The Utilization of Artificial Intelligence in Scientific Writing Education

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Abstract

Scientific writing is an essential skill for students in completing their studies. However, many students face challenges in academic writing. The integration of Artificial Intelligence (AI) in learning scientific writing is becoming increasingly important. This article aims to explore the domain of AI in scientific writing education. The method used in this research is a systematic review of Scopus databases published from 2020 to 2024. This study focuses on the application of AI in scientific writing education. The review identified 29 studies on AI implementation in scientific writing learning, encompassing: 1) real-time guidance and feedback, 2) development of writing skills and adaptive learning, 3) writing efficiency and productivity, 4) inspiration and reference resources, 5) analysis of writing quality and data, 6) development of critical thinking and digital literacy, 7) personalized learning and access to information, 8) reference resources and self-study, and 9) collaboration and interaction in the writing process. AI is significantly utilized across various domains in scientific writing education. However, the use of AI in this context should consider ethical aspects. Further research and development are crucial to address emerging challenges and ethical considerations.

INTRODUCTION

The rapid advancement of technology has had a profound impact on various areas of life, including education (Zawacki-Richter et al., 2019; Shafique et al., 2023). One significant development is the utilization of AI in scientific writing education. AI offers a range of conveniences and innovations in learning, benefiting both students and educators (Chen et al., 2020). Moreover, AI enhances the effectiveness of learning, fostering a more adaptive, diverse, inclusive, and data-driven educational environment (Du Boulay, 2016; Tapalova & Zhiyenbayeva, 2022; Liu et al., 2022; Hamal et al., 2022; Kshirsagar et al., 2022; Dogan et al., 2023). Therefore, it is essential to examine the extent to which AI is being applied in learning, specifically in the realm of scientific writing education.

AI-based scientific writing instruction can be implemented through various activities aimed at improving scientific writing skills. AI can be employed in different learning formats, such as online individual guidance and automated assessments (Grivokostopoulou et al., 2017; Tang et al., 2023). A tangible example of AI application is e-learning platforms that provide recommendations to students to improve their competencies. Additionally, AI enables responsive communication to enhance scientific writing skills.

It is necessary to reassess the impact of AI-based scientific writing education. Despite the numerous benefits AI offers in learning, it is important to consider its broader implications (Popenici & Kerr, 2017), including ethical and practical challenges (Adıgüzel et al., 2023), as well as technological disparities across different regions. Another concern is the risk of over-reliance on AI, which may diminish the educator's role as an empathetic guide.

The use of AI in scientific writing education should be positioned as a learning support tool rather than a replacement. Educators remain central to the learning process, with AI serving to enhance efficiency and speed. However, educational values and character-building should not be overshadowed by AI, ensuring its sustainable application (Kamalov et al., 2023). Thus, it is crucial to emphasize a balanced, wise relationship between humans and machines.

The findings indicate that while AI applications in education are widespread, there is a need for further reflection on its impact. Therefore, this article specifically reviews the use of AI in scientific writing education, examining the extent to which AI has been utilized and how it is ethically employed to enhance the quality of scientific writing.

METHOD

A systematic review was conducted to evaluate the use of artificial intelligence (AI) in scientific writing education. This method involved four steps. The first step was a literature search, aimed at gaining a broad understanding of AI applications in scientific writing education. The second step defined inclusion and exclusion criteria to refine the search results. At this stage, limits were set to narrow down the findings according to research needs, such as focusing only on Scopus-indexed studies published between 2020-2024. This ensures that the analyzed data are relevant and aligned with the research focus. The third step involved data extraction and synthesis, where key details from each study—such as research focus, main findings, and AI usage in scientific writing instruction—were collected. In the fourth step, a detailed analysis of the obtained information was carried out. This stage involved a deeper examination of the extracted data to identify the research focus, main findings, and AI applications in scientific writing education. This analysis allows researchers to draw conclusions about the extent to which AI effectively supports scientific writing skills and to identify areas that require further study. These steps are illustrated in Figure 1.

Figure 1. Literature Study Stages

RESULTS AND DISCUSSION
Nine Academic Domains of AI in Scientific Writing Instruction

A search of scientific articles through Scopus yielded a total of 44 relevant studies. Of these, 29 articles were selected for their direct relevance to the use of AI in scientific writing instruction. A qualitative analysis of these articles identified nine distinct domains of AI application in scientific writing education, each characterized by unique attributes. Further details can be found in Table 1.

Table 1. Scientific Articles Focused on AI Applications in Scientific Writing Instruction

No.	Authors and Year	Title	Main Focus	Key Findings	Utilization of AI in Writing Education
1.	Razack (2021)	Artificial intelligence-assisted tools for redefining the communication landscape of the scholarly world	The primary focus of this research is to explore how artificial intelligence (AI)-based technology can assist in updating and revolutionizing academic communication in scientific writing.	Enhancing Writing Efficiency, Adapting to Academic Standards, Plagiarism Detection, and Improving Scientific Accessibility.	Real-Time Guidance, Personalized Learning, and Writing Quality Analysis.
2.	Kim (2022)	Teacher's Perceptions of Using an Artificial Intelligence-Based Educational Tool for Scientific Writing	Exploring teachers' perspectives on the effectiveness, challenges, and opportunities offered by AI tools in supporting students' scientific writing, as well as the potential integration of AI into the teaching process.	Positive Perspectives on AI Effectiveness, Challenges in AI Utilization, and Opportunities for Further Development	enhancing scientific writing and providing suggestions for paragraph development.
3.	Hyder (2022)	An Artificial Intelligence Method for the Analysis of Marketing Scientific Literature: An Abstract	Introducing an efficient analysis method to extract and organize information from the extensive body of scientific research available in the marketing domain.	The application of AI to automate the literature review process, which typically demands substantial time and effort if conducted manually.	Automated analysis, AI tool usage, AI-based feedback.
4.	Sallam (2023)	ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns	Evaluating the Utility of ChatGPT in Health Education, Scientific Research, and Medical Practice	The Potential of ChatGPT in Education, Application in Research, and Validity Concerns	Supporting Draft Writing, Enhancing Structural Understanding, and Providing Automated Feedback
5.	Macdonald (2023)	Can ChatGPT draft a research article? An example of population-level vaccine effectiveness analysis	ChatGPT's capabilities in assisting with the composition of a scientific article can be exemplified by its application in analyzing the effectiveness of vaccines at the population level.	ChatGPT is capable of generating a well-structured draft of a scientific article, including essential sections such as the introduction, methodology, results, and discussion.	ChatGPT has potential applications in scientific writing education by providing examples of fundamental article structures, assisting with grammar, and offering input on sentence construction.

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6.	Herbold (2023)	A large-scale comparison of human-written versus ChatGPT-generated essays	Comparing the quality of essays written by humans with those generated by ChatGPT reveals distinct differences.	Human-written essays exhibit higher quality in terms of originality and nuance. Readers tend to show greater appreciation for human-produced work, while the perceived utility of AI in writing is significant, particularly in terms of enhancing writing skills, efficiency, and facilitating adaptive learning.	Writing Assistance: This includes the development of writing skills, improved efficiency, and adaptive learning experiences.
7.	Xie (2023)	Evaluation of the Artificial Intelligence Chatbot on Breast Reconstruction and Its Efficacy in Surgical Research: A Case Study	The effectiveness of artificial intelligence (AI)-based chatbots in the context of breast reconstruction and surgical research.	Effectiveness in terms of information accuracy, patient interaction, quality enhancement in research, and user satisfaction.	Information accessibility, skill development in writing, data collection, and feedback provision.
8.	Kim (2023)	Application of artificial intelligence chatbots, including ChatGPT, in education, scholarly work, programming, and content generation and its prospects: a narrative review	Exploring the application of artificial intelligence-based chatbots, including ChatGPT, across various fields, particularly in education, scholarly work, programming, and content generation.	Enhanced learning, content creation, ease of information access, and challenges in ethics and security.	Support in writing, instant feedback, resource provision, and the development of critical skills.
9.	Cacciuttolo (2023)	Research Thesis for Undergraduate Engineering Programs in the Digitalization Era: Learning Strategies and Responsible Research Conduct Road to a University Education 4.0 Paradigm	Investigating effective learning strategies and responsible research practices in the context of undergraduate engineering programs in the digital era.	Effective learning strategies, responsible research practices, and student engagement.	Writing assistance, data analysis, and personalized learning tools.
10.	Zaky (2023)	Chatbot Positive Design to Facilitate Referencing Skills and Improve Digital Well-Being	Designing and developing artificial intelligence (AI)-based chatbots to assist with academic referencing skills.	The use of AI-based chatbots has significantly improved students' referencing skills.	A chatbot specifically designed to facilitate the referencing process.
11.	Veras (2023)	Usability and Efficacy of Artificial Intelligence	Evaluating the usability and effectiveness of this	Describing the methodology to be used to measure	ChatGPT is used as a tool to provide automated

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		Chatbots (ChatGPT) for Health Sciences Students: Protocol for a Crossover Randomized Controlled Trial	AI chatbot in supporting learning, particularly in the development of scientific writing skills.	ChatGPT's effectiveness.	feedback, aid in idea generation, correct grammar, and suggest improvements for academic content development.
12.	Williams (2023)	Can ChatGPT pass Glycobiology?	The capabilities of AI models, specifically ChatGPT, in understanding and addressing tasks related to glycobiology.	ChatGPT has certain limitations in understanding deep scientific concepts in the field of glycobiology.	ChatGPT is employed as an aid in scientific writing by quickly responding to scientific questions and generating draft texts on glycobiology-related topics.
13.	Platt (2023)	Effectiveness of Generative Artificial Intelligence for Scientific Content Analysis	Effectiveness of the Use of Generative Artificial Intelligence in Scientific Content Analysis	Generative AI Generative AI can effectively support the process of analyzing scientific content by enhancing the speed and accuracy of understanding the structure of scientific texts.	Generative AI is employed as a tool in the scientific writing learning process, providing automated suggestions and feedback to authors.
14.	Gandhi (2023)	Does AI's touch diminish the artistry of scientific writing or elevate it?	The involvement of artificial intelligence (AI) in the scientific writing process can impact the quality and artistry of scientific writing itself.	AI has the capability to improve efficiency and accuracy in the scientific writing process, particularly in tasks such as editing, reference management, and error checking.	AI can be utilized in scientific writing education to assist students in honing technical skills such as grammar, sentence structure, and writing format.
15.	Silva (2023)	ChatGPT: a tool for scientific writing or a threat to integrity?	The potential of ChatGPT as an assistive tool in scientific writing raises questions about whether its use poses a threat to academic integrity.	ChatGPT has proven effective in helping writers organize ideas, develop outlines, and provide preliminary references for research.	ChatGPT holds significant potential in scientific writing education, especially for novice writers or researchers whose native language is not English.
16.	Silva (2023)	What if ChatGPT wrote the Abstract? - Explainable Multi-Authorship Attribution with a Data Augmentation Strategy	The use of AI models, particularly ChatGPT, for generating abstracts in the context of scientific writing.	The effectiveness of AI in Abstract Writing, Multi-Author Attribution, and Data Augmentation.	Sources of Inspiration and References, Enhancement of Creativity, Author Attribution Understanding, and Training and Feedback.
17.	Hobbs-Koch (2023)	Planning and Developing An Online English	Planning and developing an online English	Context and development needs, course design,	Writing aids, feedback analysis,

No.	Authors and Year	Title	Main Focus	Key Findings	Utilization of AI in Writing Education
		Writing Course For Computer Science: A Practical Guide	writing course specifically designed for computer science students.	teaching methods, and evaluation.	and personalized learning.
18.	Salas-Pilco (2023)	Correction to: Artificial Intelligence and Learning Analytics in Teacher Education: A Systematic Review	A systematic review of the use of Artificial Intelligence (AI) and learning analytics in teacher education.	Integration of AI in teacher education, enhancement of teaching skills, and learning analytics.	Development of writing tools, enhanced feedback, and performance analysis.
19.	Li (2023)	AI-based ChatGPT Impact on Medical Writing and Publication	Exploring the impact of using ChatGPT, a language-based AI model, in medical writing and publication.	Enhancement of writing quality, time efficiency, accessibility, and increased collaboration.	Learning tools, practical exercises, reference resources, and self-directed learning.
20.	Inam (2024)	A review of top cardiology and cardiovascular medicine journal guidelines regarding the use of generative artificial intelligence tools in scientific writing	Reviewing guidelines from leading journals in cardiology and cardiovascular medicine regarding the use of generative artificial intelligence (AI) tools in scientific writing.	Variations in guidelines, ethics and transparency, and quality and validity.	Data collection and processing, drafting initial drafts, and using appropriate language.
21.	Zangrossi (2024)	Large language model, AI and scientific research: why ChatGPT is only the beginning	Exploring the role and potential of large language models (LLMs) like ChatGPT in the context of scientific research.	Revolution in scientific research, human-AI collaboration, and ethical challenges.	Assistance in writing, learning critical skills, information access, and hypothesis development.
22.	Reddy (2024)	Implementation and Evaluation of a ChatGPT-Assisted Special Topics Writing Assignment in Biochemistry	Implementing and evaluating the use of ChatGPT in specialized writing assignments in biochemistry.	Improvement of assignment quality, student motivation, instant feedback, and AI limitations.	Generating initial ideas, enhancing article writing skills, and encouraging self-directed learning.
23.	Akpan (2024)	Conversational and generative artificial intelligence and human–chatbot interaction in education and research	Exploring the interaction between humans and generative AI-based chatbots in educational and research contexts.	Enhanced interaction, personalized learning, accessibility, and research support.	Writing guidance, real-time feedback, reference sources, and writing practice.
24.	Ghimire (2024)	Implications of ChatGPT for higher education institutions: exploring Nepali university students' perspectives	Exploring university students' perspectives in Nepal on the use of ChatGPT in higher education.	Positive and negative views, curriculum integration, challenges, and policies.	Writing guidance and support, reference sources, and enhancement of digital literacy skills.
25.	Liu (2024)	Toward Practical Hermeneutics of	Exploring and developing practical	Integration of AI and science, practical	Improvement of writing quality, data

No.	Authors and Year	Title	Main Focus	Key Findings	Utilization of AI in Writing Education
		Fourth Paradigm AI for Science	hermeneutics in the context of Fourth Paradigm AI for science.	hermeneutics, and ethical and epistemological implications.	and reference analysis, and adaptive learning.
26.	Algahtani (2024)	A comparative study of ai-based educational tools: evaluating user interface experience and educational impact	Comparing various AI-based educational tools by assessing user interface experience and educational impact.	User interface experience, educational impact, and suitability to user needs.	Improving writing quality, personalizing learning, and fostering independence
27.	Prachnakorn (2024)	Incorporating artificial intelligence into a workshop on scientific and scholarly report writing for preclinical medical students	Exploring the integration of artificial intelligence (AI) in training for scientific and academic report writing for preclinical medical students.	Improvement of writing quality, feedback, and learning adaptation.	Text analysis, adaptive learning systems, and writing simulation.
28.	Caluori (2024)	Hey Alexa, why are you called intelligent? An empirical investigation on definitions of AI	Understanding and defining artificial intelligence (AI) from the user perspective, particularly in the context of interaction with virtual assistants like Alexa.	Definitions of intelligence, influence of interaction, and negative perceptions.	PeDevelopment of learning materials, user interaction, and skepticism and critique.
29.	Bernardino (2024)	The Use of ChatGPT in Improving and Reviewing Scientific Paper Writing: An Exploratory Study	Exploring the use of ChatGPT as a tool to enhance and review scientific paper writing.	Effectiveness of ChatGPT, enhancement of writing skills, student perceptions, limitations, and challenges.	Real-time feedback, additional learning resources, and development of critical skills.

Based on Table 1, the results presented in this study indicate that the use of artificial intelligence (AI) in scientific writing education has demonstrated numerous significant benefits. Key findings from various studies highlight efficiencies in writing, improvements in writing quality, instant feedback, and the capacity for personalized tutoring. AI has also proven to support the creative process in structuring content, enhancing grammar, and assisting students and researchers in understanding the framework of scientific writing.

Despite the considerable potential of AI, there are also several challenges, such as ethical concerns and the validity of AI usage, as well as limitations in AI's ability to comprehend complex scientific concepts. Nevertheless, overall, AI plays a crucial role in supporting independent learning, enhancing information accessibility, and fostering collaboration between humans and machines in scientific writing.

Furthermore, based on Table 1, the application of AI in scientific writing education can be categorized into nine domains. These nine domains include: real-time guidance and feedback, development of writing skills and adaptive learning, writing efficiency and productivity, sources of inspiration and references, analysis of writing quality and data, development of critical skills and digital literacy, personalized learning and information access, resources for reference and self-directed learning, and collaboration and interaction in the writing process. Further details can be found in Table 2.

Table 2. Nine Domains of AI Utilization in Scientific Writing Education

No.	Academic Domain of AI	Function of AI in Scientific Writing Education
1.	Guidance and Real-Time Feedback	ChatGPT and other AI tools are utilized to provide instant feedback to writers regarding grammar, sentence structure, content development, and writing format. This significantly aids in enhancing the quality of writing and supports the revision process efficiently.
2.	Development of Writing Skills and Adaptive Learning	AI can facilitate writers in developing scientific writing skills by offering practical exercises and personalized training tailored to the user's needs. Adaptive learning through AI enables beginner writers or non-native speakers to hone their writing skills.
3.	Writing Efficiency and Productivity	By employing generative AI tools like ChatGPT, writers can draft initial versions more rapidly. This tool also assists in responding to scientific inquiries and generating drafts based on specific topics, such as glycopbiology.
4.	Source of Inspiration and References	AI can serve as a source of inspiration for initial writing ideas and provide quick access to relevant information and references. AI chatbots can be specifically employed to facilitate the referencing process and manage academic resources.
5.	Analysis of Writing Quality and Data	AI can be utilized to analyze the overall quality of writing, such as the clarity of arguments, appropriate use of data, and writing structure. AI tools are capable of processing data and delivering performance analysis of writing based on specific academic standards.
6.	Development of Critical Skills and Digital Literacy	In addition to assisting with the technical aspects of writing, AI also plays a role in developing writers' critical skills, encouraging reflection, skepticism, and deeper analysis of the written content. Writers' digital literacy is further enhanced through ongoing interaction with AI tools.
7.	Personalized Learning and Information Access	AI offers personalization in writing education, providing training and feedback according to the specific needs of each writer. This aids in facilitating faster and more effective development, particularly for novice writers.
8.	Reference Resources and Self-Directed Learning	AI tools provide supplementary references and self-directed learning resources that allow writers to explore topics in greater depth with minimal reliance on direct instructors. AI also offers continuous guidance in writing practice and argument formulation.
9.	Collaboration and Interaction in the Writing Process	AI facilitates collaboration between writers and tools through ongoing user interactions. This encourages reflection, skepticism, and critical exploration throughout the writing and idea development process.

Based on Table 2, the use of AI, particularly ChatGPT, in the scientific writing process offers various significant benefits. AI provides real-time feedback that supports rapid revisions and enhances writing quality. AI tools assist in the development of writing skills through personalized adaptive learning, which is particularly beneficial for novice writers or non-native speakers. Writing efficiency is also improved with the assistance of AI, enabling quicker drafting and scientific responses. Each domain's explanation is presented below.

Guidance and Real-Time Feedback

The utilization of AI in learning provides effective guidance and feedback. ChatGPT and other AI tools are employed to deliver instant feedback to writers regarding grammar, sentence structure, content development, and writing format. AI-based feedback is effective in enhancing learning (Sinclair et al., 2020). AI feedback is timely and personalized, helping to improve writing competence through various revisions (Nazari et al., 2021; Hwang et al., 2023; Liu et al., 2023; Shen et al., 2023). Therefore, the role of AI in writing education, particularly in providing feedback, should be considered, as it has proven to offer substantial benefits.

AI-supported feedback encourages effective collaboration in learning (Porter & Grippa, 2020). In fact, AI-supported feedback increases digital collaboration among students by 19.60% and enhances self-efficacy (Sharma et al., 2023). Furthermore, it improves academic abilities by up to 95.32%(Xu et al., 2021). Feedback can also enhance personalized learning and adaptation to students (Kamruzzaman et al., 2023). Real-time

feedback can accelerate students' learning by helping them improve assignments based on the feedback provided (Oyekan et al., 2017).

Development of Writing Skills and Adaptive Learning

AI can facilitate writers in developing their scientific writing skills by providing practical exercises and personalized training tailored to user needs. AI also enhances writing abilities and motivation, evident in organization, coherence, grammar, and vocabulary (Song & Song, 2023; Marghany, 2023). AI-based adaptive learning enhances independent learning processes (Essa et al., 2023). Furthermore, students' perceptions of AI use in learning are generally positive.

AI-based scientific writing learning assists students in planning research more effectively, but it has yet to improve content quality (Utami et al., 2023). These findings indicate that, in this context, AI use remains limited to supporting the planning stages of research. To enhance quality, students need to strengthen their argumentative skills. This is crucial as research quality depends on how arguments are constructed based on the data collected. Therefore, adaptive learning that supports students' skill development is essential.

Writing Efficiency and Productivity

By using generative AI like ChatGPT, writers can draft initial versions more rapidly. AI in writing education significantly saves time by 40% and improves writing quality by 18% (Noy & Zhang, 2023). Additionally, AI enhances writing efficiency and quality through recommended guidelines and writing refinements (Shi et al., 2023). Therefore, the extensive and professional use of AI in writing within the educational realm necessitates the development of AI literacy, focusing on applications, accountability, and agency (Cardon et al., 2023).

AI in scientific writing instruction enhances efficiency in academic writing (Waltersmann et al., 2021). This indicates that AI-supported scientific writing instruction improves efficiency and productivity in writing. This is crucial for students in scientific writing, as AI assistance enables faster writing. However, attention must be paid to the ethics of scientific writing.

Sources of Inspiration and References

AI can serve as a source of inspiration for initial writing ideas while providing quick access to relevant information and references. AI can inspire creative idea generation. Furthermore, AI produces high-quality text and efficiently summarizes information (Semrl et al., 2023). Thus, AI can be leveraged to explore and develop inspiration, serving as a reference in writing.

Analysis of Writing Quality and Data

AI can be utilized to analyze overall writing quality, such as clarity of argumentation, appropriate data usage, and writing structure. AI can enhance the content and organization of students' writing (Marzuki et al., 2023). Moreover, AI can benefit both high- and low-ability students, leading to significant improvements in their written outputs (Woo et al., 2024). Additionally, AI can be employed to enhance data validation and integrity (Whang et al., 2023). AI has demonstrated its capability to improve writing quality, particularly in content and organization.

Development of Critical Skills and Digital Literacy

In addition to assisting with technical writing aspects, AI also plays a role in developing writers' critical skills, encouraging reflection, skepticism, and deeper analysis of the written content. Writers' digital literacy improves through continuous interaction with AI tools. The responsible use of AI can be leveraged to develop critical thinking skills (Tropea et al., 2023). Critical thinking ability in scientific writing is essential. Furthermore, critical thinking skills and scientific writing are closely linked and contribute to producing high-quality scientific work (Dowd et al., 2018). Additionally, critical thinking skills can be enhanced through writing and digital literacy abilities (Cintamulya et al., 2023).

The development of critical thinking in scientific writing is important because students engage in in-depth analysis of research data in scientific writing. Therefore, thoughtful collaboration in using AI for scientific writing is crucial to maintain the originality of the work produced (Stephenson & Sadler-McKnight, 2016; Carobene et al., 2024). Thus, it is essential to foster critical thinking skills and uphold integrity in the use of AI (Rusandi et al., 2023).

Personalized Learning and Information Access

AI offers personalization in writing education, providing training and feedback according to each writer's specific needs. AI can deliver content tailored to students' requirements (Maghsudi et al., 2021). It can support students by understanding their characteristics and needs in alignment with their learning styles (Sajja et al., 2023). Based on these findings, AI-mediated writing instruction can be utilized to enhance students' learning needs, tailor necessary teaching materials, adjust the curriculum, assess students' abilities, and provide more unrestricted access beyond spatial and temporal limitations.

Reference Resources and Independent Learning

AI tools provide additional references and independent learning resources, allowing writers to explore topics more deeply with less reliance on direct instruction. AI also offers ongoing guidance in writing exercises and argumentation. Furthermore, AI-based independent learning is cost-effective (Korot et al., 2023). The proposed AI-based learning scheme in educational psychology aims to improve student learning outcomes by providing adequate resources tailored to students' needs (Wei et al., 2021). The use of AI in learning enables more adaptive and student-centered learning that aligns with students' individual requirements (Dogan et al., 2023).

This suggests that AI-mediated learning can provide diverse resources and accommodate students' needs in their learning process. Diverse resources in the digital era are essential and should be considered by both instructors and students. This is closely related to students' learning needs, as limited resources may reduce students' interest due to their mismatch with students' specific needs.

Collaboration and Interaction in the Writing Process

AI facilitates collaboration between writers and tools through ongoing user interactions. This encourages reflection, skepticism, and critical exploration in the writing process and idea development. Thus, AI can serve as a collaborative tool that enhances writing quality (Coenen et al., 2021). Collaborative scientific writing with AI enhances efficiency and teamwork, allowing time to focus on critical thinking skills, analysis, social intelligence, and creativity (Bergstrand et al., 2023). Additionally, it aids students in acquiring complex and multimodal communication skills essential for computer-mediated scientific writing (Nguyen et al., 2024). This suggests that AI in education can serve as a tool or collaborative partner in scientific writing. The use of collaborative AI is expected to improve the quality of writing, both in terms of language and the content of a scientific work.

CONCLUSION

Based on the results and discussion, AI has emerged as a crucial tool in enhancing the effectiveness of scientific writing education. The role of AI in scientific writing education, as reviewed in this study, is utilized across nine domains, including: real-time guidance and feedback, development of writing skills and adaptive learning, writing efficiency and productivity, sources of inspiration and reference materials, quality analysis of writing and data, development of critical skills and digital literacy, personalization of learning and access to information, resources for reference and self-directed learning, and collaboration and interaction within the writing process. However, the application of AI in scientific writing education necessitates careful consideration of ethical writing aspects. Furthermore, it is essential for educational institutions to leverage AI to enhance the effectiveness of scientific writing education.

This study recommends that students using AI as a tool for scientific writing should first master fundamental skills, namely thinking-centered learning, ethical considerations of AI in scientific writing, techniques for utilizing AI, and guidelines on when AI should or should not be applied. Additionally, students should pay attention to legal aspects, engage in reflection related to learning objectives, and treat AI as an aid rather than the primary resource.

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