

The Practice of Enhancing Learning and Scientific Innovative Abilities Using LLM-based AI Tools

Bingshu Wang
School of Software
Northwestern Polytechnical
University
Xi'an, China
wangbingshu@nwpu.edu.cn

Xin Zhang
School of Software
Northwestern Polytechnical
University
Xi'an, China
2021302814@mail.nwpu.edu.cn

Shuyi Li
Department of Information
Science
Beijing University of Technology
Beijing, China
syli2022@bjut.edu.cn

Yimeng Wang*
School of Software
Northwestern Polytechnical
University
Xi'an, China
Corresponding author:
ymym@mail.nwpu.edu.cn

Abstract—With the explosive growth of data and the rapid development of artificial intelligence(AI) technology, scientific research requires to process a large amount of information. Recently AI tools based on large-scale language models (LLM) have emerged, providing researchers with new problem-solving ways. In this paper, we focus on the application of AI tools in the field of scientific research, and conduct a comprehensive analysis of LLM-based AI tools. Firstly, we introduce different types of LLM softwares and analyze their characteristics and advantages. Next, we select some typical cases, explore the value and limitations of these tools in practice. Moreover, we summarize the main findings of the existing study and suggest some possible research directions in future. It is expected that this paper can provide reference and guidance for the use of AI tools in scientific and educational research.

Keywords—artificial intelligence, scientific innovative abilities, large language models, research efficiency

I. INTRODUCTION

With the arrival of the "Fourth Industrial Revolution", revolutionary changes have taken place in production technology, especially the rapid development of artificial intelligence and the Internet, which has profoundly changed higher education. In the recent years, the emergence of large language models (LLM), such as GPT (Generative Pre-trained Transformer), LaMDA (Language Models for Dialog Applications), BERT (Bidirectional Encoder Representations from Transformers), and so on, has brought significant transformations in the field of artificial intelligence (AI) [1].

These LLMs, which were trained by large amounts of text data, have excellent language comprehension and generation capabilities, including answering questions, generating human-like responses in conversations, summarizing text, and translating language, etc [2]. As a result, LLMs have not only become a revolutionary force in various fields of the society, but also provide brand new thinking and supporting tools for the scientific research field. Such AI techniques have been applied into education [3]-[7]. This paper specially focuses on how to use AI tools for researchers when learning and research is limited. In the practical research work, scientific researchers and engineers are often confused how to find the latest ideas and hot topics[8]. They have to struggle with the vast number

of literatures. Therefore, to improve the working efficiency, it is essential for people to know how to utilize LLM-based AI tools in the field of education.

Traditional learning and scientific research tends to search literatures from electronic databases, organize people to analyze them and discuss together, and finally output some conclusions. This way takes much time and it is hard to meet personalized needs. With the large amount of knowledge and publications springing out every day, it is difficult for people to manage and summarize these literatures. Thus, it requires an intelligent method to finish the task [9]. The LLM-based AI tools can quickly discover the required information in a large number of literatures, provide personalized support to researchers, and greatly save researchers' time.

With the help of LLMs, researchers can simplify the steps of research, including literature search, data analysis, and even manuscript writing [10]. These AI tools are expected to change the way of research, making it more efficient, collaborative, and influential. This is positive effects. However, some potential risks should be noticed [11]. The intelligence level of these tools is not comparable to that of human beings. People need to have their own judgement abilities to select the results generated by LLM-based tools [12]-[14].

In this paper, we firstly summarize the mainstream LLM-based AI tools. Specially, the advanced AI softwares and their links are highlighted to provide researchers a straightforward understanding. Then, we deepen case studies and conduct a comparative analysis to assess the effectiveness and limitations of these tools in real research situations. Lastly, we share some key findings and insights, propose some emerging trends for research and development in this rapidly growing field.

II. LLM-BASED AI TOOLS

According to their functions and application areas, LLM-based AI tools can be divided into four categories, including literature analysis tools, literature search tools, paper writing tools, and comprehensive scientific research tools [13], [14]. These tools have their own characteristics and advantages. Fig. 1 outlines the framework of the impact of AI tools on research work. These AI tools can effectively assist researchers in scientific research and improve their efficiency.

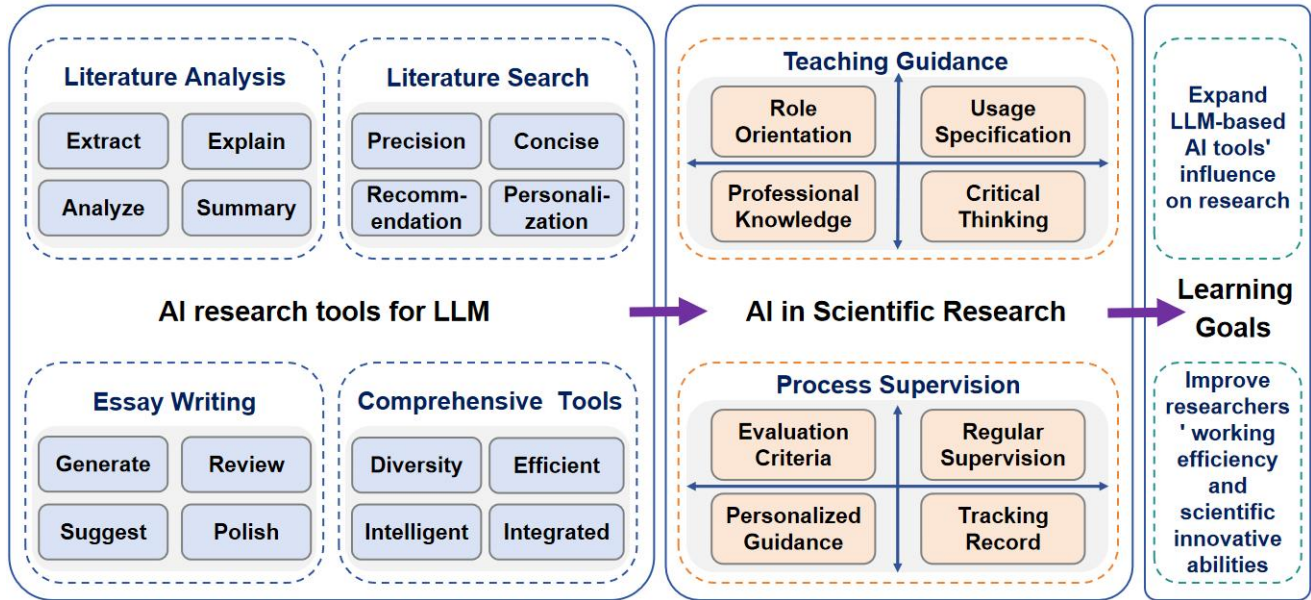


Fig. 1. Research framework on the impact of AI tools on scientific research

A. The Usage Situation of LLM-based AI Tools

We have conducted a questionnaire about the use of LLM-based AI tools. Some visual analyzed results are presented in Fig. 2 and Fig. 3. The questionnaire contains 19 questions. It primarily faces undergraduates, postgraduate students in University from February to March in 2024. Finally, we received 57 survey responses.

It can be seen from Figure 2 that 72.22% of teachers and students are supported by such AI tools, while only 2.78% people disagreed with this statement. As far as the Q2 in questionnaire, more than 50% of people agree that the use of LLM-based AI tools can improve their reputations. Overall, most people have a positive attitude towards the use of LLM-based AI tools.

Among the various AI tools, ChatGPT is the most popular tool, with 82.46% usage from teachers and students in university. The second type of most used tools are online course platforms (70.18%), and followed by intelligent learning type tool (49.12%). Students are more likely to use these tools to finish academic tasks and daily assignments. When students are under academic pressure, they will select to employ AI tools as assistant to improve their efficiency. The questionnaire results verify it. The proportion of students using AI tools for intelligent tutoring, homework consultation, and research assistance exceeds 60%. Even some people have a strong demand and dependence on AI tools [15], [16].

However, although students often use AI tools, they are only familiar with the basic functions. The advanced functions are only used within a small proportion. This limits students' learning and academic abilities. Making full use of LLM-based AI tools can strengthen the learning and innovative abilities, and help them adapt to the future work environment.

B. Representative AI Tools for Scientific Research

Currently, LLM-based AI tools have been widely used in the field of scientific research and daily learning. Table I summarizes a series of AI tools for scientific research. These tools are summarized from the Internet including the homepages and related literature. It is believed that new tools are generated day by day. Herein, we list some typical LLM-based AI tools for scientific research.

These tools are categorized into four types, literature search tools, literature analysis tools, paper writing tools, and comprehensive scientific research tools. Detailed analysis and discussions about their characteristics are presented as follows.

1) Literature search tools

The semantic matching technology in Semantic Scholar is used to understand the user's search intention, and provide personalized recommendation of literature highly related to the query topic. It is suitable for quickly searching relevant literature and locating the latest and advanced research areas.

Elicit provides heuristic associations based on the input questions. It is able to recommend useful publications and give detailed analysis about the core ideas, the used datasets of these publications. Additionally, Elicit allows users to filter and sort publications by multiple dimensions, such as author, journal, and topic, making it easy to obtain required information.

2) Literature analysis tools

Explain Paper can efficiently extract and display the core information from papers. Users only need to select paragraphs to obtain synchronized explanations, which is very helpful for academic researchers to quickly grasp the core contents when facing a large amount of papers.

With the design of natural language processing technology and a user-friendly interface by ChatPDF, users can easily read and understand the contents of PDF files. It is suitable for users to interactively obtain information.

3) Paper writing tools

Grammarly is an assistant software that help people improve the quality of their papers through grammar checking, spell checking, and writing suggestions. It has obvious advantages in improving the accuracy and fluency of papers. Hemingway refines the contents, monitors and improves the writing style of papers, makes texts clearer. As a result, the modified papers are easier to understand.

4) Comprehensive scientific research tools

XingHuo Research Assistant is a comprehensive tool that provides one-stop literature searching, organizing, analyzing, and managing functions. It aims at helping researchers quickly obtain the latest academic papers and analyze the advanced topics. Love Academic is a comprehensive platform focusing on academic research, integrating the functions of literature search, paper writing, academic communication, etc. It also includes abundant academic resources and personalized recommendation services. This tool is developed to cover the whole process of academic research.

In summary, AI tools can greatly reduce the burden of researchers by providing intelligent services. These tools not only improve the efficiency of acquiring literature, but also support real-time parsing and discussion to promote knowledge sharing and exchange. Moreover, these tools can provide strong support in the process of paper writing and publication, and improve the quality of papers.

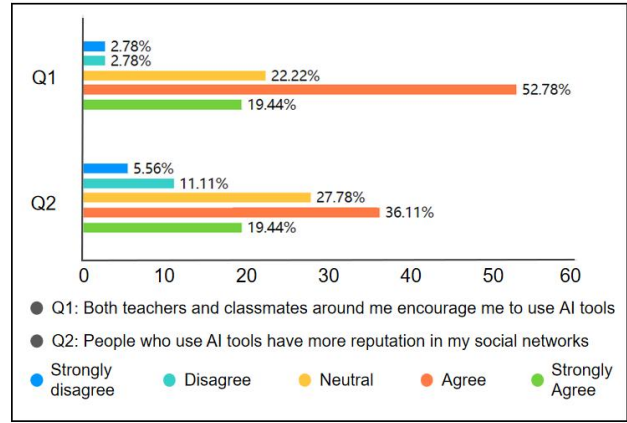


Fig. 2. Statistics on attitudes toward “social impact” of LLM-based AI tools for scientific research.

TABLE I. THE CLASSIFICATION AND STATISTICS OF LLM-BASED AI TOOLS FOR SCIENTIFIC RESEARCH

Type	Name	Link Address	Main Characteristics
Literature search tools	Semantic Scholar	https://www.semanticscholar.org/	Online intelligent literature retrieval.
	Elicit	https://elicit.com/	Heuristic associative retrieval.
	Consensus	https://consensus.app/	Integrating and analyzing multifaceted data, extracting the main theme.
	PubScholar	https://pubscholar.cn/	Abundant academic resources and networking opportunities.
	ChongBuluo	https://scholar.chongbuluo.com/	Integration of multiple mainstream academic search engines.
	Annual Reviews	https://www.annualreviews.org/	Compilation of latest research advances and review articles.
Literature analysis tools	Explain Paper	https://www.explainpaper.com/	Generate explanatory notes in sync with the article.
	ChatPDF	https://www.chatpdf.com/	Upload academic papers for discussion.
	Chat With Paper	https://chatwithpaper.org/	Generate summaries for multiple papers in bulk.
	SciSpace	https://typeset.io/	Popular explanation of abstract scientific concepts.
Paper writing tools	Paperpal, Grammarly	https://paperpal.com/ https://www.grammarly.com/	Real-time monitoring of written content, providing grammar checks and readability suggestions.
	Hemingway	https://hemingwayapp.com/	Tools for refining and optimizing academic papers.
	Wordtune	https://www.wordtune.com/	Tools for sentence restructuring and rewriting.
Comprehensive scientific research tools	XingHuo Research Assistant	https://paper.iflytek.com/research	All-in-one literature retrieval, organization, analysis, and management.
	Read Paper	https://readpaper.com/	Literature retrieval, reading, note-taking, and citation management.
	LoveXueshu	https://www.ixueshu.com/	Supports literature retrieval, filtering, and analysis functions.
	MaoMaochong	https://www.mymmc.cn/	Paper writing, reviewing, plagiarism checking, and intelligent matching of reference materials.
	QingNi XueShu	https://www.xueshuchuangxin.com/	Provides one-stop service for academic literature data analysis and intelligent academic writing.
	Aminer	https://www.aminer.cn/	An academic search engine that integrates literature retrieval, analysis, and citation analysis functionalities

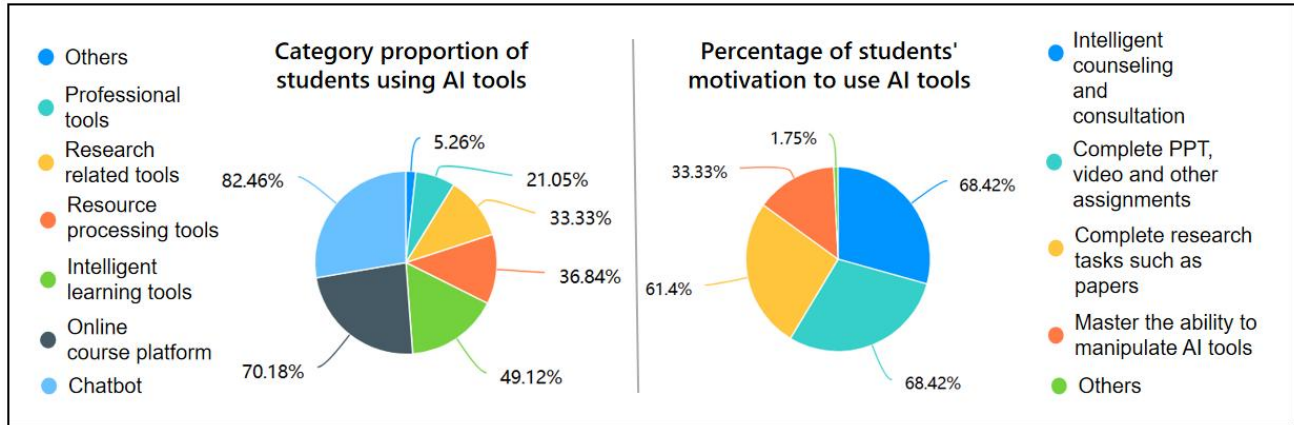


Fig. 3. Statistics on usage and motivation of scientific research AI tools.

III. PRACTICE AND DISCUSSION

In this section, we focus on how to effectively apply AI tools into scientific research practice, as well as the role and impact of these tools in the research process. We explore the application scenarios of AI tools in scientific research from both teaching and supervisory perspectives, and discuss the conveniences and potential challenges. Meanwhile, we investigate how to avoid the limitations of AI tools to fully develop their value in scientific research [17].

A. Teaching Guidance

The introduction of AI tools not only reduces the cost of learning for students, but also significantly improves the efficiency of scientific research. However, on the other hand, it also causes the problems that some students rely on AI tools too much, even blindly follow AI tools [18]. Therefore, it is particularly critical to guide students to make reasonable use of AI tools to support research [19].

1) Clarify the role of AI tools: AI tools should be regarded as supplementary aids rather than tools to replace students' thinking. Teachers should guide students to treat them as beneficial assistants.

2) Develop the norms for using AI tools: It includes regulations on the scope, and frequency of tools' usage. Meanwhile, academic integrity should be emphasized. Students must avoid abusing tools or being academic misconduct [20].

3) Combine AI tools with professional knowledge: teachers can teach students how to apply AI tools in their professional fields by case analysis and practical operation [21], [22]. Professional discussion is a good way to broaden their academic horizons.

4) Encourage innovation and critical thinking: Students are encouraged to critically examine the data and analysis provided by AI tools. Critical thinking ability is suggested to be trained by putting forward their own opinions [23].

B. Research Supervision

Considering the limitations of AI tools, we explore some corresponding improvement strategies, and avoid the possible adverse effects.

1) Develop clear assessment criteria and indicators: They may include usage frequency of tools, correctness, and academic integrity [24]. Teachers can effectively monitor and assess the situations of tools' usage.

2) Implement regular supervision and inspection: It is a good way for teachers to regularly supervise and check students through team discussions and practice reports. This can evaluate the actual effect of the LLM-based AI tools on scientific research.

3) Provide personalized feedback and guidance: For different problems in the process of using AI tools, teachers can provide valuable suggestions for students to help improve the usage effects of LLM-based AI tools [25].

4) Establish research archives and track records: By recording students' performance of using AI tools, it can help teachers find problems in time and give specific guidance.

In summary, LLM-based AI tools have great potential value in the field of scientific research. It requires people to obey rules and being self-discipline. By discovering these tools' advantages and making full use of them, it is believed that the learning and scientific research become an easy and comfortable work.

IV. CONCLUSION

In this paper, we mainly focus on the characteristics and applications of LLM-based AI tools in the field of scientific research. We summarize the mainstream tools for research and divide them into four types, literature search tools, literature analysis tools, paper writing tools, and comprehensive scientific research tools. It is expected to be useful for researchers even beginners to make use of these tools when facing a new direction or accomplishing a task. In future work, prompt can be combined with LLM-based AI models. It is a

promising research direction. This is beneficial for talent cultivation and scientific research.

ACKNOWLEDGEMENT

This work is supported by the Education and Teaching Reform Research Project of Northwest Polytechnical University, under the number 2024JGZ36.

REFERENCES

- [1] Han, W., & Ma, L. (2023). Challenges and Responses of Higher Education to ChatGPT. *Proceedings of the 9th International Conference on Economics, Management, Law and Education (EMLE)*, 125-132.
- [2] Zangrossi, P., Martini, M., Guerrini, F., & Spena, G. (2024). Large language model, AI and scientific research: why ChatGPT is only the beginning. *Journal of Neurosurgical Sciences*.
- [3] Hmoud, M., Swaity, H., Hamad, N., Karram, O., & Daher, W. (2024). Higher Education Students' Task Motivation in the Generative Artificial Intelligence Context: The Case of ChatGPT. *Information*, 15(1), 33.
- [4] Guo, K., Zhong, Y., Li, D., & Chu, S. K. W. (2023). Effects of chatbot-assisted in-class debates on students' argumentation skills and task motivation. *Computers & Education*, 104862.
- [5] Wu, R., & Yu, Z. (2024). Do AI chatbots improve students learning outcomes? Evidence from a meta - analysis. *British Journal of Educational Technology*, 55(1), 10-33.
- [6] Yilmaz, R., & Yilmaz, F. G. K. (2023). The effect of generative artificial intelligence (AI)-based tool use on students' computational thinking skills, programming self-efficacy and motivation. *Computers and Education: Artificial Intelligence*, 100147.
- [7] Zhou, L., & Li, J. J. (2023). The impact of ChatGPT on learning motivation: A study based on self-determination theory. *Educ Sci. Manag.*, 1(1), 19-29.
- [8] Wang, B., Liu, W., Dong, Y., & Luo, Z. (2022). The Practice of Literature Knowledge Mining and Analysis Management for Improving Students' Information Literacy. In *2022 4th International Conference on Computer Science and Technologies in Education (CSTE)* (pp. 202-206). IEEE.
- [9] Elbanna, S., & Armstrong, L. (2024). Exploring the integration of ChatGPT in education: adapting for the future. *Management & Sustainability: An Arab Review*, 3(1), 16-29.
- [10] Wang, B., Shen, M., Ma, C., & Zhao, Y. (2023). Designing A general information literacy course for first-year postgraduate students: Improving academical and innovative abilities. *Education and Information Technologies*, 1-15.
- [11] Borger, J. G., Ng, A. P., Anderton, H., Ashdown, G. W., Auld, M., Blewitt, M. E., ... & Naik, S. H. (2023). Artificial intelligence takes center stage: exploring the capabilities and implications of ChatGPT and other AI - assisted technologies in scientific research and education. *Immunology and Cell Biology*, 101(10), 923-935.
- [12] Meyer, J. G., Urbanowicz, R. J., Martin, P. C., O'Connor, K., Li, R., Peng, P. C., ... & Moore, J. H. (2023). ChatGPT and large language models in academia: opportunities and challenges. *BioData Mining*, 16(1), 20.
- [13] Borger, J. G., Ng, A. P., Anderton, H., Ashdown, G. W., Auld, M., Blewitt, M. E., ... & Naik, S. H. (2023). Artificial intelligence takes center stage: exploring the capabilities and implications of ChatGPT and other AI - assisted technologies in scientific research and education. *Immunology and Cell Biology*, 101(10), 923-935.
- [14] Lin, Z. (2023). Why and how to embrace AI such as ChatGPT in your academic life.
- [15] Polyportis, A. (2023). A longitudinal study on artificial intelligence adoption: understanding the drivers of ChatGPT usage behavior change in higher education. *Frontiers in Artificial Intelligence*, 6.
- [16] Yan, L., Sha, L., Zhao, L., Li, Y., Martinez - Maldonado, R., Chen, G., ... & Gašević, D. (2024). Practical and ethical challenges of large language models in education: A systematic scoping review. *British Journal of Educational Technology*, 55(1), 90-112.
- [17] Hasanein, A. M., & Sobaih, A. E. E. (2023). Drivers and Consequences of ChatGPT Use in Higher Education: Key Stakeholder Perspectives. *European Journal of Investigation in Health, Psychology and Education*, 13(11), 2599-2614.
- [18] Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro, D. E., Thierry-Aguilera, R., & Gerardou, F. S. (2023). Challenges and opportunities of generative AI for higher education as explained by ChatGPT. *Education Sciences*, 13(9), 856.
- [19] De Winter, J. C., Dodou, D., & Stienen, A. H. (2023). ChatGPT in Education: Empowering educators through methods for recognition and assessment. In *Informatics* (Vol. 10, No. 4, p. 87). MDPI.
- [20] Tayan, O., Hassan, A., Khankan, K., & Askool, S. (2023). Considerations for adapting higher education technology courses for AI large language models: A critical review of the impact of ChatGPT. *Machine Learning with Applications*, 100513.
- [21] Khlaif, Z. N., Mousa, A., Hattab, M. K., Itmazi, J., Hassan, A. A., Sanmugam, M., & Ayyoub, A. (2023). The potential and concerns of using AI in scientific research: ChatGPT performance evaluation. *JMIR Medical Education*, 9, e47049.
- [22] Liang, Y., Zou, D., Xie, H., & Wang, F. L. (2023). Exploring the potential of using ChatGPT in physics education. *Smart Learning Environments*, 10(1), 52.
- [23] Kong, W. (2023). Research on the Impact and Countermeasures of ChatGPT on Graduate Ideological and Political Education Work. *Advances in Educational Technology and Psychology*, 7(12), 16-21.
- [24] Dengel, A., Gehrlein, R., Fernes, D., Görlich, S., Maurer, J., Pham, H. H., ... & Eisermann, N. D. G. (2023). Qualitative Research Methods for Large Language Models: Conducting Semi-Structured Interviews with ChatGPT and BARD on Computer Science Education. In *Informatics* (Vol. 10, No. 4, p. 78). MDPI.
- [25] Fütterer, T., Fischer, C., Alekseeva, A., Chen, X., Tate, T., Warschauer, M., & Gerjets, P. (2023). ChatGPT in Education: Global Reactions to AI Innovations.