



The emergent role of artificial intelligence, natural learning processing, and large language models in higher education and research

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ABSTRACT

Artificial Intelligence (AI) has revolutionized various domains, including education and research. Natural language processing (NLP) techniques and large language models (LLMs) such as GPT-4 and BARD have significantly advanced our comprehension and application of AI in these fields. This paper provides an in-depth introduction to AI, NLP, and LLMs, discussing their potential impact on education and research. By exploring the advantages, challenges, and innovative applications of these technologies, this review gives educators, researchers, students, and readers a comprehensive view of how AI could shape educational and research practices in the future, ultimately leading to improved outcomes. Key applications discussed in the field of research include text generation, data analysis and interpretation, literature review, formatting and editing, and peer review. AI applications in academics and education include educational support and constructive feedback, assessment, grading, tailored curricula, personalized career guidance, and mental health support. Addressing the challenges associated with these technologies, such as ethical concerns and algorithmic biases, is essential for maximizing their potential to improve education and research outcomes. Ultimately, the paper aims to contribute to the ongoing discussion about the role of AI in education and research and highlight its potential to lead to better outcomes for students, educators, and researchers.

1. Introduction

Artificial intelligence (AI) has become an essential element of modern society, revolutionizing various domains such as education and research.¹ Large Language Models (LLMs) are an emerging Natural Language Processing (NLP) technology that has seen considerable advancement in recent years.² Trained on vast amounts of textual data sets using publicly available data and data licensed from third parties, followed by fine-tuning of output using reinforcement learning from human feedback (RLHF) algorithms, LLMs can produce human-like language and perform various language processing tasks. Examples include OpenAI's Generative Pretrained Transformer (GPT) and

Google's BARD.^{3–5} NLP, one of AI's core capabilities, focuses on how computers and human languages interact.⁶ It allows computers to comprehend, analyze, and generate human language with practical applications across numerous industries such as management, investing, retail, legal, architectural, and transportation fields.⁶ These LLMs have significantly advanced our comprehension and application of AI in these fields. Furthermore, NLPs and LLMs hold immense promise for improving education and research quality. In addition, it profoundly affects our daily lives, with its presence growing stronger every day.

As AI progresses and improves, we can expect even more groundbreaking applications that will positively affect the future of education and research for the better. For example, the previous GPT models, such

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as GPT-3 and GPT-3.5, lack major advantages that were implemented and optimized in the newest version, GPT-4, including safety improvements, the availability of several languages, the generation of text from images, and drug discovery-related tools. Despite its promising features, GPT-4 has several problems in use. One major issue is hallucinations, which refer to generating non-existent or incorrect content and other related concerns associated with limited contexts, reliability, and the lack of learning from experience.⁷ Adopting AI technologies also presents challenges, such as data privacy concerns, algorithmic bias, and ethical ramifications of AI-driven decision-making.^{2,8} Addressing these obstacles and creating guidelines for responsible AI use is essential to maximize its potential in improving education and research outcomes.

This review introduces the fundamental concepts of AI, NLP, and LLMs, emphasizing their potential impact on education and research.^{9,10} Moreover, it will demonstrate how AI can revolutionize research and education, creating a bright future for this profession by exploring these technologies' advantages, challenges, and innovative applications. Aiming to foster greater comprehension of these technologies and stimulate further exploration into their innovative potential for educators, researchers, and readers.

2. The role of AI in higher education

2.1. Transforming education through personalized learning

AI can assist educators in educational support and personalized learning by analyzing data on student performance and behavior, identifying areas where students may be struggling, and providing personalized recommendations for improvement. AI tools are utilized to aid in developing adaptive learning systems that adjust the difficulty level of assignments and assessments based on each student's individual needs and abilities, providing a tailored learning experience, which would also allow educators to assess individual students learning achievements accurately. This can help ensure that students are challenged but not overwhelmed, leading to better engagement and motivation.¹¹ Moreover, AI provides targeted feedback, pinpointing areas for improvement and recommending strategies, helping students understand their strengths and weaknesses while developing effective study habits. This tailored learning experience and focused training promote autonomy, competence, and relatedness, significantly enhancing student support and building a more effective learning environment. AI and NLP foster metacognitive skill development through timely feedback and guidance, encouraging learners to reflect on their improvement strategies whilst training learners to develop time management skills and learning methods to enhance their educational process.¹²

Furthermore, AI helps develop individualized learning plans, considering each student's learning style, interests, and objectives, which keeps students motivated and engaged, leading to better academic results.^{13,14} Furthermore, AI can keep up to date with the latest and most effective teaching and learning strategies and methodologies due to advancing research in the educational field. Thus, learners can utilize a personalized and effective strategy for optimal learning and achievement. Ultimately, AI has the potential to transform how educators deliver personalized learning and support, improving outcomes for all students.

Moreover, traditional tutoring often faces obstacles due to a shortage of qualified instructors and the requirement for hourly fees to provide sufficient educational support. GPT-4, for instance, addresses these obstacles by offering precise answers and comprehensive explanations promptly.^{13,15} Chatbots using NLP can quickly answer basic questions about topics or subjects, making fundamental knowledge more accessible.^{16,17}

However, balancing using AI technologies and human engagement in learning is essential. While AI can offer student support, its value of human connection should never be overlooked.¹⁸ Consider the great impact of positive emotional behavior and empathy on learners'

performance. So, with the utilization of AI, an optimal amount of human engagement must be determined and incorporated into the teaching plan. By the thoughtful incorporation of technologies like chatbots into educational settings, educators can foster feelings of belonging and connectedness for their students - improving retention rates and overall academic success.

AI technology is expected to profoundly affect pharmacy education and education in general. Personalized learning experiences tailored to each student's needs, interests, and preferences could become commonplace soon. To fully take advantage of this paradigm shift in instruction, educators must be willing to try new approaches and embrace technology as an essential tool for improvement.

2.2. Transforming the grading landscape with artificial intelligence

Research on automating grading and assessment with AI and NLP techniques has grown significantly in recent years. Numerous studies have investigated how these technologies can enhance grading processes' efficiency, accuracy, and consistency.^{19–21} One method, automated essay grading (AEG), uses machine learning algorithms to assess written responses to open-ended questions. Researchers have employed features like grammar, syntax, vocabulary, and coherence to create AEG models.^{22,23} These models can be integrated with NLP techniques such as semantic analysis or discourse analysis to gauge a student's comprehension of a subject.²² Another educational application of AI and NLP is automated short answer grading (ASAG), in which students submit concise answers evaluated by machine learning algorithms. Deep learning methods have been utilized for ASAG tasks due to their ability to learn complex data representations.²⁴ However, acquiring quality training data for ASAG remains challenging.

Several advantages could be associated with using these technologies in grading and assessment. First, it can save educators significant time and effort compared to traditional manual grading. Second, AI grading can be more consistent and systematic, with no impact of fatigue, unlike human grading, thus, helping to reduce subjectivity and bias. Third, AI grading is much faster than manual grading, which can help educators to provide feedback to students more quickly, allowing them to spend more time on other important tasks. Fourth, AI can analyze data on student performance and provide insights into areas where students may be struggling or excelling. This can help educators identify areas where students may need additional support or where teaching methods must be adjusted. Lastly, with AI, educators can develop customized rubrics and grading criteria that are tailored to their specific needs and teaching styles, which adequately reflect the outcomes of the lesson providing a genuine assessment of student achievement. While AI and NLP offer numerous advantages, they also present certain challenges. A notable concern is the potential for students to use these models to generate answers for assignments or tests, instead of engaging in authentic learning. This can lead to a situation where students are not truly understanding or mastering the material but are merely finding ways to exploit the system. Therefore, while those technologies have considerable potential to support teaching and learning, their use must be carefully managed and supplemented with strategies that encourage genuine understanding and critical thinking. It's also crucial to cultivate an educational environment that values academic integrity and discourages misuse of such technologies.

2.3. Strengthening curriculum design for student success in the job market

Artificial intelligence technologies hold the potential to facilitate pharmacy curriculum development and simultaneously align it with job market needs.²⁵ By streamlining course design, crafting descriptions, outlining learning objectives, and devising assessment methodologies, AI can help achieve program-specific goals while addressing stakeholders' challenges in keeping up with emerging pedagogical approaches and the evolving job market.²⁶ Moreover, an AI framework for

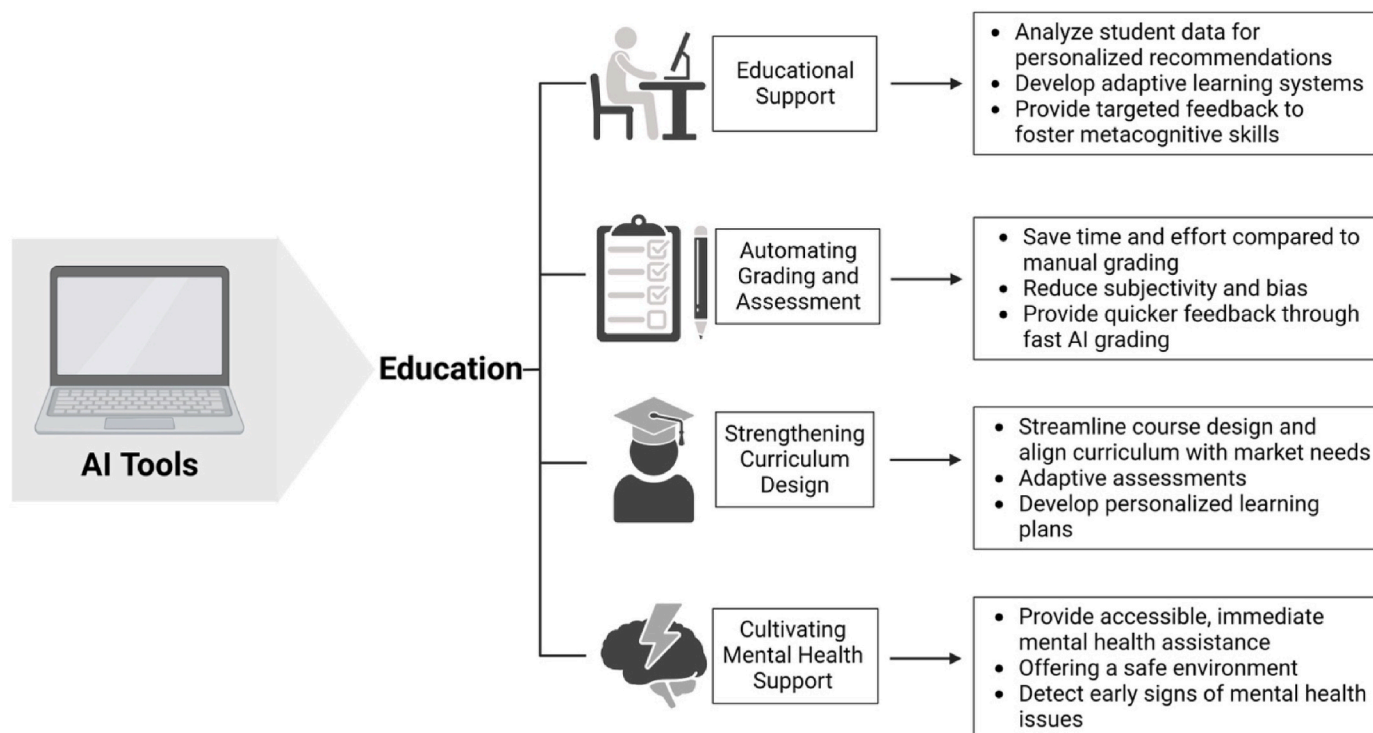


Fig. 1. The Benefits and Applications of using AI NLM tools in Higher Education.

using a multi-tiered curriculum can enhance educational assessment tools by analyzing multiple data points and creating adaptive assessments that adjust and deliver specific aspects of the curriculum based on student responses. AI tools can also contribute to developing personalized learning plans, ensuring students acquire the necessary skills and knowledge for their chosen careers.²⁷ These plans can adapt over time as students' needs and circumstances change, with AI tools providing targeted resources to support their learning journey. Overall, the application of AI allows a personalized and standardized level of learning excellence that is at par with institutes worldwide. Thus, learners graduate with high competency, ready for the global job market, irrespective of their educational demographics.

Regarding student careers, AI-driven career guidance and job selection can help students identify their strengths, interests, and aptitudes, guiding them toward fulfilling career paths. AI tools can facilitate career decision-making and offer personalized support by providing tailored advice on potential career paths based on an individual's unique abilities, preferences, and goals.^{28,29}

However, several limitations should be considered when relying on AI for career guidance and curriculum development. AI systems may lack the human touch required to empathize with students' emotions and unique personal circumstances.⁶⁸ They may also be unable to predict or incorporate emerging trends and opportunities due to their reliance on existing data. Furthermore, potential bias in AI algorithms may lead to skewed career suggestions, perpetuating existing inequalities.^{30,31} Lastly, overreliance on AI tools could diminish the development of critical thinking skills, as students may grow overly dependent on AI-generated advice instead of learning to make informed decisions independently.³² By considering these limitations and harnessing the power of AI effectively, educational institutions can develop curricula that cater to individual student needs while preparing them for the evolving job market.

2.4. Cultivating mental health support for a resilient future

The increasing prevalence of mental health issues among students

has necessitated exploring innovative solutions to support and alleviate their psychological distress.³³ One such emerging technology is the application of NLP models in offering mental health assistance to students.³⁴ With their advanced NLP capabilities, these AI models can play a crucial role in augmenting traditional mental health support systems and improving students' psychological well-being.³⁵ GPT-4 and similar AI models can facilitate mental health support by offering accessible and immediate assistance to students experiencing emotional distress. These AI models can engage in empathetic and coherent conversations with students, providing them with a safe and non-judgmental environment to express their concerns and emotions.

Moreover, AI-powered tools can assist in the early identification of mental health issues among students by analyzing their communication patterns and detecting subtle signs of emotional distress.^{35–37} For instance, during the COVID-19 pandemic, NLP and AI tools were employed to monitor Twitter for indications of mental health concerns among the public, including students.³⁸ This real-time analyzed evidence could act as a useful intelligence source to help stakeholders understand the impact of the crisis on mental health and devise appropriate interventions or support systems. Thus, adopting AI-based mental health monitoring systems in academia may be considered for receiving early healthcare guidance, promoting health and well-being, and undoubtedly also learners' overall academic achievements.

While AI and NLP technologies offer significant potential in supporting students' mental health, we must acknowledge their limitations and ethical implications. A critical constraint of these technologies is their inability to substitute for human interaction or expert medical counsel. Mental health issues are intricate, necessitating tailored treatment strategies that take into account the individual's unique circumstances and requirements. Thus, while AI-driven interventions can offer emotional assistance and counseling services, they are envisioned as supplemental tools that enhance existing healthcare provisions, rather than replacements for human-based therapy. The primary function of AI is to bolster the efforts of healthcare professionals, not to supplant them. AI still lacks the depth of empathy and comprehension that a human therapist possesses. The subtle intricacies of human emotions, non-

verbal cues, and complex personal experiences often pose challenges for AI to completely understand. During emergencies or severe mental health episodes, human intervention remains crucial. The applications of AI NLM in higher education are described in Fig. 1.

3. Role of artificial intelligence in research

3.1. Facilitating text generation

ChatGPT, other AI models, and advances in AI technology have transformed how scientific text is drafted. These models can be trained on large amounts of scientific data and produce high-quality scientific texts based on prompts or input data.³⁹ Investigators can input data such as research papers and articles to generate scientific text. Then, the AI model analyzes and synthesizes the data to create a coherent, relevant scientific text that accurately represents the input data. This can help investigators save considerable time and effort as they no longer have to read through research papers or write designated sections. In addition, AI-generated scientific texts are generally high-quality since they are trained using large amounts of scientific data and can use sophisticated NLP techniques.^{10,13} If sufficient information and references exist, the generated text will likely be relevant and exact, making it an invaluable resource for researchers looking to write scientific articles. Moreover, it could be trained to tailor its writing towards specific requests, such as being detailed or concise, formal or informal.

Junior faculty members face the difficult task of balancing research, publishing, and teaching. To maintain their employment or seek promotion and tenure at the institution, they are required to publish a certain number of research articles per year.⁴⁰ Writer's block is particularly harmful to junior faculty members, who may have less time or resources to dedicate to writing.⁴¹ Both novice and experienced writers, whether students or teachers, suffer from writer's block. AI-generated text can be used by investigators to help overcome writer's block. Utilizing AI to generate scientific text can provide a starting point and improve the quality of scientific publications. Moreover, it can help investigators ensure that abstracts, introductions, and conclusions are relevant and accurate. This is especially important for the pharmacy and medicine fields, where accuracy in scientific publications can significantly impact public safety and health. In addition, AI-generated scientific texts can also be cost-effective. Writing a scientific article can be time-consuming and costly, especially if the researcher has to hire editors or writers. Researchers can save money by using AI-generated text. Utilizing these technologies allows researchers to cut expenses, eliminating the need to hire professional writers or editors for their work.

In general, these types of technology also come with certain drawbacks. Models may struggle to grasp the intricacies and complexities of scientific subjects, and their output could be less sophisticated and innovative than human-generated text.^{5,42} Addressing ethical issues, such as unintentional plagiarism or generating deceptive information “hallucination” is crucial.⁴³ When dealing with novel findings with limited reference materials, AI-generated text may fail to convey the nuance and context of human authors, potentially compromising quality and readability. In conclusion, fully depending on AI-generated text to start writing research outside of your expertise may inadvertently limit your thought process and writing style, potentially hindering your creativity and unique ideas.⁴⁴

AI tools offer promising formatting, style-checking and editing solutions in scientific papers. One major advantage is their ability to quickly and efficiently analyze and correct language errors, thereby improving the readability and clarity of the manuscripts.⁴⁵ These tools can also ensure adherence to scientific journals' specific formatting and citation style requirements, saving authors time and reducing the likelihood of submission errors. However, there are also disadvantages associated with using AI tools in scientific writing. A primary concern is the lack of transparency regarding the use of AI in the writing process, which may lead to ethical issues.^{46–48} Moreover, the inclusion of

AI-generated content in scientific papers can be met with disapproval by some scientists who may question the authenticity of the work.⁴⁹

It is essential to highlight that major publishers such as Elsevier have endorsed using AI and AI-assisted tools in scientific writing. However, authors using such tools must disclose their use in a separate section of the manuscript, but they do not qualify for authorship. Elsevier underscores that AI tools can improve efficiency and reduce costs but cannot replace human expertise entirely. Ethical considerations for using AI in scientific writing include the potential risk of bias and errors, energy consumption, and “learning losses” in writing skills. Personal judgment and continued learning are essential for human development and progression. As such, developers should disclose the training sets used and measures taken to offset adverse scientific effects.

3.2. Assisting in data analysis and interpretation

AI technologies have revolutionized data mining and analysis across various disciplines. These advanced tools have demonstrated significant potential in areas such as bioinformatics, drug discovery, clinical trials, image analysis, pharmacy, and public health.^{50–54}

In bioinformatics, AI and NLP techniques facilitate managing and analyzing large-scale biological data, contributing to understanding complex biological systems. By automating data analysis and enabling the identification of patterns and correlations, these technologies accelerate scientific discoveries and provide valuable insights for hypothesis generation and experimental design.^{53,55,56}

Bioinformatics has become a crucial tool in drug discovery due to its capacity for analyzing large datasets of biological information, such as genomics, proteomics, and metabolomics data.⁵⁷ Utilizing bioinformatic data can help researchers identify novel drug targets or repurpose existing drugs for new indications.^{58,59} This technology can go a step further after analyzing the bioinformatic data by creating a drug discovery library and finding hits. A recently published study examined and explored the potential application of Chat GPT in multiple computational chemistry questions. Many questions were correctly answered related to determining the multiplicity of the molecule, converting Simplified Molecular Input Line Entry System (SMILES) to files, generating input files for Gaussian software, and providing input files to docking software with specific parameters.⁶⁰ These processes accelerated data analysis, streamlined the drug discovery process, reduced costs, and increased the likelihood of identifying novel therapeutic candidates.⁶¹

GPT-4's application in drug discovery presents both benefits and risks, with some arguing that generated data may lack quality, reliability, accuracy, transparency, intellectual property, and validity. While GPT-4 cannot replace scientists in synthesizing novel molecules or evaluating biological activities of proposed compounds, it does offer a rapid and cost-effective way to process, characterize and filter large datasets expanding and converging current knowledge.⁶² However, continuous improvements, safety metric enhancements, and accuracy in answering complex questions are needed to further optimize GPT models in drug discovery.

AI and NLP have become increasingly important tools in clinical and research settings to analyze large amounts of data to detect patterns that would otherwise go undetected. For instance, in healthcare, NLP can extract crucial information from unstructured clinical notes, such as reasons for treatment discontinuation or specific medical conditions. It can also analyze genetic variability, clinical trial data for treatment efficacy and safety, and epidemiological data to monitor disease spread, enabling pharmacists to make better-informed decisions regarding patient care.^{63,64} AI and NLP can also improve population health outcomes by offering tailored care to specific population groups. For instance, an agile digital platform has been created with IoT (Internet of Things), NLP, and AI technologies, to support patients with delirium.⁶⁵ Although AI and NLP technologies hold great potential in enhancing healthcare outcomes, there are notable limitations and challenges that must be

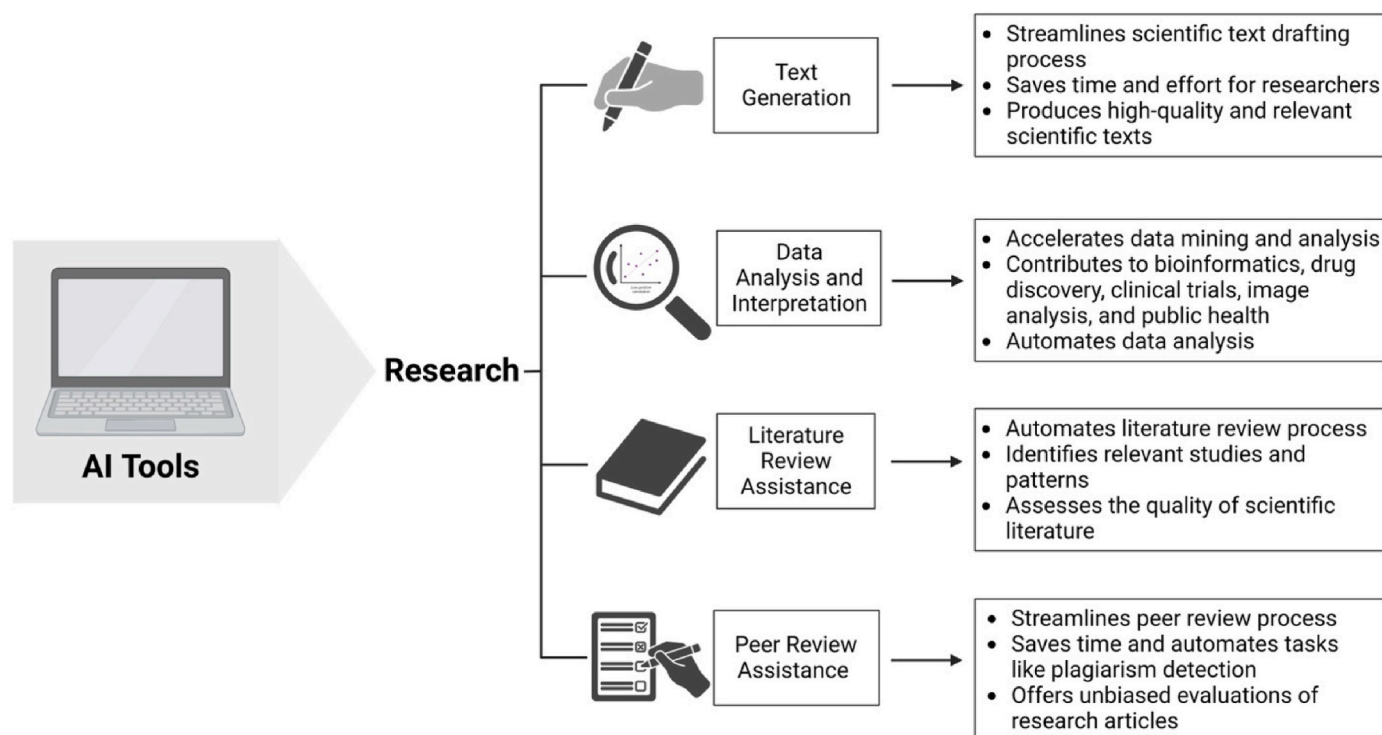


Fig. 2. The benefits and applications of using AI NLM tools in Research.

addressed before widespread adoption. The refinement of transformer-based chatbots for clinical use is essential, and ethical concerns surrounding patient data privacy must be considered.⁶⁶

3.3. Accelerating literature reviews with AI assistance

The process of reviewing scientific literature is essential for any research project, as it involves identifying relevant studies related to a particular research question. However, this process can be time-consuming and labor-intensive. Advances in AI have made it possible to automate this process, making it faster and more efficient.^{67,68} AI's primary advantage in reviewing scientific literature is its ability to process vast amounts of data rapidly and efficiently, saving researchers time and allowing them to focus on other aspects of their projects. AI systems can accurately identify relevant studies using NLP algorithms for keyword and concept recognition, finding articles that human reviewers may overlook. They can also identify patterns and trends, highlighting new research directions or gaps in the literature. Furthermore, AI systems can assess the quality of scientific literature by analyzing study design, sample size, and statistical methods, helping researchers evaluate a study's reliability and its relevance to their review.^{47,67–69}

Despite these advantages, there are some limitations to using AI and NLP in the literature review process. AI systems might not fully comprehend the context and nuances within the scientific literature, which could lead to the inclusion of irrelevant studies or the exclusion of important ones. The performance of AI systems also depends on the quality and quantity of training data. The AI system may not accurately represent the literary landscape if the training data is biased or incomplete.⁷⁰ Furthermore, AI-generated literature reviews may lack the critical thinking and expert insight that human reviewers bring to the process, which is essential for synthesizing complex information and identifying meaningful connections between studies.^{3,8}

3.4. Enhancing the peer review experience through AI

Research publications are the cornerstone of scientific communication. Most scientific communities rely on peer review to ensure publication quality and to prioritize research outputs. This decentralized process involves independent reviewers evaluating whether a manuscript meets the field's standards whilst scrutinizing the content's quality.⁷¹ Although peer review is highly useful and extensively employed, it is a labor-intensive process that demands expertise and is susceptible to bias.^{72–74}

NLP and AI can significantly reform the peer review process for scientific articles, addressing various challenges and improving the overall quality of published research. By leveraging AI's capabilities, the peer review process can become unbiased, more efficient, accurate, and objective.^{75–77} A primary benefit of chatbots powered by AI systems, such as GPT-4, is their time-saving capabilities. Rapidly processing extensive information considerably decreases the time human reviewers spend assessing content. Furthermore, AI can streamline the review process by automating tasks such as plagiarism detection and data fabrication identification, thus, safeguarding research integrity.^{75,76} An additional benefit is the potential enhancement of peer review quality. AI systems can impartially examine the research design, methodology, and statistical analysis, offering a comprehensive evaluation. This thorough approach can result in precise assessments and valuable feedback for authors to refine their work. Moreover, AI can tackle conflicts of interest by delivering unbiased evaluations of research articles, ensuring the peer review process stays equitable and transparent by reducing human bias.^{72,74,75}

Nonetheless, the application of AI in peer review can come with its own set of challenges. One potential drawback is that these systems may lack complexity or context specific to certain research fields, leading to misunderstandings or omissions. Furthermore, AI could give rise to ethical dilemmas in cases such as biased algorithms and automating a process usually requiring and centered around human involvement. Lastly, implementing AI technology in peer review may face resistance from researchers and reviewers who are wary of replacing human

judgment with AI systems.⁷¹

AI-powered chatbots like ChatGPT can support journal editors in multiple ways. Managing routine tasks, such as addressing initial queries, organizing submissions, and sending reminders, allowing editors to concentrate on enhancing content quality, fostering relationships, and devising editorial strategies. Furthermore, chatbots can aid in language editing and proofreading, enabling editors to create or revise content and spot manuscript errors efficiently. Lastly, chatbots can personalize the publishing experience for authors and reviewers by analyzing their submission history and offering tailored guidance on manuscript preparation and evaluation, improving submission quality and reviewer feedback. The applications of using AI NLM in research are described in Fig. 2.

4. Conclusion

The emergence of AI and chatbots resembles the early days of the internet in the 1980s, starting small and gradually integrating into our lives. Adapting to these technologies while implementing strict regulations and guidance to safeguard users from potential harm is crucial. In conclusion, integrating AI and NLP in education and research presents both opportunities and challenges that must be carefully managed. As the education and research landscape evolves, adopting AI tools and innovative learning approaches is vital for cultivating a flexible and adaptive environment. A thoughtful, balanced, integrated combination of AI and human support can develop comprehensive support systems that benefit researchers, educators, and students across various domains. To guarantee the effective adoption and responsible use of AI technologies, including relevant courses in the curriculum, organizing webinars on AI's impact on education and research, and providing essential resources can facilitate the smooth incorporation of AI into our lives.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used [Chatsonic/GPT4] in order to [edit and change format of the paper]. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Declaration of competing interest

The authors have declared no conflict of interest.

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