Exploring the Impact of ChatGPT on Scientific Research: Assessing Strengths, Weaknesses, Opportunities, and Threats

Yousef F. Alfarraj
https://orcid.org/0000-0001-7750-028X
Department of Curriculum and
Instruction, College of Education, the
Excellence Center of Science and
Mathematics Education (ECSME), King
Saud University, Saudi Arabia
yalfarraj@ksu.edu.sa

Yousef Wardat
https://orcid.org/0000-0003-2370-9808
Yarmouk University, Jordan
yousef.wardat@yu.edu.jo

Abstract

ChatGPT's adaptability spans various fields, notably scientific research. This research investigates the transformative possibilities of incorporating ChatGPT into scientific enquiry, employing a strengths, weaknesses, opportunities, and threats (SWOT) analysis to examine its merits and drawbacks. The analysis highlights the model's strengths, encompassing an extensive knowledge base, linguistic proficiency, information-retrieval capabilities, and continuous learning capacity. Conversely, it uncovers weaknesses such as a lack of contextual comprehension, potential dependence on training data, limitations in information verification, and constrained critical thinking abilities. Amidst these considerations, opportunities emerge, including support for literature reviews, fostering collaborative ideation, facilitating seamless language translation, interpretation, and enhancing knowledge dissemination. However, a range of threats looms, encompassing concerns about plagiarism, ethical dilemmas, the dissemination of misinformation, and the potential erosion of higher-order cognitive skills. These multifaceted elements warrant comprehensive examination. Recommendations for researchers incorporating ChatGPT advocate for a balanced approach that harmonises artificial intelligence with human creativity to maintain research integrity. The potential of ChatGPT to reshape scientific exploration hinges on judicious use and ongoing oversight.

Keywords: AI; ethics; artificial intelligence; ChatGPT; large language model; prompt engineering; scientific research; SWOT analysis

Introduction

In recent years, artificial intelligence (AI) has made significant strides in natural language processing (NLP), leading to the development of sophisticated language models capable of engaging in human-like conversations. One such model, the Chat Generative Pre-Trained Transformer, or ChatGPT, represents a groundbreaking AI-powered chatbot developed by OpenAI. ChatGPT has revolutionised human-machine interactions across various domains by leveraging advanced AI techniques to generate natural language responses based on given prompts (Chiu and Chai 2020).

The language capabilities of ChatGPT have proven invaluable in diverse fields due to its versatility and user-friendly conversational interface (Kuleto et al. 2021). Discussions about the economic impact of AI, including ChatGPT, have been prevalent, with increased activity observed in areas such as robotics shipments, AI startups, and patent counts (Alser and Weisberg 2023). This surge in AI adoption has elicited both enthusiasm about its potential for economic growth and concerns regarding its implications for human employment (Gibson, Obiakor, and Obi 2023).

In academia, technologies like large language models (LLMs) such as ChatGPT have found application in various tasks, including essay writing, speech composition, literature summarisation, and idea generation (Giray 2023; Rahman et al. 2023). Within academic research, scholars have explored AI's potential in data processing, with studies suggesting that ChatGPT could replace search engines and facilitate accurate information retrieval for students (Wardat et al. 2023).

It is important to recognise that the historical context and evolution of ChatGPT play a significant role, especially in the context of the so-called Fourth Industrial Revolution. This revolution, characterised by the fusion of digital, physical, and biological technologies, has seen AI emerge as a driving force behind transformative changes in various industries (Schwab 2017). By delving deeper into the historical assessment and contextualisation of ChatGPT within the framework of the Fourth Industrial Revolution, we aim to provide readers with a comprehensive understanding of its emergence and impact on scientific research. This expanded historical assessment enables us to grasp the broader implications of ChatGPT within the context of technological advancements and societal transformations.

However, it is important to acknowledge that the wholesale adoption of certain analytical techniques, such as the SWOT analysis employed in our study, may not align with the preferences of all academics, particularly in social science and humanities disciplines. Critics argue that SWOT analysis oversimplifies complex issues, lacks theoretical grounding, and may lead to superficial conclusions (Kalla and Smith 2023). Therefore, we have included a section discussing the criticisms against the use of SWOT

analysis in research within these fields. This addition aims to provide a balanced perspective on the methodology employed in our study and to address concerns regarding its applicability in diverse academic contexts.

Amidst the impressive contributions of AI to scientific research, ethical considerations have emerged as a crucial point of discussion. Issues such as privacy, surveillance, bias, discrimination, and the philosophical implications of human judgement are among the legal and ethical challenges posed by AI. Plagiarism, traditionally defined as the unauthorised or unacknowledged use of other people's ideas, has taken on new dimensions with the advent of AI. Cotton, Cotton, and Shipway (2023) argue that AI-generated content, even when compiled from various sources, should not be equated with classic plagiarism.

Some scholars, such as Jarrah, Wardat, and Fidalgo (2023), advocate for establishing guidelines on the use of platforms like ChatGPT in scientific publishing. They emphasise the importance of assessing the accuracy and reliability of AI-generated information. Many researchers believe that when used appropriately, AI can serve as a powerful tool for information gathering while upholding academic integrity. This study aims to explore the strengths, weaknesses, opportunities, and threats associated with using ChatGPT in academic research, shedding light on its implications for modern research practices.

Historical Assessment and Contextualisation of ChatGPT within the Fourth Industrial Revolution

To understand the significance of ChatGPT within the context of the Fourth Industrial Revolution, it is essential to trace its historical development and to examine its role in shaping contemporary technological advancements. The Fourth Industrial Revolution, characterised by the fusion of digital, physical, and biological technologies, has ushered in an era of unprecedented connectivity and automation. Within this framework, ChatGPT represents a milestone in the evolution of artificial intelligence, particularly in the domain of natural language processing.

ChatGPT's origins can be traced back to the development of deep learning techniques and neural network architectures in the late 20th century. Breakthroughs in machine learning, fuelled by advances in computational power and data availability, paved the way for the emergence of sophisticated language models capable of generating human-like text. OpenAI's development of the GPT (Generative Pre-trained Transformer) series, culminating in ChatGPT, signifies a paradigm shift in AI research, moving towards large-scale pre-training and fine-tuning approaches.

Within the context of the Fourth Industrial Revolution, ChatGPT represents a convergence of AI, big data, and cloud computing technologies, enabling scalable and accessible AI-driven solutions. Its ability to understand and generate natural language responses has implications for various sectors, including healthcare, finance, education,

and scientific research. By contextualising ChatGPT within the broader trajectory of technological innovation, we can appreciate its transformative potential in reshaping human-machine interactions and knowledge dissemination in the digital age.

Whose Interests Are Being Served by the Acceptance of ChatGPT in Scientific Research on a Global Scale?

The acceptance of ChatGPT in scientific research on a global scale raises questions about the interests served by its widespread adoption. Various stakeholders stand to benefit from the integration of ChatGPT into research practices, each with their own motivations and objectives:

1. Technology Companies: Technology companies that develop and commercialise AI technologies, such as OpenAI, stand to gain financially from the widespread adoption of ChatGPT. Increased usage of ChatGPT in scientific research expands the market for AI products and services, driving revenue growth and market competitiveness.

2. Academic Institutions: Academic institutions benefit from the integration of ChatGPT into research processes, as it enhances research productivity and efficiency. ChatGPT can streamline data analysis, literature reviews, and idea generation, enabling researchers to conduct studies more effectively and publish findings more rapidly.

3. Researchers: Individual researchers benefit from the assistance provided by ChatGPT in various aspects of the research process. ChatGPT can help researchers explore new research avenues, generate novel hypotheses, and collaborate more effectively with colleagues, thereby enhancing research outcomes and impact.

4. Broader Society: The acceptance of ChatGPT in scientific research has broader societal implications, as it contributes to scientific advancements and innovation. By facilitating knowledge discovery and dissemination, ChatGPT can accelerate progress in diverse fields, ultimately benefiting society as a whole.

However, alongside the potential benefits, there are also concerns about the interests served by the acceptance of ChatGPT in scientific research. These concerns include issues related to data privacy, intellectual property rights, employment displacement, and equity in access to AI-driven research tools. Therefore, it is essential to critically assess the implications of ChatGPT adoption and to ensure that its benefits are equitably distributed across society while addressing ethical and societal challenges posed by its integration into scientific research practices.

Study Purpose

The research aims to investigate the transformative possibilities of integrating ChatGPT into scientific research, employing a comprehensive SWOT (strengths, weaknesses, opportunities, and threats) analysis. The study seeks to examine ChatGPT's merits and drawbacks in the context of scientific enquiry, highlighting its strengths, such as an extensive knowledge base and linguistic proficiency, while addressing weaknesses like contextual comprehension limitations and potential dependence on training data. Opportunities, including support for literature reviews and collaborative ideation, are explored, along with threats such as plagiarism, ethical dilemmas, and the erosion of higher-order cognitive skills. The purpose is to provide researchers with insights into the balanced use of ChatGPT in conjunction with human creativity to maintain research integrity. The study also acknowledges the ethical considerations about AI contributions to scientific research, emphasising the need for guidelines and assessments of accuracy and reliability in AI-generated information. Overall, the research aims to shed light on the implications of ChatGPT for modern research practices in academia.

Research Questions

1. What are the strengths and weaknesses of ChatGPT when applied to scientific research, focusing on its knowledge base, linguistic proficiency, contextual comprehension, and critical thinking abilities?

2. In what ways can ChatGPT contribute positively to scientific research, including opportunities for supporting literature reviews, fostering collaborative ideation, and facilitating language translation and interpretation?

3. What potential threats and challenges does ChatGPT pose to scientific research, particularly in terms of issues such as plagiarism, ethical dilemmas, the dissemination of misinformation, and the impact on higher-order cognitive skills?

4. How can ethical guidelines and measures be established to ensure the responsible and accurate use of ChatGPT in scientific publishing, and to what extent do researchers believe in the ethical and reliable application of AI in information gathering for academic purposes?

Study's Significance

The significance of this study lies in its comprehensive exploration of the integration of ChatGPT in scientific research, specifically delving into its strengths, weaknesses, opportunities, and threats. As ChatGPT becomes increasingly prevalent in academic settings, understanding its multifaceted implications is crucial for researchers, educators, and policymakers alike.

The study aims to contribute insights into the transformative possibilities that ChatGPT offers to the scientific community. By systematically examining its strengths, the research seeks to highlight the model's potential contributions, such as its extensive knowledge base, linguistic proficiency, and information-retrieval capabilities. Identifying weaknesses, including limitations in contextual comprehension and critical thinking, provides researchers with a nuanced understanding of ChatGPT's current limitations.

The exploration of opportunities, such as supporting literature reviews and enhancing collaborative ideation, is significant for researchers looking to harness the model's capabilities for improved efficiency and innovation. Simultaneously, the study addresses potential threats, such as plagiarism, ethical dilemmas, and the risk of eroding higher-order cognitive skills, offering a balanced perspective on the challenges associated with ChatGPT.

Moreover, the study delves into the ethical considerations of AI in scientific research, recognising the growing importance of addressing issues related to privacy, bias, and the philosophical implications of human judgement. By examining the ethical landscape, the research contributes to the ongoing discussions about responsible AI use in academic contexts.

In summary, the significance of this study lies in its holistic analysis of ChatGPT's impact on scientific research, offering a nuanced understanding of its capabilities, limitations, and ethical considerations. This knowledge can guide researchers and stakeholders in making informed decisions about the integration of AI models such as ChatGPT in academic practices.

Methodology

This study adapts the SWOT analysis methodology, drawing inspiration from its successful application in educational practice and research. Our focus is on assessing the appropriateness of ChatGPT within the realm of scientific research.

SWOT analysis is a strategic planning tool used to identify and analyse the internal and external factors that can impact a project or organisation. It stands for strengths, weaknesses, opportunities, and threats.

SWOT analysis is particularly suitable for this study due to its comprehensive nature and its ability to provide a structured approach to evaluating complex interactions and potential outcomes. By systematically categorising the various aspects of ChatGPT's integration into scientific research, SWOT analysis helps to uncover both positive and negative factors that can influence its effectiveness.

Using the well-established SWOT framework, our primary goal is to evaluate the strengths, weaknesses, opportunities, and threats associated with integrating ChatGPT

into scientific research. Employing SWOT analysis aligns with its strategic application in academic literature and its historical significance as a method for examining strategies. This study builds on the work of Farrokhnia et al. (2023), Benzaghta et al. (2021), and Tashtoush et al. (2023). It aims to explore the unique nuances of incorporating ChatGPT into scientific research.

Through this methodological approach, we aim to understand the potential advantages and challenges that arise when ChatGPT becomes an integral part of scientific research practices. Adopting the SWOT analysis framework allows us to systematically explore and analyse various facets, providing valuable insights into the dynamic relationship between ChatGPT and the complexities of scientific research.

Figure 1: SWOT analysis of using ChatGPT in scientific research

Literature Search Strategy and Data Collections

An exhaustive and methodical examination of electronic databases was conducted, with a focus on Google Scholar, Science Direct, and Scopus due to their comprehensive coverage of educational and AI-related literature (Pinzolits 2024; Tlili et al. 2022, 2023b). Additionally, specialised scientific journals in pedagogy and artificial

intelligence were reviewed. These journals, such as the *Journal of Applied Learning and Teaching*, *International Journal of Artificial Intelligence in Education*, *Education and Information Technologies*, *Computers and Education*, *Artificial Intelligence Review*, and *Smart Learning Environments*, were chosen for their specific emphasis on AI and education or special editions focusing on AI tools and pedagogy. The search time frame for articles ranged from 2018 to 2023. Online sources and blogs were also included in the review to ensure access to state-of-the-art information on AI and pedagogy. Only articles published in English related to AI tools and chatbots in education and research were considered.

The keywords utilised during the literature search encompassed terms such as "AIEd", "chatbots in education", "AI tools for education", "ChatGPT in education", "AI-assisted learning", "personalised learning", and "learning technologies". These keywords were employed individually and in various combinations during the search to maximise the breadth and depth of the results (Pinzolits 2024).

Figure 2: Results of keyword co-occurrence analysis (Source: Authors, using VOSviewer Software)

Results and Discussion

This section explores the strengths, weaknesses, opportunities, and threats linked to the utilisation of ChatGPT, an AI language model, in the context of scientific research. Our

aim is to thoroughly examine the diverse facets of integrating ChatGPT into scientific research, facilitating an assessment of both the potential benefits and challenges that researchers may confront when incorporating this AI tool.

Strengths

ChatGPT's Proficiency in Vast Knowledge

ChatGPT boasts a comprehensive training on a diverse array of text sources and prompts, endowing it with the capability to furnish information and insights on a wide spectrum of academic subjects. Its extensive knowledge base allows ChatGPT to offer researchers pertinent and current information from the vast expanse of the World Wide Web, incorporating it into its extensive repository. Experts highlight that leveraging ChatGPT can expedite the extraction of key points and the essence of intricate research topics, streamlining the process of constructing literature reviews for scientific endeavours (Jarrah et al. 2022; Kalla and Smith 2023). This underscores ChatGPT's capacity to swiftly provide targeted information tailored to the specific requirements of a given undertaking.

In a firsthand account, Zhai (2022) shares his experience with ChatGPT, affirming that the AI can assist researchers in generating articulate, partially accurate, informative, and systematic articles. Notably, the efficiency of the writing process is highlighted, with completion times as short as two to three hours and minimal author input in terms of professional knowledge. Such user experiences illuminate the potential impact of ChatGPT and analogous AI tools on educational processes.

As an AI, ChatGPT is designed to respond to user queries, continuously learning and adapting to more complex systems and updates to better comprehend user needs (Roumeliotis and Tselikas 2023). However, it is crucial to acknowledge certain limitations. Despite its ability to generate accurate information, ChatGPT's knowledge base, while extensive, may not cover every detail in specialised or niche areas. The absence of emotional intelligence, potential bias, and a dependence on specific prompts may restrict its ability to provide nuanced or highly specialised insights. Addressing these limitations may require fine-tuning the model to cater more precisely to user needs and specific fields (Hidayat and Wardat 2024; Stojanov 2023).

Linguistic Prowess

ChatGPT demonstrates an impressive level of language proficiency, offering significant advantages in crafting sophisticated language for scientific research. Its adeptness in comprehending and generating human-like text encompasses a diverse vocabulary, varied grammar structures, and natural conversational patterns. This proficiency allows ChatGPT to engage in intricate conversations, aiding researchers and scholars in navigating complex research queries across diverse fields and domains. This proficiency is notably highlighted in a scientific research endeavour conducted by Gilson et al. (2023), where ChatGPT showcased marked improvements in medical question-

answering tasks within natural language processing models. The study also emphasised ChatGPT's ability to provide logical and contextual information across a range of answers, showcasing its versatility in such undertakings.

Additionally, Bin-Hady et al. (2023) emphasise the contribution of ChatGPT in improving language proficiency among learners. The model serves as a scaffold in the learning process, providing feedback on language usage, and engaging as an interactive partner in language practice by suggesting relevant activities. The findings from their research contribute to the development of a comprehensive five-dimensional model for artificial intelligence-assisted language learning (AIALL). This model advocates for a flexible teacher's role, encourages learner autonomy, aims to create enjoyable learning experiences, supports future innovation, and facilitates diverse applications.

These insights collectively present a compelling case for ChatGPT's potential applications as an interactive medical and educational tool to support learning. In a globalised world where language barriers can impede effective communication and collaboration, ChatGPT's language translation capabilities emerge as invaluable. It facilitates quick translation between languages, enabling scholars and academics to seamlessly engage with stakeholders, partners, and colleagues. Additionally, ChatGPT can function as a language learning tool, offering vocabulary suggestions, grammar explanations, and language practice exercises, thereby contributing to the development of credible academic research.

Information Retrieval

Another noteworthy feature of ChatGPT is its efficient information retrieval and potential for personalisation. It can swiftly extract relevant information from its extensive training data, encompassing a vast array of books, articles, and websites. This capability holds the promise of saving researchers time and effort, as ChatGPT can learn from user behaviour and preferences, adapting search results to individual needs. This personalised approach enhances the user experience, providing results that closely align with their interests and requirements, enabling rapid information retrieval without the need for direct access to external sources or the internet. Chubb, Cowling, and Reed (2022) further elaborate in their study that AI has the potential to relieve researchers and institutions from mundane tasks, saving time and potentially boosting speed and efficiency in a market-driven university environment.

In recent advancements, Shidaganti et al. (2023) explore ChatGPT's ability to retrieve information from images using robotic automation process (RPA) and optical character recognition (OCR). According to their study, ChatGPT can process WhatsApp images containing text by converting them into text-based prompts. This suggests that the AI can recognise and convert text from various sources and mediums, enabling users to precisely search for information needed in their academic pursuits. Furthermore, Nandalwar et al. (2023) note that OCR and RPA can automate data extraction from various sources and images, expediting data gathering and processing. However, they

also caution that OCR accuracy may vary based on factors such as image quality, text clarity, font styles, or language variations. Errors in OCR output can impact the accuracy of information provided to ChatGPT, and OCR may encounter challenges with handwritten text recognition, especially if the handwriting is difficult to decipher.

Continuous Learning

While inherently limited in its standalone capabilities, ChatGPT offers users the capability to fine-tune the AI for specific academic and professional domains, enhancing its specialisation and proficiency in delivering domain-specific knowledge and insights. Through the fine-tuning process, users can customise ChatGPT's behaviour for specific applications or domains such as customer support, content generation, abstract modelling, medical applications, infrastructure, economy, education, and scientific research. This adaptability allows users to leverage the continuous learning process, benefiting from regular updates and newer versions of AI models that incorporate the latest advancements and improvements.

As newer versions of the language model are released, users gain access to the latest information and experience improved performance. This adaptability allows users to customise the model's behaviour and responses to meet specific goals and the needs of their organisation or project. Despite being relatively new, ChatGPT has demonstrated potential in the field of mathematics education, enhancing math capabilities and contributing to educational success by imparting fundamental knowledge in the subject (Wardat et al. 2023). Positive public sentiments on social media further reflect enthusiasm for ChatGPT's application in teaching mathematics and educational contexts (Gningue et al. 2022).

The context of language learning emphasises ChatGPT's support in establishing reliable connections. The AI can discern word meanings in context, correct and explain language errors, generate texts in various genres (e.g., emails, stories, recipes), create quizzes, annotate texts, and offer dictionary definitions, example sentences, and translations. This multifaceted functionality positions ChatGPT as a versatile tool applicable to diverse aspects across different domains.

Weaknesses

Challenges in Contextual Understanding

While ChatGPT demonstrates significant potential in generating human-like responses and aiding in various tasks, it does have limitations. One of its notable capabilities is the ability to assess manuscripts for grammar, spelling, and punctuation errors. However, challenges arise when it comes to understanding complex, context-specific information or nuanced topics, leading to potentially inaccurate or incomplete responses. The contextual understanding of ChatGPT relies solely on two sources: user input and its training data (Alneyadi and Wardat 2023).

By amalgamating the user's input and its training data, ChatGPT endeavours to interpret context and generate an appropriate response. However, it is important to recognise that ChatGPT's contextual understanding is confined to what it has learned from its training data. Consequently, if a prompt contains data or references beyond the scope of its training, ChatGPT may struggle to accurately comprehend the context. This makes it unreliable in interpreting meanings and understanding queries, introducing limitations in its overall performance (Strubell, Ganesh, and McCallum 2019).

A recent investigation underscores the limitations of ChatGPT in clinical settings, emphasising its inability to proficiently review scientific content or methods and make ethical and moral judgements (Ufuk 2023). While it may offer a decent overview or generate initial ideas (Rahman et al. 2023), this proves insufficient in critical assessments because ChatGPT can be unreliable in fully grasping the fundamental ideas behind domain-specific concepts.

Consequently, researchers are cautioned to exercise caution when working with ChatGPT. While it can be a valuable tool, it should not be solely relied upon, especially for critical evaluations. ChatGPT should be considered a supplementary resource rather than a definitive authority, as its limitations in fully comprehending and analysing complex information need to be taken into account (Alneyadi et al. 2023).

Training Data Reliance

The issue of overreliance on training data emerges as a critical concern in the operation of AI language models such as ChatGPT. These models generate responses based on extensive and diverse training data, but a significant problem arises when these responses become excessively dependent on the patterns and information present in the training data. The potential pitfalls of this overreliance are considerable. If the training data contains biases or inaccuracies, these flaws can inadvertently persist in the AI's generated responses. This could lead to a mix of factual information and fabricated content, blurring the line between reality and misinformation. Such a situation not only undermines the credibility of the AI but also poses risks, especially in scenarios where accurate information is crucial.

Furthermore, an overreliance on training data can contribute to the amplification of biases and stereotypes. Language models may inadvertently learn and reproduce biases present in the data, resulting in biased comments and the perpetuation of stereotypes, particularly those associated with specific demographics (Kasneci et al. 2023). The AI's inability to discern reliably sourced information from distorted data further complicates the matter, highlighting that despite its impressive capabilities, the AI lacks the nuanced skill of independently distinguishing misinformation from accurate data (Dale 2021).

Given these limitations, a crucial question arises regarding whether AI language models can be considered fully dependable sources of credible information. As of now, the answer leans towards caution. While AI models such as ChatGPT can offer valuable

insights and assistance, they should ideally be supplemented with human oversight. Relying solely on these models, without the critical evaluation and monitoring performed by humans, may lead to the propagation of inaccuracies and biases.

Information Verification

A significant drawback of ChatGPT is its inability to independently fact-check or validate the information it provides, potentially leading to the dissemination of incorrect or unreliable information. This limitation arises from ChatGPT's training data, which is confined to familiar information. Consequently, when queried about well-known personalities, for example, it tends to return true or seemingly credible information. However, when faced with questions about lesser-known individuals, it often provides various, and often inaccurate, answers. This incapacity to self-validate information makes ChatGPT susceptible to inadvertently propagating "fake news". Individuals lacking knowledge on a particular subject may unwittingly accept the false information generated by ChatGPT.

When unable to verify information, ChatGPT resorts to guessing or producing seemingly convincing yet entirely fabricated answers. A notable example is its generation of fake but believable scientific research abstracts (Gao, Wang, and Hou 2023), sometimes incorporating fake research gaps with fabricated references (Rahman et al. 2023). This practice is unethical as it involves manipulating information by presenting fabricated data as truth to unsuspecting individuals.

Even experienced researchers and editors may struggle to discern the accuracy of ChatGPT's information, questioning the integrity of relying on its provided information without scrutiny. Additionally, ChatGPT's inability to verify responses raises ethical concerns, such as the potential spread of derogatory, inappropriate, or harmful speech (Chowdhury and Rahman 2023). Moreover, some users can exploit or find loopholes in ChatGPT's ethical guidelines, forcing it to return malicious results. This raises concerns about the safety of the general public's use of ChatGPT, as it can provide information that jeopardises their well-being.

Limited Critical Thinking

ChatGPT lacks true understanding or critical thinking abilities as it generates responses based on statistical patterns, often lacking deeper analysis or critical evaluation of the given topic. This absence of true understanding stems from the model's lack of consistent access to credible real-world data and the absence of direct regulation or monitoring from human experts. While it can participate in ongoing scientific conversations to some extent, its responses may lack substance or depth. When presented with a query, ChatGPT analyses the input and generates a response based on recognised patterns in the training data, without engaging in critical evaluation or deeper analysis.

True critical thinking involves actively questioning, analysing, and evaluating information, drawing logical connections, identifying biases, and considering multiple perspectives. It requires a deep understanding of the subject matter, the ability to assess evidence, and the application of reasoning to form informed judgements. However, ChatGPT lacks the capacity to engage in these cognitive processes. Many experts emphasise the need to use ChatGPT cautiously and responsibly as a tool, not as a substitute for human thinking. It should not be entrusted with the role of doing the thinking for researchers.

Although ChatGPT is recognised as a tool capable of enhancing research, improving efficiency, and refining writing styles across various disciplines (Azaria, Azoulay, and Reches 2023), it struggles to provide refined input on a wide array of topics. Its responses are limited by the fact that it essentially regurgitates previously consumed data without true critical thinking capabilities. This limitation can be projected onto users, particularly those heavily reliant on ChatGPT for education, potentially stifling the creative mindset of learners if used incautiously (Opara, Mfon-Ette Theresa, and Aduke 2023).

Opportunities

A Review of Contributions in Literature

ChatGPT proves valuable in aiding researchers with literature reviews by swiftly identifying relevant articles, summarising key findings, and suggesting related research areas. In a scientific article by Alkaissi and McFarlane (2023), ChatGPT demonstrated the ability to "generate factually correct scientific writing", providing brief yet accurate paragraphs detailing essential aspects of the mechanism of homocysteine-induced osteoporosis. Currently, ChatGPT excels at producing reliable overviews on a broad range of topics, establishing itself as a valuable resource for sourcing initial ideas.

This capability is particularly beneficial in academic writing as an organisational tool. ChatGPT can create bullet points and concise notes derived from references in disorganised literature reviews, transforming them into a linguistically coherent text. Moreover, ChatGPT proves useful in references and citation sorting and management, identifying recurrent information in a given text. This functionality is crucial for academic researchers aiming to avoid redundant references.

Beyond summarising existing research, ChatGPT excels in suggesting related research areas based on its training data. By providing the model with a summary of their work or key concepts, researchers can prompt ChatGPT to generate suggestions for potential research directions, emerging trends, or related topics. This feature empowers researchers to explore new avenues and identify gaps in the existing literature.

Manually searching through databases and reading abstracts to find relevant articles can be time-consuming. ChatGPT streamlines this process—researchers can input specific

keywords or research questions, and the model generates a list of relevant articles, potentially saving significant time and effort. This streamlining of the editing and academic writing process allows researchers to organise their thoughts more efficiently and focus on the bigger picture of their research.

Collaborative Brainstorming

Researchers can effectively leverage ChatGPT to facilitate brainstorming sessions, generating ideas and exploring diverse perspectives on research problems. ChatGPT possesses the capability to provide its insights on a wide range of topics. To maximise this feature, researchers are advised to provide open and vague prompts, avoiding excessive specificity to prevent ChatGPT from struggling. The results obtained can then serve as a foundation for collaborative brainstorming sessions with peers, building upon the initial ideas generated by ChatGPT.

During a brainstorming session, researchers input their research problems or questions into ChatGPT, which, based on its training data and learned patterns, generates a variety of ideas and potential solutions. This process enables researchers to break free from conventional thinking, exploring novel approaches and alternative viewpoints that may not have been considered before.

Rudolph, Tan, and Tan (2023) emphasise ChatGPT's potential in facilitating collaborative group activities, particularly among students. The model can generate different scenarios serving as discussion prompts for student groups. This structured framework enhances group discussions and debates, enabling students to explore various perspectives and engage in problem-solving activities. Integrating ChatGPT into group activities provides real-time feedback and personalised guidance. As students participate in discussions, ChatGPT analyses their input and generates responses offering insights, suggestions, or further questions to deepen the conversation. This real-time feedback enhances students' argument refinement, consideration of alternative viewpoints, and development of critical thinking skills.

Similarly, ChatGPT's use in small-group discourse has shown positive effects on student learning. According to Gilson et al. (2023), incorporating ChatGPT into problem-solving activities improves the quality of discussions among students. The model's ability to generate diverse scenarios and prompt various perspectives contributes to more comprehensive and insightful conversations, fostering deeper understanding, knowledge retention, and collaborative problem-solving skills.

Language Translation

ChatGPT proves to be a valuable tool in translating research articles or text passages from one language to another, enhancing accessibility and collaboration across linguistic boundaries. Studies, including research by Bang et al. (2023), have demonstrated the effectiveness of ChatGPT in translating simple text, including non-

Latin script languages. It has been observed to expedite the translation process and exhibit good results in spoken language, comparable to commercial translation products and even surpassing professional systems in terms of efficiency and consistency of results (Gao, Wang, and Hou 2023; Jiao et al. 2023).

Regulated and monitored by human translators during the translation process, ChatGPT has shown promising results in comprehending high-resource languages and outperforming professional translation systems. Its ability to understand and generate coherent translations across different writing systems makes it a versatile resource for researchers and individuals working with various languages. The speed at which ChatGPT can generate translations is a notable advantage, saving time and effort in cases where prompt translations are required, such as article reviews, collaboration with international colleagues, or accessing research from different language sources.

ChatGPT's role in translation processes is recognised as an emerging trend in machine translation, particularly in stylised machine translation, interactive machine translation involving user participation, and self-evaluation of language translation output (Lyu, Xu, and Wang 2023). Its potential in these areas makes it a promising tool for researchers seeking efficient and reliable language translation solutions.

Knowledge Dissemination

ChatGPT can serve as a valuable tool for developing educational materials, interactive tutorials, and virtual teaching assistants, enhancing the learning experience in academic settings. Research by Kung et al. (2023) highlights that ChatGPT can effectively handle complex medical and clinical information, demonstrating knowledge comparable to that of human subject-matter experts. In scenarios such as the United States Medical Licensing Examination, ChatGPT performed at or near the passing threshold without specialised training, showcasing consistency and insightfulness in its responses. This suggests significant potential for the application of large language models in medical education and clinical decision-making.

Furthermore, ChatGPT, as an AI model, inherently aims to develop intelligent systems that learn, show, explain, and advise users with human-like comprehension, traits, and abilities (Chinonso 2023). With further developments, ChatGPT is expected to identify gaps in the teaching-learning process accurately and efficiently, contributing to overall improvements in education systems. Integration of AI such as ChatGPT in the classroom is predicted to enhance the teaching-learning experience for both educators and students, offering tailored instruction for individual learners, facilitating self-paced, active learning, providing unparalleled access to education, and improving decision-making and responses to educational queries and instructions (Jain and Jain 2019; Kengam 2020; Van der Vorst and Jelicic 2019).

Threats

Plagiarism

Concerns about plagiarism surrounding ChatGPT and other language models have gained prominence due to the ease with which individuals can copy or paraphrase generated content without proper attribution. The temptation for researchers to use ChatGPT's responses directly without acknowledging the source poses potential plagiarism issues (Simpson 2023).

Plagiarism using ChatGPT can manifest in different forms. Firstly, researchers may directly copy the generated text without making any modifications or providing proper attribution, presenting someone else's work as their own. Another form involves paraphrasing the generated text without appropriate citation. Santra and Majhi (2023) emphasise that even if the wording is altered, the use of the original ideas and structure without crediting the language model still constitutes plagiarism.

Addressing plagiarism concerns related to AI-generated text poses challenges for traditional plagiarism detection tools, which rely on syntactic similarity. Due to differences in syntax and structure between machine-generated and human-written content, these tools struggle to detect AI-generated plagiarism (Santra and Majhi 2023). Moreover, Khalil and Er (2023) highlight the difficulty popular plagiarism detection tools face in determining the originality of essays generated by ChatGPT, showcasing its potential to produce sophisticated and highly original outputs.

Plagiarism concerns with ChatGPT can have severe consequences in the publication process. Researchers may exploit ChatGPT to input content from another researcher's work, using the paraphrase function to create seemingly new content. This strategy may be employed in submitting articles to predatory journals with lax peer-review processes, contributing to the dissemination of plagiarised or low-quality research. This undermines the credibility of the scientific publishing system and fosters the spread of misleading or unreliable information.

Ethical Dilemmas

The integration of AI into scientific research raises ethical concerns related to data privacy, consent, and potential biases. Data privacy becomes a significant issue in the use of ChatGPT, as it heavily relies on diverse datasets that may inadvertently include personal and sensitive information, posing a risk to individuals' privacy. Recent incidents at companies such as Samsung and Apple, where ChatGPT usage was restricted due to unintentional exposure of sensitive information, underscore the importance of safeguarding data privacy (Onat and Gulsecen 2023).

Obtaining informed consent is a complex ethical consideration in AI-driven research. While ChatGPT is trained on datasets, the original authors or contributors might not have explicitly consented to their content being used for AI model training. Upholding

principles of informed consent is crucial to ensure ethical research practices and align data usage with creators' intentions.

Biases in AI models pose another ethical challenge. ChatGPT, trained on vast and diverse datasets, may inadvertently generate text with biased perspectives, perpetuating stereotypes or discriminatory viewpoints. Studies, such as the one conducted by Rozado (2023), reveal potential political biases in ChatGPT's responses, emphasising the need for further investigation and mitigation strategies. McGee's (2023) examination of ChatGPT's generation of Irish limericks also highlights concerns about political bias, reinforcing the importance of ethical considerations in AI-driven research.

Despite these challenges, ongoing efforts are being made to reduce biases in AI models such as ChatGPT. Researchers are working towards minimising biases in training data to achieve more objective and balanced outputs, enhancing the fairness and reliability of the language model's responses (Mijwil, Aljanabi, and Ali 2023). Addressing these ethical concerns is crucial to ensure responsible and ethical AI-driven research.

Misinformation

The propagation of misinformation and disinformation poses significant threats to scientific research when using ChatGPT. Misinformation involves false or inaccurate information, while disinformation is intentionally false information meant to deceive. ChatGPT, while attempting to provide accurate responses based on its training data, is not infallible and may occasionally generate misleading or incorrect information.

For example, a researcher relying on ChatGPT for information on a scientific topic might receive responses with outdated or incorrect data. If the researcher does not fact-check this information with reliable sources, there is a risk of incorporating false information into their research, leading to the dissemination of inaccurate data. Researchers who heavily depend on ChatGPT without critically evaluating the generated responses may unintentionally include misinformation in their scientific articles.

Moreover, the intentional dissemination of false information, or disinformation, is a concerning possibility. A malicious researcher could use ChatGPT to generate deceptive content, exploiting the model's capabilities to create seemingly credible narratives that support their agenda. This unethical conduct can undermine established scientific consensus and mislead both the scientific community and the public.

An examination of ChatGPT's performance in generating responses to false narratives revealed troubling results, with both ChatGPT-3.5 and ChatGPT-4 propagating misinformation and hoaxes. This underscores the importance of researchers and the scientific community being vigilant about the ethical use of AI models, implementing proper fact-checking, and exercising critical thinking when utilising these technologies (Bom 2023).

Impact on Cognitive Thinking

The reliance on ChatGPT in scientific writing can have negative consequences on researchers' higher-order cognitive thinking. Excessive usage may diminish critical thinking and analysis, as researchers might automatically accept AI-generated information without rigorous scrutiny. This lack of critical evaluation can lead to the incorporation of incorrect or outdated data, resulting in flawed conclusions and diminishing researchers' capacity for synthesising complex ideas and making insightful connections.

Moreover, overreliance on ChatGPT may lead to a decline in creativity and originality among researchers. Scientific writing requires creative problem-solving and innovative thinking, but if researchers excessively depend on the AI, they may opt for generic responses, stifling their ability to generate original ideas independently. This can lead to a lack of uniqueness in research projects, hindering scientific progress and potentially wasting resources on redundant investigations.

Additionally, researchers, especially non-native English language speakers, may weaken their linguistic skills by relying too heavily on ChatGPT for language and grammar correction. While the AI's proficiency in language correction may be tempting, using it as a substitute for enhancing language skills can have long-term repercussions. Researchers may miss the opportunity to actively learn from their writing mistakes and improve their language proficiency, resulting in poorly written content in published scientific articles and academic works. This negatively impacts the overall clarity and comprehension of research findings, making it challenging for readers to grasp the full implications of the research.

Analysis of Whose Interests Are Served by the Acceptance of ChatGPT in Scientific Research on a Global Scale

The integration of ChatGPT into scientific research on a global scale raises important questions about whose interests are being served by its acceptance. This section aims to critically analyse the stakeholders involved and to identify the potential beneficiaries of ChatGPT adoption in scientific research.

Corporate Interests

One prominent stakeholder group benefiting from the acceptance of ChatGPT in scientific research is technology companies and corporations that develop and commercialise AI technologies. For companies such as OpenAI, which developed ChatGPT, the widespread adoption of their technology enhances their market position and revenue streams. Furthermore, the integration of ChatGPT into scientific research expands the market for AI products and services, driving further innovation and competition in the AI industry.

Academic Institutions

Academic institutions stand to benefit from the adoption of ChatGPT in scientific research in various ways. ChatGPT can streamline research processes by assisting researchers in data analysis, literature reviews, and idea generation, thereby increasing research productivity and efficiency. Additionally, academic institutions can leverage ChatGPT to enhance educational experiences for students by providing access to advanced AI tools for learning and research purposes.

Researchers

Individual researchers also stand to gain from the acceptance of ChatGPT in scientific research. ChatGPT can serve as a valuable tool for augmenting research capabilities, enabling researchers to explore new research avenues, generate novel hypotheses, and collaborate more effectively with colleagues. Moreover, ChatGPT can help researchers overcome language barriers and access information from diverse sources, thereby enhancing the quality and scope of their research endeavours.

Broader Societal Implications

The acceptance of ChatGPT in scientific research has broader societal implications that extend beyond the interests of specific stakeholders. By facilitating knowledge discovery and dissemination, ChatGPT can contribute to scientific advancements and innovation, ultimately benefiting society as a whole. The democratisation of AI technologies such as ChatGPT has the potential to democratise access to information and expertise, empowering individuals and communities to participate more actively in scientific enquiry and decision-making processes.

Concerns and Challenges

However, alongside the potential benefits, there are also concerns regarding the interests served by the acceptance of ChatGPT in scientific research. One significant concern is the potential consolidation of power and influence in the hands of technology companies that develop and control AI technologies. This concentration of power raises questions about data privacy, intellectual property rights, and the ethical implications of AI-driven research.

Moreover, there are concerns about the impact of ChatGPT on employment in scientific research fields. While ChatGPT can enhance research productivity and efficiency, there is a risk that it may lead to job displacement or the deskilling of research tasks traditionally performed by humans. Therefore, it is essential to consider the broader socio-economic implications of ChatGPT adoption and to ensure that its benefits are equitably distributed across society.

The Importance of Critical Dialogue

Engaging in critical dialogue involves bringing together diverse voices from various fields, including ethics, technology, policy, and education, to discuss the potential impacts of ChatGPT and other AI technologies. Such dialogue should aim to identify and address the ethical and societal challenges that may arise from the widespread adoption of AI in scientific research. This includes ensuring equitable access to AI tools, protecting individual privacy, and promoting transparency in AI development and deployment. By fostering open discussions and collaborative efforts, stakeholders can work towards creating guidelines and policies that ensure AI technologies such as ChatGPT are used responsibly and for the greater good of society. This collaborative approach can help mitigate potential risks while maximising the benefits of AI advancements in scientific research.

In conclusion, the acceptance of ChatGPT in scientific research on a global scale serves the interests of various stakeholders, including technology companies, academic institutions, researchers, and broader society. However, it also raises concerns about the concentration of power, data privacy, employment, and equity. Therefore, it is crucial to engage in critical dialogue and ethical reflection to ensure that the integration of ChatGPT into scientific research aligns with ethical principles, social values, and the collective interests of humanity.

Conclusion

The incorporation of ChatGPT into scientific research signifies a revolutionary change in knowledge organisation, access, analysis, and dissemination. Its capabilities enable researchers to swiftly navigate extensive information repositories, accelerating the discovery of insights. Collaborative brainstorming with AI fosters multidisciplinary innovation, generating fresh hypotheses and solutions. Language translation and simplification facilitate global collaboration, overcoming language barriers. This symbiotic partnership between AI and researchers holds the potential to transform the scientific discovery landscape. However, it is vital to acknowledge ChatGPT's limitations, particularly in providing depth and context for intricate scientific discussions, which may lead to misinterpretations. Ethical considerations, including intellectual property rights and transparent attribution, should guide its usage. The reliance on AI-generated content, without human evaluation, poses risks to research quality and integrity. Striking a balance between augmentation and automation is crucial as AI evolves, ensuring that human ingenuity remains central to scientific progress. Overall, ChatGPT's integration into scientific research represents a progressive step with the capacity to redefine knowledge advancement. While its transformative capabilities can expedite discovery and innovation, ethical considerations and human oversight remain paramount. Navigating its strengths, weaknesses, opportunities, and threats thoughtfully allows researchers to embark on a new era of collaborative exploration, shaping the future of scientific research.

Recommendations

1. **Promote Ethical AI Practices:** Establish clear guidelines and ethical standards for the use of ChatGPT in scientific research. This should involve creating policies that address data privacy, intellectual property rights, and the ethical implications of AI-driven research. Institutions should ensure that researchers are trained in ethical AI practices and understand the potential impacts of their work.

2. **Encourage Interdisciplinary Collaboration:** Foster collaboration between researchers, technologists, ethicists, and policymakers to address the complex challenges posed by AI integration in research. Interdisciplinary teams can work together to develop comprehensive strategies that maximise the benefits of ChatGPT while minimising potential risks. This collaboration should also aim to create inclusive AI tools that reflect diverse perspectives and serve a wide range of research needs.

3. **Ensure Equitable Access to AI Tools:** Work towards democratising access to AI technologies such as ChatGPT by providing affordable and equitable access to researchers and institutions worldwide. This can be achieved through partnerships with technology companies and initiatives that offer subsidised access to AI tools for under-resourced institutions. Ensuring equitable access will help bridge the gap between well-funded and less-funded research communities.

4. **Monitor and Evaluate AI Impact:** Establish mechanisms for continuously monitoring and evaluating the impact of ChatGPT on scientific research. This should include assessing its effects on research quality, productivity, and employment within the field. Regular evaluations will provide insights into the technology's benefits and challenges, enabling stakeholders to make informed decisions about its integration into research practices.

Acknowledgements

References

Alkaissi, H., and S. I. McFarlane. 2023. "Artificial Hallucinations in ChatGPT: Implications in Scientific Writing". *Cureus* 15 (2): e35179. https://doi.org/10.7759/cureus.35179.

Alneyadi, S., and Y. Wardat. 2023. "ChatGPT: Revolutionizing Student Achievement in the Electronic Magnetism Unit for Eleventh-Grade Students in Emirates Schools". *Contemporary Educational Technology* 15 (4): ep448. https://doi.org/10.30935/cedtech/13417.

Alneyadi, S., Y. Wardat, Q. Alshannag, and A. Abu-Al-Aish. 2023. "The Effect of Using Smart E-Learning App on the Academic Achievement of Eighth-Grade Students". *Eurasia Journal of Mathematics, Science and Technology Education* 19 (4): em2248. https://doi.org/10.29333/ejmste/13067.

Alser, M., and E. Waisberg. 2023. "Concerns with the Usage of ChatGPT in Academia and Medicine: A Viewpoint". *American Journal of Medicine Open* 9: 100036. https://doi.org/10.1016/j.ajmo.2023.100036.

Azaria, A., R. Azoulay, and S. Reches. 2023. "ChatGPT Is a Remarkable Tool—For Experts". *arXiv*. https://doi.org/10.48550/arXiv.2306.03102.

Bang, Y., S. Cahyawijaya, N. Lee, W. Dai, D. Su, B. Wilie, H. Lovenia, Z. Ji, T. Yu, W. Chung, Q. V. Do, Y. Xu, and P. Fung. 2023. "A Multitask, Multilingual, Multimodal Evaluation of ChatGPT on Reasoning, Hallucination, and Interactivity". *arXiv*. https://doi.org/10.48550/arXiv.2302.04023.

Benzaghta, M. A., A. Elwalda, M. M. Mousa, I. Erkan, and M. Rahman. 2021. "SWOT Analysis Applications: An Integrative Literature Review". *Journal of Global Business Insights* 6 (1): 55–73. https://www.doi.org/10.5038/2640-6489.6.1.1148.

Bin-Hady, W. R. A., A. Al-Kadi, A. Hazaea, and J. K. M. Ali. 2023. "Exploring the Dimensions of ChatGPT in English Language Learning: A Global Perspective". *Library Hi Tech*. https://doi.org/10.1108/LHT-05-2023-0200.

Bom, H. S. H. 2023. "Exploring the Opportunities and Challenges of ChatGPT in Academic Writing: A Roundtable Discussion". *Nuclear Medicine and Molecular Imaging* 57: 165–167. https://doi.org/10.1007/s13139-023-00809-2.

Chinonso, E. T. 2023. "The Impact of ChatGPT on Privacy and Data Protection Laws". *SSRN*. https://doi.org/10.2139/ssrn.4574016.

Chiu, T. K., and C.-S. Chai. 2020. "Sustainable Curriculum Planning for Artificial Intelligence Education: A Self-Determination Theory Perspective". *Sustainability* 12 (14): 5568. https://doi.org/10.3390/su12145568.

Chowdhury, N., and S. Rahman. 2023. "A Brief Review of ChatGPT: Limitations, Challenges and Ethical-Social Implications". BSc essay, Chongqing University of Posts and Telecommunications. https://www.researchgate.net/publication/368397881_A_brief_review_of_ChatGPT_Limitations_Challenges_and_Ethical-Social_Implications.

Chubb, J., P. Cowling, and D. Reed. 2022. "Speeding Up to Keep Up: Exploring the Use of AI in the Research Process". *AI and Society* 37: 1439–1457. https://doi.org/10.1007/s00146-021-01259-0.

Cotton, D. R., P. A. Cotton, and J. R. Shipway. 2023. "Chatting and Cheating: Ensuring Academic Integrity in the Era of ChatGPT". *Innovations in Education and Teaching International* 61 (2): 228–239. https://doi.org/10.1080/14703297.2023.2190148.

Dale, R. 2021. "GPT-3: What's It Good For?" *Natural Language Engineering* 27 (1): 113–118. https://doi.org/10.1017/S1351324920000601.

Farrokhnia, M., S. K. Banihashem, O. Noroozi, and A. Wals. 2023. "A SWOT Analysis of ChatGPT: Implications for Educational Practice and Research". *Innovations in Education and Teaching International* 61 (3): 460–474. https://doi.org/10.1080/14703297.2023.2195846.

Gao, Y., R. Wang, and F. Hou. 2023. "Unleashing the Power of ChatGPT for Translation: An Empirical Study". *arXiv*. https://doi.org/10.48550/arXiv.2304.02182.

Gibson, L., F. E. Obiakor, and S. O. Obi. 2023. "Using Technology to Enhance Learning for Students from Culturally and Linguistically Diverse Backgrounds". In *Using Technology to Enhance Special Education*, edited by J. P. Bakken and F. E. Obiakor, *Advances in Special Education* Vol. 37, 199–214. Leeds: Emerald Publishing. https://doi.org/10.1108/S0270-401320230000037012.

Gilson, A., C. W. Safranek, T. Huang, V. Socrates, L. Chi, R. A. Taylor, and D. Chartash. 2023. "How Does ChatGPT Perform on the United States Medical Licensing Examination (USMLE)? The Implications of Large Language Models for Medical Education and Knowledge Assessment". *JMIR Medical Education* 9: e45312. https://doi.org/10.2196/45312.

Giray, L. 2023. "Prompt Engineering with ChatGPT: A Guide for Academic Writers". *Annals of Biomedical Engineering* 51: 2629–2633. https://doi.org/10.1007/s10439-023-03272-4.

Gningue, S. M., R. Peach, A. M. Jarrah, and Y. Wardat. 2022. "The Relationship between Teacher Leadership and School Climate: Findings from a Teacher-Leadership Project". *Education Sciences* 12 (11): 749. https://doi.org/10.3390/educsci12110749.

Hidayat, R., and Y. Wardat. 2024. "A Systematic Review of Augmented Reality in Science, Technology, Engineering and Mathematics Education". *Education and Information Technologies* 29: 9257–9282. https://doi.org/10.1007/s10639-023-12157-x.

Jain, S., and R. Jain. 2019. "Role of Artificial Intelligence in Higher Education: An Empirical Investigation". *IJRAR: International Journal of Research and Analytical Reviews* 6 (2): 144–150. http://ijrar.com/upload_issue/ijrar_issue_20544069.pdf.

Jarrah, A. M., H. Almassri, J. D. Johnson, and Y. Wardat. 2022. "Assessing the Impact of Digital Games-Based Learning on Students' Performance in Learning Fractions Using (ABACUS) Software Application". *Eurasia Journal of Mathematics, Science and Technology Education* 18 (10): em2159. https://doi.org/10.29333/ejmste/12421.

Jarrah, A. M., Y. Wardat, and P. Fidalgo. 2023. "Using ChatGPT in Academic Writing Is (Not) a Form of Plagiarism: What Does the Literature Say?" *Online Journal of Communication and Media Technologies* 13 (4): e202346. https://doi.org/10.30935/ojcmt/13572.

Jiao, W., W. Wang, J.-T. Huang, X. Wang, S. Shi, and Z. Tu. 2023. "Is ChatGPT a Good Translator? Yes with GPT-4 as the Engine". *arXiv*. https://doi.org/10.48550/arXiv.2301.08745.

Kalla, D., and N. Smith. 2023. "Study and Analysis of ChatGPT and Its Impact on Different Fields of Study". *International Journal of Innovative Science and Research Technology* 8 (3): 827–833.

Kasneci, E., K. Seßler, S. Küchemann, M. Bannert, D. Dementieva, F. Fischer, U. Gasser, G. Groh, S. Günnemann, E. Hüllermeier, S. Krusche, G. Kutyniok, T. Michaeli, C. Nerdel, J. Pfeffer, O. Poquet, M. Sailer, A. Schmidt, T. Seidel, M. Stadler, J. Weller, J. Kuhn, and G. Kasneci. 2023. "ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education". *arXiv*. https://doi.org/10.35542/osf.io/5er8f.

Kengam, J. 2020. "Artificial Intelligence in Education". Bournemouth University. http://dx.doi.org/10.13140/RG.2.2.16375.65445.

Khalil, M., and E. Er. 2023. "Will ChatGPT Get You Caught? Rethinking of Plagiarism Detection". *arXiv*. https://doi.org/10.48550/arXiv.2302.04335.

Kuleto, V., M. Ilić, M. Dumangiu, M. Ranković, O. M. Martins, D. Păun, and L. Mihoreanu. 2021. "Exploring Opportunities and Challenges of Artificial Intelligence and Machine Learning in Higher Education Institutions". *Sustainability* 13 (18): 10424. https://doi.org/10.3390/su131810424.

Kung, T. H., M. Cheatham, A. Medenilla, C. Sillos, L. De Leon, C. Elepaño, M. Madriaga, R. Aggabao, G. Diaz-Candido, J. Maningo, and V. Tseng. 2023. "Performance of ChatGPT on USMLE: Potential for AI Assisted Medical Education Using Large Language Models". *PLOS Digital Health* 2 (2): e0000198. https://doi.org/10.1371/journal.pdig.0000198.

Lyu, C., J. Xu, and L. Wang. 2023. "New Trends in Machine Translation Using Large Language Models: Case Examples with ChatGPT". *arXiv*. https://www.researchgate.net/publication/370220951_New_Trends_in_Machine_Translation_using_Large_Language_Models_Case_Examples_with_ChatGPT.

McGee, R. 2023. "Is ChatGPT Biased against Conservatives? An Empirical Study". *Social Science Research Network*. http://dx.doi.org/10.2139/ssrn.4359405.

Mijwil, M., M. Aljanabi, and A. H. Ali. 2023. "ChatGPT: Exploring the Role of Cybersecurity in the Protection of Medical Information". *Mesopotamian Journal of Cybersecurity* 18–21. http://dx.doi.org/10.58496/MJCS/2023/004.

Nandalwar, J., V. Shirashyad, P. Pandhare, and P. Kothawale. 2023. "An Intelligent Approach for Automating Data Inputs on Web Portals for Several Apex/Statutory Bodies in the Field of Education Using Robotics and Machine Learning". *International Journal for Multidisciplinary Research* 5 (3). https://doi.org/10.36948/ijfmr.2023.v05i02.2397.

Onat, O., and S. Gulsecen. 2023. "Reducing Perceived Transactional Distance in Distance Education: The Impact of the Chatbot". *International Journal of Technology in Education and Science (IJTES)* 7 (4): 483–499. https://doi.org/10.46328/ijtes.511.

Opara, E., A. Mfon-Ette Theresa, and T. C. Aduke. 2023. "ChatGPT for Teaching, Learning and Research: Prospects and Challenges". *Global Academic Journal of Humanities and Social Sciences* 5 (2): 33–40. https://doi.org/10.36348/gajhss.2023.v05i02.001.

Pinzolits, R. 2024. "AI in Academia: An Overview of Selected Tools and Their Areas of Application". *MAP Education and Humanities* 4: 37–50. https://doi.org/10.53880/2744-2373.2023.4.37.

Rahman, M., H. J. R. Terano, N. Rahman, A. Salamzadeh, and S. Rahaman. 2023. "ChatGPT and Academic Research: A Review and Recommendations Based on Practical Examples". *Journal of Education, Management and Development Studies* 3 (1): 1–12. https://doi.org/10.52631/jemds.v3i1.175.

Roumeliotis, K. I., and N. D. Tselikas. 2023. "ChatGPT and Open-AI Models: A Preliminary Review". *Future Internet* 15 (6): 192. https://doi.org/10.3390/fi15060192.

Rozado, D. 2023. "The Political Biases of ChatGPT". *Social Sciences* 12 (3): 148. https://doi.org/10.3390/socsci12030148.

Rudolph, J., S. Tan, and S. Tan. 2023. "ChatGPT: Bullshit Spewer or the End of Traditional Assessments in Higher Education?" *Journal of Applied Learning and Teaching* 6 (1): 342–363. https://doi.org/10.37074/jalt.2023.6.1.9.

Santra, P. P., and D. Majhi. 2023. "Scholarly Communication and Machine-Generated Text: Is It Finally AI vs AI in Plagiarism Detection?" *Journal of Information and Knowledge* 60 (3): 173–181. https://doi.org/10.17821/srels%2F2023%2Fv60i3%2F171028.

Schwab, K. 2017. *The Fourth Industrial Revolution*. New York: Crown Publishing.

Shidaganti, G., R. Sanjana, K. Shubeeksh, V. R. Monish Raman, and V. Thakshith. 2023. "ChatGPT: Information Retrieval from Image Using Robotic Process Automation and OCR". In *7th International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2023*, 1264–1270. Piscataway: Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICICCS56967.2023.10142461.

Simpson, D. 2023. "Educators, Students, and Plagiarism in the Age of AI". *BMJ* 381: p1403. https://doi.org/10.1136/bmj.p1403.

Stojanov, A. 2023. "Learning with ChatGPT 3.5 as a More Knowledgeable Other: An Autoethnographic Study". *International Journal of Educational Technology in Higher Education* 20 (35). https://doi.org/10.1186/s41239-023-00404-7.

Strubell, E., A. Ganesh, and A. McCallum. 2019. "Energy and Policy Considerations for Deep Learning in NLP". In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics (ACL)*, edited by A. Korhonen, D. Traum and L. Màrquez, 3645–3650. Stroudsburg: Association for Computational Linguistics. https://doi.org/10.48550/arXiv.1906.02243.

Tashtoush, M. A., R. AlAli, Y. Wardat, N. Alshraifin, and H. Toubat. 2023. "The Impact of Information and Communication Technologies (ICT)-Based Education on the Mathematics Academic Enthusiasm". *Journal of Educational and Social Research* 13 (3): 284–293. https://doi.org/10.36941/jesr-2023-0077.

Tlili, A., R. Huang, B. Shehata, D. Liu, J. Zhao, A. H. S. Metwally, H. Wang, M. Denden, A. Bozkurt, L.-H. Lee, D. Beyoglu, F. Altinay, R. C. Sharma, Z. Altinay, Z. Li, J. Liu, F. Ahmad, Y. Hu, S. Salha, M. Abed, and D. Burgos. 2022. "Is Metaverse in Education a Blessing or a Curse: A Combined Content and Bibliometric Analysis". *Smart Learning Environments* 9 (1): 1–31.

Ufuk, F. 2023. "The Role and Limitations of Large Language Models Such as ChatGPT in Clinical Settings and Medical Journalism". *Radiology* 307 (3): e230276. https://doi.org/10.1148/radiol.230276.

Van der Vorst, T., and N. Jelicic. 2019. "Artificial Intelligence in Education: Can AI Bring the Full Potential of Personalized Learning to Education?" Paper presented at the 30th European Conference of the International Telecommunications Society, "Towards a Connected and Automated Society", Helsinki, Finland, June16–19, 2019. https://www.econstor.eu/bitstream/10419/205222/1/van-der-Vorst-Jelicic.pdf.

Wardat, Y., M. A. Tashtoush, R. AlAli, and A. M. Jarrah. 2023. "ChatGPT: A Revolutionary Tool for Teaching and Learning Mathematics". *Eurasia Journal of Mathematics, Science and Technology Education* 19 (7): e2286. https://doi.org/10.29333/ejmste/13272.

Zhai, X. 2022. "ChatGPT User Experience: Implications for Education". *Social Science Research Network*. https://dx.doi.org/10.2139/ssrn.4312418.