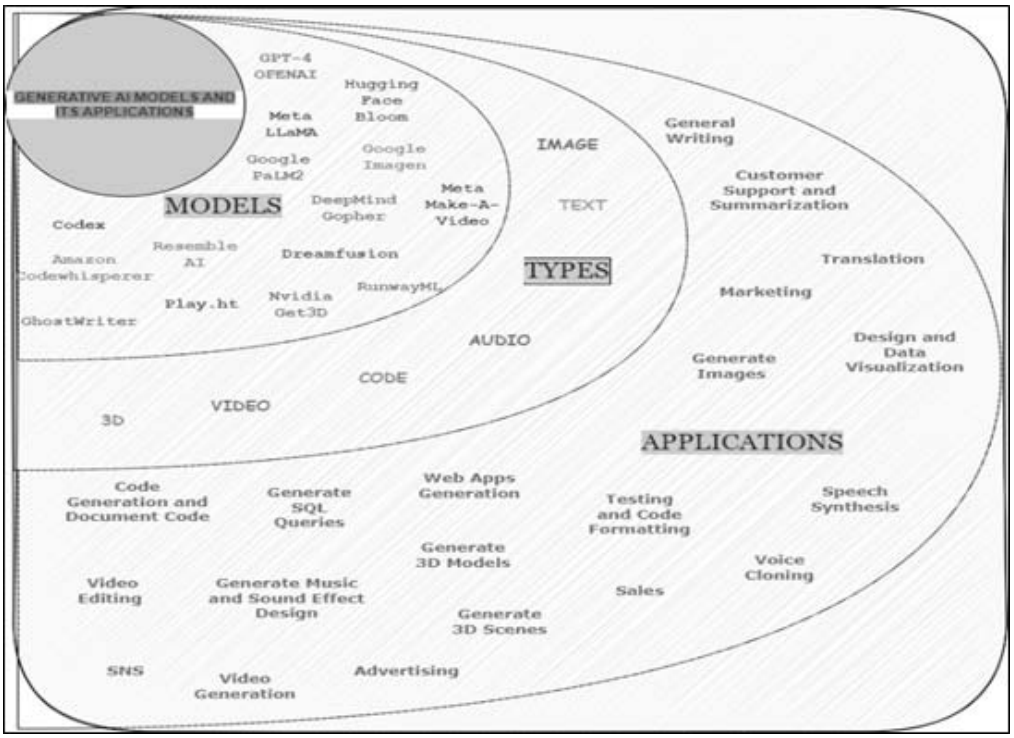

Fig. 1. Generative AI models and its applications
Source: Author only

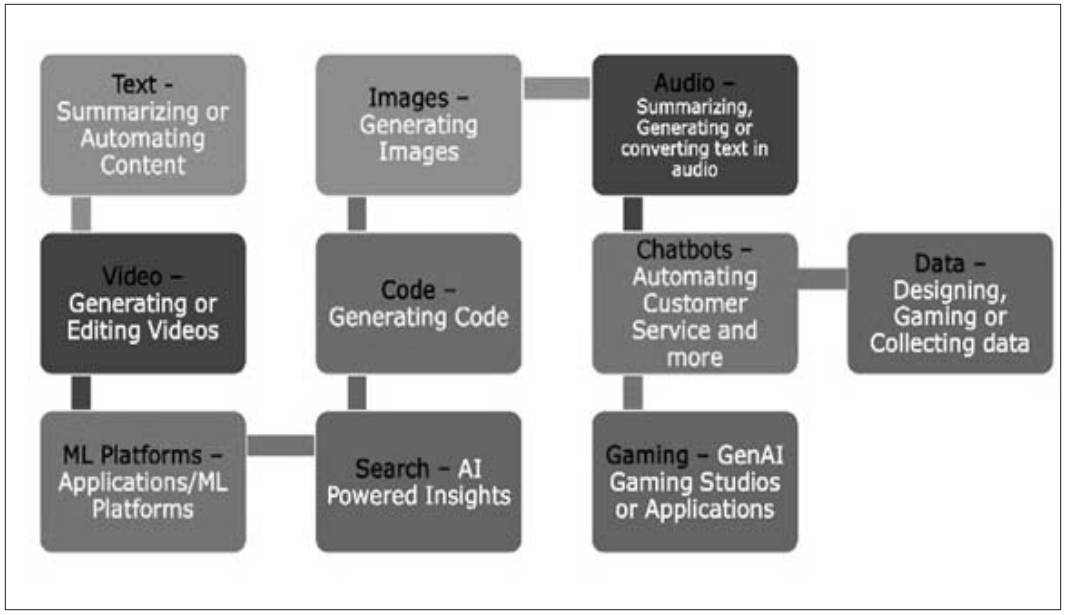

Fig. 2. Applications of generative AI landscape
Source: Author only

Furthermore, many companies are developing their own generative AI models, including Samsung Electronics, Falcon and Meta LLaMA. These open-source LLMs are gaining popularity and prioritise learning volume over model size. NVIDIA is currently pursuing the concept of "AI Factory", which involves integrating AI models into commercial data centres. Furthermore, they are developing small Large Language Models (sLLM) that are intended to save costs and provide models with high simplicity and reliability. NAVAR Cloud launched HyperCLOVA X, an incredibly huge AI model built in Korea, intended for banking, e-commerce, legal, and education during August 2023. It is implemented via API, customised for any organisation, and deployed via cloud technologies (Zhao et al. 2023).

This shift shows that the LLM market is transitioning from a performance-based competition to a more specific one, marking the beginning of a new stage in the market's growth. The LLaMA architecture, an open-source LLM architecture, is currently gaining popularity. Some LLMs, such GPT4All, have surfaced after the release of Alpaca. More precisely, GPT4All is based on the LLaMA 7B concept, inspired by Alpaca. It collected 800,000 GPT-3.5-Turbo model prompt-response pairings (code, conversations, and narratives). These pairs are around 16 times larger than the Alpaca dataset since about 430,000 of them were generated using a prompt-response method similar to an assistant. One notable benefit of this model is its ability to operate on CPUs without the need for GPUs. Startups are currently making efforts to develop such LLMs (Zhao et al. 2023).

LLM has hardware limitations and cost issues due to the high number of parameters required for training. Conversely, in an attempt to overcome these challenges. In light of this evolution, the drawbacks of traditional LLMs are examined as a potential solution (Mohan et al. 2024).

Many technical researchers have devoted their research to explore the ways to incorporate LLMs and generative AI to deliver a personalised AI experience across various industries including healthcare, software, retail, finance, trade and linguistics. However, from the technological perspective, the use of LLMs for education have not been succinctly outlined in the latest research. The knowledge of teachers on educational methods should be taken into account while developing and implementing LLMs in the education sec-

tor. This critical review is conducted to demonstrate opportunities and challenges involved in AI-LLM integration in education.

Objective

The field of education is currently facing issues with striking a balance between implementation of innovative technology and guarding against the risk due to the lack of necessary expertise development at the same time. The primary contribution of this paper is to give a comprehensive overview about the history of LLMs, and the procedures for creating pedagogical content using LLMs, and various toolkits used in teaching. This paper also discusses the difficulties in integrating the aforementioned into teaching and learning, as well as the potential applications of LLM with generative AI in education. This critical review presents a strong argument on efficacy of LLMs outweighing its risks in learning environments to enhance the teaching and learning. This review also recommends a few strategies to encounter the problems pertaining to LLM and AI implementation in regard to education.

METHODOLOGY

This systematic review study recruited descriptive research design using secondary data collection and analysis to analyse the role of LLMs in education. This research synthesised the data from peer-reviewed articles to provide a structured assessment of AI-driven educational pedagogy, its application and challenges (Snyder 2019).

Data Collection

The data was collected during January 2024 to April 2024 from reputable databases like IEEE, Springer, Elsevier and Google Scholar. "LLMs in education", "AI-powered learning", "adaptive learning systems", "AI in pedagogy", "challenges of AI integration in education" and "educational chatbots" are the keywords used for fetching the data.

Selection Criteria

The study includes empirical research papers, conference articles and industry reports that discuss the use of LLMs in education.

The inclusion criteria were:

- Studies published between 2020-2024 focusing on AI-driven learning tools.
- Research evaluating the effectiveness, challenges, and ethical considerations of LLM adoption in classrooms.
- Case studies from academic institutions and EdTech companies showcasing LLM integration in pedagogy.
- Studies discussing the impact of AI on student performance, engagement, and accessibility.

Exclusion criteria included:

- Papers unrelated to AI in education.
- Studies lacking empirical data or case study validation.
- Articles published before 2020 unless cited for historical context.

Research Questions

This study explores the following key questions:

- How are LLMs being integrated into educational settings, and what tools are currently in use?
- What measurable improvements have been observed in student engagement, learning outcomes, and administrative efficiency due to AI-driven educational tools?
- What are the primary barriers to LLM adoption, and how do institutions address concerns related to data privacy, AI bias, and over-reliance on AI?

Data Analysis

The collected data was analysed using the qualitative thematic analysis method (Braun and Clarke, 2006). Findings were classified into three major themes as follows.

Theme 1: LLMs in Teaching and Learning

The studies examined the content generation using Artificial Intelligence and the incorporation of content tutoring, both of which are critical to adaptive learning technology. LLMs provide feedback, assessments, and lessons to students in an AI-powered teaching process that is more engaging and responsive than before. Platforms that rely on artificial intelligence, including ChatGPT and Khanmigo, have been implemented in both

face-to-face and remote classrooms to aid the learning of learners in all subjects, even those in STEM fields.

Theme 2: Tools Used for Student and Classroom Support

This second major theme focused on AI technologies that attempt to help students interactively. Integrating LLMs to automatic grading systems, translating, and smart tutoring, and to give less academic work for the teachers, with more effective results. Also, chatbots and virtual assistants powered by AI can provide academic support at any time, thereby increasing the access of students who need further assistance beyond the normal class hours.

Theme 3: Opportunities and Challenges in AI-driven Education

This section highlights both benefits and also documents several challenges, including data privacy risks, AI biases, high costs, and teacher training gaps associated with AI-driven education. Institutions face difficulties in ensuring ethical AI deployment, particularly in addressing bias in AI-generated content and preventing student over-reliance on AI for academic work. The analysis suggests that without proper regulation and teacher training, AI could reinforce inequalities rather than bridge educational gaps.

RESULTS

Among 78 articles collected from different peer-reviewed academic journals, conference proceedings, case studies and industrial reports, only 55 met the criteria for the data analysis in this study and the remaining 23 articles were excluded due to lack of empirical evidence and vague discussions (Table 1). Table 2 illustrates that 40 percent of the studies focused on LLMs in Teaching and Learning, 32 percent studies shed light on Tools used for Student and Classroom support and the rest 27 percent focused on opportunities and challenges involved in AI-driven education.

Longitudinal growth trends of AI driven education were observed from all 55 articles. Table 3 clearly shows the steady-state increase of AI implementation in education from 18 percent in 2020 to 75 percent in 2024. AI-oriented tutoring systems, automated grading tools, adaptive learning systems, and AI student support systems drove growth in this segment. Case studies from MIT, Stanford and Khan Academy pointed out an increasing dependence on AI-powered learning, while industry reports focused on AI's role in broadening educational access, engagement, and tailoring learning paths. The evidence does suggest that the adoption of AI is not uniform across the globe or nations, as it depends on infrastructure, availability of funds, and teacher preparedness. It is advisable for regulators and teachers to prepare for the gradual shift AI promises towards integrated education by developing frameworks that promote ethical AI use in classrooms.

Table 2: Distribution of reviewed articles by key themes

Key theme	*Number of articles*	*Percentage (%)*
LLMs in teaching and learning	22	40
Tools used student and classroom support	18	32
Opportunities and challenges	15	27

Source: Author only

Table 3: Growth in AI adoption in education (2020 – 2024)

Year	*AI adoption rate (%)*
2020	18
2021	30
2022	45
2023	60
2024	75

Source: Author only

Table 4 demonstrates the before and after of LLM implementation on student performance centred from the obtained research data to measure the impact of LLMs on student performance, student engagement, and learning outcomes. The findings indicate that student engagement was enhanced by 20 percent, assignment submission rates rose from 70 percent to 90 percent, and concept retention was enhanced from 60 percent to 80 percent upon LLM implementation. Additionally, exam performance was enhanced by 14 percent, and research paper quality was enhanced

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Table 1: Summary of articles subjected to thematic analysis

S. No.	Theme	Article title	Author(s)	Year	Source type	Key findings
1	LLMs in and Teaching Learning	AI and Personalized Learning Systems	Holmes et al.	2021	Peer-Reviewed Journal	LLMs improve student engagement through adaptive learning.
2		AI-Driven Adaptive Learning	Baker et al.	2020	Peer-Reviewed Journal	AI personalizes student learning experiences effectively.
3		The Role of AI in Teaching Assistance	Li et al.	2023	Journal Article	AI helps automate quiz and content generation.
4		AI for Content Creation in EdTech	Johnson and Patel	2022	Industry Report	AI generates interactive educational content.
5		Automating Lesson Planning with LLMs	Google AI Team	2024	Industry Report	AI improves curriculum development efficiency.
6		AI Chatbots in Higher Education	Sharma et al.	2021	Journal Article	AI-powered chatbots support real-time learning.
7		Khanmigo: AI-Powered Learning Assistant	Khan Academy Research	2023	Case Study	AI tutoring improves self-paced learning.
8		ChatGPT for Student Interaction	OpenAI Research	2022	Conference Paper	AI chatbots enhance engagement and feedback.
9		Enhancing AI-Powered Tutoring Systems	Stanford AI Lab	2023	Case Study	AI tutors increase student comprehension and retention.
10		Using AI for Online Course Adaptation	Coursera AI Team	2023	Industry Report	LLMs optimize learning pathways for e-learning students.
11		AI in STEM Education	Microsoft Research	2024	Journal Article	AI supports problem-solving in STEM courses.
12		LLMs for Literature and Language Studies	Harvard AI Lab	2022	Peer-Reviewed Journal	AI-driven analysis helps students interpret literary texts.
13		The Future of AI in Higher Education	MIT Media Lab	2023	Journal Article	AI facilitates adaptive learning for university students.
14		LLMs and Curriculum Design	Smith and Wong	2021	Journal Article	AI assists in structuring effective course modules.
15		Transforming Traditional Learning with AI	OpenAI	2024	Industry Report	AI creates engaging, interactive learning content.
16		AI-Powered Question Generation	IBM Watson	2023	Industry Report	AI automates quiz and test development for teachers.
17		AI-Powered Virtual Classrooms	EdTech Research	2022	Conference Paper	AI enables real-time virtual classroom interaction.
18		Next-Gen AI Tutoring Systems	Pearson AI	2023	Case Study	AI enhances one-on-one tutoring experiences.
19		Future Trends in AI-Powered Learning	Google Brain	2024	Industry Report	AI will shape future education models.
20		Improving Student Retention with AI	DeepMind	2023	Journal Article	AI-based adaptive learning increases student retention.
21		Personalized Learning Through AI	FutureLearn	2022	Industry Report	AI optimizes individualized learning experiences.

Table 1: Contd...

S. No.	Theme	Article title	Author(s)	Year	Source type	Key findings
22		AI-Powered Writing Assistance for Students	Brown and Davis	2023	Journal Article	AI improves academic writing quality by assisting with grammar, coherence, and structure.
23	Tools used for Student and Classroom Support	AI in Automated Grading Systems	Singh and Lee	2020	Peer-Reviewed Journal	AI reduces grading workload and ensures fairness.
24		AI-Powered Assessment Tools	Gradescope Research	2023	Case Study	AI-based grading improves efficiency in large classes.
25		AI for Language Translation in Education	Torres et al.	2022	Journal Article	LLMs bridge language barriers for international students.
26		AI-Powered Translation for Academia	DeepL Research Team	2024	Industry Report	AI improves multilingual accessibility in digital learning.
27		AI-Driven Future of Learning	IBM Watson Education	2024	Industry Report	AI is transforming online and hybrid education.
28		AI Chatbots in Student Support	Stanford AI Lab	2023	Case Study	AI chatbots provide instant academic assistance.
29		AI Chatbots for Self-Guided Learning	Khan Academy	2023	Case Study	AI improves independent student learning.
30		Adaptive Learning Through AI	Coursera	2022	Industry Report	AI personalizes online learning pathways.
31		AI-Powered Skill-Based Learning	Udacity AI	2023	Journal Article	AI focuses on developing career-relevant skills.
32		Data Collection in AI-Powered Learning	Harvard AI Ethics	2022	Peer-Reviewed Journal	Ethical issues in AI-based student performance tracking.
33		Data-Driven Student Analytics	Google AI Research	2023	Industry Report	AI helps track student progress and predict outcomes.
34		AI-Based Speech Recognition for Accessibility	Wilson et al.	2022	Peer-Reviewed Journal	AI improves accessibility for students with speech or hearing impairments.
35		AI-Driven Classroom Behavior Monitoring	Roberts and Singh	2023	Industry Report	AI tracks student engagement and behavior in real-time, helping teachers adjust teaching strategies.
36		The Role of AI in Digital Libraries	Chang et al.	2024	Journal Article	AI streamlines research by curating and summarizing academic resources.
37		AI-Assisted Career Counseling	Patel and Kumar	2023	Conference Paper	AI-powered career guidance tools help students make informed decisions.
38		Smart Attendance Systems Using AI	Hernandez and Lopez	2022	Industry Report	AI automates student attendance tracking, reducing administrative workload.

Table 1: Contd...

S. No.	Theme	Article title	Author(s)	Year	Source type	Key findings
39		AI-Enhanced Peer Tutoring Platforms	Nakamura and Lee	2023	Journal Article	AI facilitates peer-to-peer learning by matching students based on skill levels.
40		AI-Powered Feedback for Student Assignments	Carter and Nguyen	2023	Peer-Reviewed Journal	AI provides instant, personalized feedback on student essays and assignments.
41	Challenges and Ethical Considerations	Bias in Large Language Models	Bender et al.	2021	Peer-Reviewed Journal	LLMs can reinforce biases in educational content.
42		Data Privacy in AI-Powered Education	Shah et al.	2022	Journal Article	AI raises concerns about student data privacy and security.
43		AI in Education: Global Perspectives	UNESCO Report	2023	Industry Report	Ethical AI deployment requires policy frameworks.
44		Challenges in AI Integration in Schools	Stanford AI Lab	2023	Case Study	High costs and infrastructure gaps hinder adoption.
45		The Risks of Over-Reliance on AI in Classrooms	Harvard EdX	2024	Journal Article	AI-generated content may weaken students' critical thinking skills.
46		Addressing AI Bias in Education	MIT AI Policy Group	2023	Peer-Reviewed Journal	AI bias can impact grading fairness and accessibility.
47		Fair AI for Education	OpenAI Ethics Team	2022	Industry Report	Bias mitigation strategies are needed for AI fairness.
48		Balancing AI and Human Instruction	FutureEd	2023	Peer-Reviewed J Journal	AI should supplement, not replace, teachers.
49		Algorithmic Fairness in Education	IBM AI Research	2024	Industry Report	AI fairness and transparency are crucial in education.
50		AI's Impact on Student Learning Autonomy	Google AI Ethics	2023	Industry Report	AI reliance could affect student independence.
51		Over-Reliance on AI in Academic Research	Jones and Patel	2022	Journal Article	Students may rely too heavily on AI-generated research insights.
52		Security Risks in AI-Driven Educational Tools	Singh et al.	2023	Conference Paper	AI tools pose cybersecurity threats to sensitive student data.
53		Ethical Concerns in Automated Grading	Li and Zhang	2023	Peer-Reviewed J Journal	Automated grading may introduce bias in assessment methods.
54		The Need for AI Governance in Schools	Torres et al.	2024	Industry Report	Institutional policies are required for responsible AI adoption.
55		AI Misuse and Plagiarism in Education	Miller and Chen	2023	Journal Article	LLMs increase the risk of academic dishonesty and plagiarism.

Source: Author only

Table 4: Comparison of student performance in AI-driven education

Semester	*Before LLMs (%)*	*After LLMs (%)*
Spring 2021	55%	60%
Fall 2021	58%	65%
Spring 2022	60%	70%
Fall 2022	63%	75%
Spring 2023	67%	80%
Fall 2023	72%	85%

Source: Author only

by 15 percent, as AI-based study tools were found to be effective. The findings suggest that LLMs are extremely effective in enhancing learning experiences by facilitating adaptive tutoring, automated testing, and AI-based study assistance. The effectiveness is, however, dependent on course design, educator engagement, and institutional policies. The findings indicate the growing significance of LLMs in education while prescribing responsible AI integration to ensure the maximum benefits of LLMs.

Risks and challenges involved in LLM implementation in education are illustrated in Table 5. The data was extracted from 15 articles focusing on AI risk, privacy, and institutional issues articles and policy brief lessons from UNESCO, Stanford AI Lab, and OpenAI Ethics Team. The findings reveal that concerns over data privacy (25%) and gaps in teacher training (22%) pose the greatest threat to AI adoption, followed by AI bias (20%), infrastructure limitations (18%), and students' over-reliance on AI-generated work (15%). The study identified issues that AI models can perpetuate biases, violate students' data privacy, and increase gaps in AI-enabled learning tool access.

Table 5: Challenges in of AI in education

Challenge	*Percentage (%)*
Data Privacy Concerns	25
Teacher Training Gaps	22
AI Bias	20
Infrastructure Gaps	1
Student Over-Reliance on AI	15%

Source: Author only

Additionally, teachers tend to lack the proper training to utilise AI to inform their instructional practices, contributing to unequal AI adoption across institutions. Literature also cautions against students' over-reliance on AI tools to compromise critical thinking and problem-solving skills unless used with adequate guidance. These issues highlight the importance of robust governance frameworks, teacher training programs, and ethical AI deployment models to ensure AI improves, not degrades, educational outcomes.

DISCUSSION

The findings of the study highlight the transformative role of LLMs in education focusing on applications and challenges. The discussion is structured based on the three key themes of analysis.

Large Language Models in Teaching and Learning

Thematic analysis of 22 articles comprehensively shows that LLM has significantly upregulated personalised learning, automated content generation, and adaptive assessments. Table 6 indicates that AI-powered tutoring systems, such as ChatGPT and Khanmigo, provide real-time student feedback and personalised study plans, leading to a 20 percent increase in student engagement. Similarly, the adoption of automated content creation tools like MagicSchool and Eduaide.ai has streamlined curriculum development, enabling teachers to generate lesson plans, quizzes, and assignments more efficiently. The primary design of the LLM model is illustrated in Figure 3. The procedure involves gathering textual data from multiple sources, preprocessing the text, training the LLM model, and producing an output. For initial processing, the text data is sent to the pre-processing stage. Subsequently, it proceeds through several stages of the model training process, beginning with initialising random parameters, supplying numerical data as input, computing the loss function, refining parameters, and engaging in iterative training. After that, it generates output for tasks like text summarisation, sentiment analysis, grammar and style checking, and translation services (Hu et al. 2024). The chronology of different LLM models is shown in Figure 4. Many academicians investigated the possibility of the LLM model in various NLP tasks

Table 6: Comparison of AI-powered educational tools

Tool name	*Primary function*	*Usage in education*	*Example institutions*
ChatGPT	AI-based tutoring	Provides personalized student support	Stanford, MIT
Gradescope	Automated grading	Assists educators in evaluating assignments	Harvard, UC Berkeley
Eduaide.ai	Lesson planning and content creation	Helps teachers generate quizzes, worksheets	K-12 Schools, Online Academies
DeepL	Language translation	Supports multilingual education	European Universities
Khanmigo	AI-powered learning assistant	Enhances student engagement through interactive lessons	Khan Academy
Perplexity AI	Research assistant	Summarizes articles and assists in academic writing	Academic Research Institutions

Source: Author only

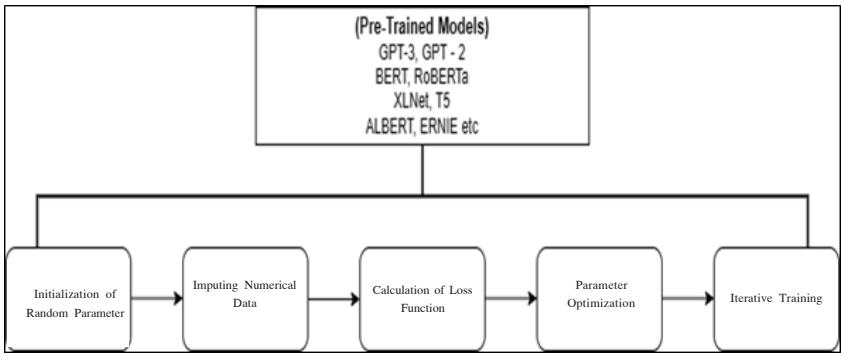

Fig. 3. Steps in pre-trained LLM Model
Source: Author only

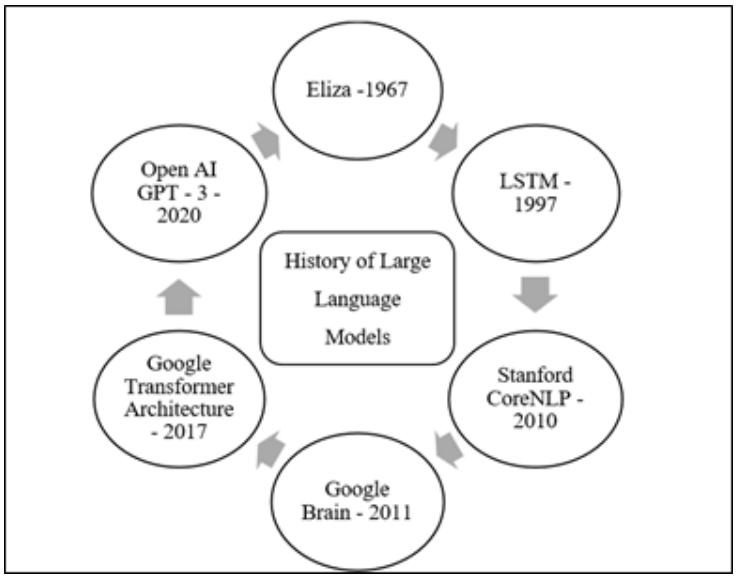

Fig. 3. Steps in pre-trained LLM Model
Source: Author only

in medical, health sciences, and political domains. Pre-training, fine-tuning, and multimodal models are the three categories under which the LLM models fall (Zhao et al. 2024).

Pre-trained Models

Larger data sets are used to train models like GPT-3/3.5, T5, and XLNet, which enable them to pick up on linguistic structures and trends. These models are quite good at creating coherent, grammatically correct writing on a variety of topics. They act as a basis for additional direction and task-specific fine-tuning (Jeong 2023).

Fine-Tuning Models

Three pre-trained and optimised models such as BERT, ALBERT, and RoBERTa are designed to complete a certain task using less data. These models perform exceptionally well in situations involving sentiment analysis, question answering, and text classification. They are often used in industrial environments where language models specific to a given activity are needed.

Multimodal Models

In models like CLIP and DALL-E, text is mixed with other modalities, including images or video, to create more complete language models. Because these models can understand the connections between words and visuals, they can generate images from textual descriptions or even provide text explanations of images.

Tools Used for Student and Classroom Support

Thematic analysis from 18 articles suggests the strong role of LLMs in enhancing classroom experiences, automating assessments, and improving multilingual accessibility (Table 6). LLMs integrated with generative AI are capable of generating new media files to enhance learning experiences. LLMs like ChatGPT use large datasets of text combined with artificial neural networks. It processes and generates text with billions of parameters. It is possible to obtain human-like responses upon entering arbitrary prompts in chat interfaces (Lee et al. 2024). LLMs assist teachers to develop, design and revise learning materials, helps in personalised learning and understands the learner's perspectives. It also enhances critical thinking and problem-based learning if utilised properly (Jost et al. 2024). The technical industry has created a plethora of commercial technologies to support LLM-based applications in academic settings. The tools can be divided into chatbots, instructional aids, quizzes, content generators, and teamwork tools. The following are the software applications that are currently being used in the field of education. Table 3 demonstrates some of the role of AI chatbots in educational applications.

Chatbot

A chatbot is a teaching tool that employs LLM and provides a number of benefits and potential. Based on responses, the LLM chatbot provides tailored help and feedback according to learners' needs. It enables the user to alter the learning environment to suit their preferences, learning styles, and learning pace. Jost et al. (2024) revealed that students can access it at any time, from anywhere, and it is available around-the-clock. Chatbots offer an interactive learning environment that enhances the enjoyment and engagement of learning. Given that chatbots are capable of handling hundreds of queries at once, they provide educational institutions with a scalable learning solution that supports a big number of students. This technology automates repetitive teaching tasks like quiz grading and basic feedback, freeing up teachers' time to focus on more complex and creative topics. A few e-chatbots that serve as examples are Pi.ai, ChatGPT, Google Bard, Perplexity, and Bing Chat.

Content Creation

Based on user input, Curipod generates an interactive slide deck that includes word clouds, polls, open-ended questions, and sketching tools (Haque and Li 2023). Users of the Diffit platform can access levelled information on any subject. It provides teachers with the tools to change pre-existing materials to meet the needs of every reader, offer original resources on any subject, and disseminate the contents to students. The purpose of MagicSchool, an LLM-powered educational platform, is to assist teachers save time by

automating tasks like lesson planning, grading, and content development. Access to more than forty AI tools organised into planning, productivity, community tools, and student assistance categories is provided. Keyword searches are available for these services. (Lorè and Heydari 2024)

Education Copilot (Wang et al. 2024) offers LLM-generated templates for a variety of educational needs, including lesson plans, writing prompts, handouts, student reports, project outlines, and much more, to make the preparation process for teachers easier. Eduaide.ai, an LLM-powered teaching assistant, was created to help teachers with lesson planning, instructional design, and content creation. With its resource generator, teaching assistant, feedback bot, and AI chat, it provides teachers with complete support. Lesson planning and other administrative tasks are also made easier for teachers, which enhances instruction. Content.ai is an LLM-powered writing tool that uses machine learning to create a range of text formats, including as emails, blog headlines, social media postings, and website content. Khanmigo is another LLM-powered learning platform that offers debate and virtual tours developed by Khan Academy (Wang et al. 2024).

Teaching Aids

gotFeedback allows instructors to quickly connect into the gotLearning platform so they can provide students with feedback right away. It is goal-referenced, concrete and transparent, actionable, user-friendly, timely, ongoing, and consistent in order to effectively meet students' requirements. Grammarly is an online writing program that helps students write well-written, comprehensible, and error-free content by utilising LLM (Shen et al. 2023).

Grammarly's artificial intelligence thoroughly reviews one's work to ensure that it is professional and polished by looking for mistakes in grammar, spelling, style, tone, and other areas. To help neurodivergent people to complete their tasks, Goblin Solutions offers a variety of simple, one-task solutions. These tools, which usually include Magic ToDo, Formaliser, Judge, Estimator, and Compiler, streamline routine processes to boost comfort and efficiency. Every tool has a distinct function. Users can engage with PDF documents with a conversational interface with ChatPDF (Shen et al. 2023), an application powered by LLM. This innovative approach simplifies navigation and interaction, making PDF content more approachable and user-friendly.

Quiz Generator

Von and Mayer (2023) reported that with QuestionWell, an LLM-based tool, educators may focus on what matters by creating an infinite number of questions. By using reading material to create critical questions, learning objectives, and related multiple-choice questions, artificial intelligence (AI) can speed up the process of developing educational materials and assessments. Formative AI (*Formative | Real-Time instruction* ND), a platform for tests and assignments that offered a range of question types, has enhanced its functionalities now that ChatGPT has been integrated. Using LLM's capacity to enhance learning outcomes and enable customised learning pathways, learners can now generate new standard-aligned questions, learner tips, and student feedback.

Quizizz AI (*Quizizz AI | Your personalized teaching assistant* ND) is an LLM-powered function that focuses on formulating multiple-choice questions. Depending on the supplied content, it can automatically calculate the number of questions to produce. Moreover, existing quizzes can be modified by Quizizz AI to customise the tasks to each student's unique requirements. Conker is an application that allows one to make read-and-respond, multiple-choice, and fill-in-the-blank quizzes on specific topics that are suitable for learners with varying skill levels. It also makes the efficient application of knowledge easier. To make lesson planning for English teachers easier, Twee is an LLM-powered tool that generates educational content such as questions, dialogues, stories, letters, articles, multiple choice questions, and true or false statements. Teachers can improve their lesson plans and engage students with this comprehensive support when they have an abundance of learning resources at their disposal (Von and Mayer 2023).

Collaboration Tool

Curipod (Marzuki et al. 2023), a software driven by ChatGPT, has the ability to compress any

long YouTube video, including speeches, live events, and official meetings. For use in the classroom, Parlay Genie creates higher-order thinking questions based on an article, YouTube video, or supplied topic. It makes use of ChatGPT's capabilities to offer engaging and thought-provoking conversations that motivate students to participate in lengthy discussions and exercise critical thinking.

Opportunities and Challenges of LLMs in Education

Generally speaking, Artificial Intelligence (AI) refers to algorithms that have been developed to replicate, extend, or replace certain aspects of human cognition or behaviour. Modern LLMs like ChatGPT, parse and generate text by combining artificial neural networks with billions of parameters with massive text datasets. With potential advantages, integrating LLM into education has downsides. Table 5 demonstrated the key Challenges of AI in Education. Data privacy issues (25%) and insufficient training of teachers (22%) are the greatest issues observed in AI integration into education. Most teachers do not possess the ability to effectively utilise AI tools, so there are sporadic adoption levels in organisations. Moreover, research cautions that AI models are capable of solidifying biases, as in the case of reported AI bias by Bender et al. (2021) on education material.

Furthermore, fears of AI over-reliance by students (15%) point to the danger of students becoming passive consumers of AI-provided content instead of acquiring problem-solving and critical thinking skills. Table 4 indicates that examination performance increased by 14 percent following AI uptake, but the long-term cognitive development implications remain unknown. The policies of the institutions need to be framed so that AI-enhanced learning is complemented with traditional pedagogy, whereby AI is a complementary system and not a substitute for human teaching.

Opportunities

Personalised Learning

As seen earlier, LLMs can come up with personalised content for the students to learn so that it becomes easier to manage the learning process and have an adaptive pathway. Individual student needs could also be met through the tutoring, which may include changing the level of task difficulty depending on the results obtained by students (Baker et al. 2019). In addition, as Holmes et al. (2021) pointed out that LLMs can also be employed for providing immediate feedback and formative assessments in that students can recognise concepts or ideas they do not understand hence enhancing learning.

Content Creation

Teachers can design the LLMs during the construction of lesson plans, as well as quizzes or exams so that they can save time on mundane chores. These models can easily create educational material, ranging from different topics in the sciences, with a lot of flexibility (Li and Li 2022). Also, LLMs are helpful in translating material to be used in education, ensuring that the information is understood by candidates without an understanding of the dominant language.

Automation of Administrative Tasks

In terms of efficiency or effectiveness, LLMs can partly handle administrative responsibilities by using time and effort saving tools like graders, schedulers, and reporters among others. This results in freeing the teachers' time so that they can spend the majority of their time delivering instruction rather than performing monotonous functions (Norris et al. 2020).

Support for Special Needs Education

This includes text-to-speech for students with reading disabilities, translation of sign language, and captioning them for videos. Through the application of this technology, learners who have difficulties in participating in certain educational activities can do so comfortably (Anderson 2020).

Challenges

Data Privacy and Ethical Concerns

In this respect, the following are the major challenges. The first one is the protection of stu-

dents' data privacy. Table 7 shows adoption barriers faced by educational institutions for AI-LLM implementation in education settings. These intricate models necessitate the analysis of an abundance of data to perform efficiently and this has prompted questions on how students' data is gathered, managed, and utilized (Shah et al. 2022). There are also some issues of ethical implications related to bias, since AI models tend to also extend and deepen existing biases (Bender et al. 2021).

Cost and Infrastructure

The concept of LLMs' application in educational systems are often most dependent on the sole technological platform, and there can be a problem of accessibility of this kind of support in various schools, especially when focusing on schools in developing countries or low-income areas. In addition, the cost incurred for running such models can be so expensive that it puts schools with limited budgets off (Lan et al. 2020).

Misuse and Dependence

Although LLMs can be valuable resources at their best, there can be the problem of misuse of the same. They may rely on generated contents and failure to the critical thinking and problem-solving skills that are supposed to be developed by the students. Sometimes, LLMs may produce wrong or misleading information that can be detrimental to the learning process provided they are not well monitored (Zellers et al. 2019).

Teacher Training and Acceptance

In order to help LLMs become a part of the education system, teachers have to be provided with learning on how they are supposed to apply the tools in their practice. Thus, apprehensiveness towards change, in combination with the absence of skills, can affect the implementation of LLMs in classrooms (Holmes et al. 2021).

CONCLUSION

Integration of LLM in education has revolutionised teaching and learning. Artificial intelligence-based platforms such as ChatGPT, Khanmigo, Gradescope, and Eduaide.ai are increasingly common in areas of personalised tutoring, computer-graded work, curriculum design, and translation. These platforms enable adaptive learning through real-time feedback and personalised learning plans for students. AI is increasingly being applied in schools to enhance administrative efficiency, maximise content creation, and enable learning among various student populations. Research findings indicate quantifiable student engagement, learning, and performance improvement through the use of LLM.

The study indicates 20 percent student engagement improvement, assignment completion rate from 70 percent to 90 percent, and recall of concepts from 60 percent to 80 percent. AI-based tools have also promoted better performance in exams and improved quality of research work. Besides, automated grading tools have allowed teachers to have less workload so that they can devote more time to interactive teaching and mentoring of students.

Despite these advancements, there are grave impediments to the mass application of LLMs in education. Data privacy concerns, AI bias, inadequate teacher upskilling, and infrastructure limitations remain critical issues. Organisations are imposing strict data governance policies, spending money on AI literacy training for teachers, and working towards more explainable AI models

Table 7: Adoption barriers of LLMs in educational institutions

Barrier	*Description*	*Percentage of institutions affected (%)*
High implementation costs	AI models require expensive infrastructure	40
Lack of teacher training	Educators need AI literacy programs	35
Data privacy concerns	Risks of student data misuse	30
Resistance to AI adoption	Traditional educators sceptical of AI tools	25
Dependence on AI responses	Over-reliance on AI-generated content	20

Source: Author only

to counteract these concerns. Inequities in access to AI-driven resources remain, and more policy interventions and technology innovations are needed to enable widespread equitable adoption through different educational institutions.

RECOMMENDATIONS

Educational institutions should establish systematic ways to ensure the responsible AI usage in education to achieve maximum potential outweighing its risks. Educator training courses need to be augmented to impart educators with AI literacy competencies that will enable them to seamlessly integrate LLMs into pedagogical practice. Institutions should incorporate strong data privacy practices to protect student data while addressing AI bias through ongoing training dataset improvement. Infrastructure upgrades are imperative to enable equal AI adoption, especially in under-funded schools. New policies should be developed to manage AI-generated content usage to prevent over-reliance on automated tools by students. Ongoing research and multilateral discussion among educators, technologists, and policymakers will be central to the development of an AI-based education system that enables improved learning experience while maintaining ethical and pedagogical requirements.

AUTHOR CONTRIBUTIONS

Author 1 conceptualised the study, designed the research framework, and conducted the literature review. She provided insights into the applications of large language models (LLMs) in education and identified key challenges in their integration. She led the data collection process, drafted the initial manuscript, structured the discussion, ensured alignment with the research objectives, and reviewed and refined the final version of the paper.

Author 2 assisted with data collection and synthesis, contributed to the development of the research methodology, and analysed trends in AI adoption. He also conducted the thematic analysis and interpretation of findings, contributed to writing and structuring the results and discussion sections, and reviewed and edited the manuscript for clarity, coherence, and academic rigour

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CONFLICT OF INTEREST

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REFERENCES

Anderson C 2020. AI and Special Needs Education: Transformative potential. *Educational Technology Research and Development*, 68(5): 1037-1050.

Awada G, Burston J, Ghannage R 2019. Effect of student team achievement division through WebQuest on EFL students' argumentative writing skills and their instructors' perceptions. *Computer Assisted Language Learning*, 33(3): 275-300. https://doi.org/10.1080/09588221.2018.1558254

Baker RS, Gowda SM, Corbett AT 2019. An analysis of how intelligent tutoring systems adapt to learners. *Journal of Educational Data Mining*, 11(1): 1-20.

Batool S, Rashid J, Nisar MW, Kim J, Kwon HY, Hussain A 2023. Educational data mining to predict students' academic performance: A survey study. *Education and Information Technologies*, 28: 905-971.

Bender EM, Gebru T, McMillan-Major A, Shmitchell S 2021. On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, Toronto, Canada, March 3 to 10, 2021, pp. 610-623.

Braun V, Clarke V 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2): 77-101. https://doi.org/10.1191/1478088706qp063oa.

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

Cui J, Li Z, Yan Y, Chen B, Yuan L 2024. Chatlaw: Open-source legal large language model with integrated external knowledge bases. *arXiv preprint*, arXiv:2306.16092.

Formative | Real-Time instruction (n. d.). From <https://www.formative.com/> (Retrieved on 5 June 2024).

Haque A, Li S 2023. The potential use of ChatGPT for debugging and bug fixing. *EAI Endorsed Transactions on AI and Robotics*, 2(1): e4. https://doi.org/10.4108/airo.v2i1.3276

Holmes W, Bialik M, Fadel C 2021. *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*. London: Centre for Curriculum Redesign.

Hohenstein J, Kizilcec RF, DiFranzo D, Aghajari Z, Mieczkowski H, Levy K, Naaman M, Hancock J, Jung MF 2023. Artificial Intelligence in Communication Impacts Language and Social Relationships. Scientific Reports, 13(1). From <https://www.nature.com/articles/s41598-023-30938-9> (Retrieved on 02 May 2024).

Hu B, Zheng L, Zhu J, Ding, L et al. 2024. Teaching plan generation and evaluation with GPT-4: Unleashing the potential of LLM in instructional design. *IEEE Transactions on Learning Technologies*, 1-15. https://doi.org/10.1109/tlt.2024.3384765

Jeong CS 2023. A study on the service integration of traditional Chatbot and ChatGPT. *Journal of Information Technology Application and Management*, 30: 11-28.

Jeong JH, Jeong CS 2022. Ethical issues with artificial intelligence (A case study on AI chatbot and self-driving car). *International Journal of Scientific and Engineering Research*, 1: 468-471.

Jošt G, Taneski V, Karakatic S 2024. The impact of large language models on programming education and student learning outcomes. *Applied Sciences*, 14(10): 4115. https://doi.org/10.3390/app14104115.

Lan J, Jin Z, Wang Y 2020. The economic impact of AI on educational systems. *Journal of Technology in Education*, 45(6): 334-347.

Lee J, Hicke Y, Yu R, Brooks C et al. 2024. The life cycle of large language models in education: A framework for understanding sources of bias. *British Journal of Educational Technology* [Preprint]. https://doi.org/10.1111/bjet.13505.

Li H, Xu T, Zhang C, Chen E, Liang J, Fan X, Li H, Tang J, Wen Q 2024. Bringing generative AI to adaptive learning in education. *arXiv preprint*, arXiv:2402.14601.

Li X, Li Y 2022. Applications of Generative Models in curriculum development. *Computers and Education*, 180: 104432.

Lorè N, Heydari B 2024. Strategic behavior of large language models and the role of game structure versus contextual framing. *Scientific Reports*, 14(1). https://doi.org/10.1038/s41598-024-69032-z.

Marzuki, Widati U, Rusdin D et al. 2023. The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective. *Cogent Education*, 10(2). https://doi.org/10.1080/2331186x. 2023. 2236469

Mohan GB, Kumar RP, Krish, PV Keerthinathan A et al. 2024. Correction: An analysis of large language models: Their impact and potential applications. *Knowledge and Information Systems* [Preprint]. https://doi.org/10.1007/s10115-024-02157-9

Norris D, Sullivan J, Reynolds, R 2020. AI tools for automating administrative tasks in education: A review. *Journal of Educational Technology and Society*, 23(4): 153-162.

Quizizz AI | Your Personalized Teaching Assistant (n.d.). From <Https://Quizizz.Com/Home/Quizizz-Ai.> (Retrieved on 4 May 2024).

Nowell LS, Norris JM, White DE, Moules NJ 2018. Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, 17(1): 1-13.

Sánchez-Díaz X, Ayala-Bastidas G, Fonseca-Ortiz P, Garrido L 2018. A knowledge-based methodology for building a conversational Chatbot as an intelligent tutor. *Advances in Computational Intelligence*, 165-175. https://doi.org/10.1007/978-3-030-04497-8_14

Shah N, Mishra P, Kalyani K 2022. Data privacy in AI-powered educational tools. *Computers in Human Behavior*, 129: 107124.

Shen Y, Heacock L, Elias J, Hentel KD, Reig B, Shih G, Moy L 2023. ChatGPT and other large language models are double-edged swords. *Radiology*, 307(2). https://doi.org/10.1148/radiol.230163

Snyder H 2019. Literature review as a research methodology: An overview and guidelines**.** *Journal of Business Research*, 104: 333-339.

Von GJ, Mayer J 2023. Artificial Intelligence in studies—use of ChatGPT and AI-based tools among students in Germany. *Humanities and Social Sciences Communications*, 10(1). https://doi.org/10.1057/s41599-023-02304-7

Wang S, Xu T, Li H, Zhang C, Liang J, Tang J, Yu PS, Wen Q 2024. Large language models for education: A survey and outlook. *arXiv:2403.18105* [cs.CL]. https://doi.org/10.48550/arXiv.2403.18105

Zellers R, Holtzman A, Bisk Y, Farhadi A, Choi Y 2019. Defending against neural fake news. *Advances in Neural Information Processing Systems*, 32: 9054-9065.

Zhao H, Chen H, Yan F, Liu, N et al. 2024. Explainability for large language models: A survey. *ACM Transactions on Intelligent Systems and Technology*, 15(2): 1-38. https://doi.org/10.1145/3639372.

Zhao WX, Zhou K, Li J, Tang T, et al. 2023 A Survey of Large Language Models. From <https://arxiv.org/abs/2303.18223> (Retrieved on 2 May 2024).

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