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CHALLENGES OF CHEMISTRY TEACHERS IN SCHOOLS

Abstract. This study explores the application of artificial intelligence (AI) in chemistry education through an extensive review of ten academic articles. AI's integration into chemistry education has led to the development of various educational tools, such as personalized learning platforms and virtual labs. These advancements have greatly contributed to enhancing student learning and teacher experiences. The primary activities facilitated by AI include creating and solving open-ended and multiple-choice questions, and answering questions and solving problems. However, the utilization of AI for laboratory work and making scientific predictions remains less common, suggesting these areas are more appealing to college and university students. Recommendations for future research include developing a comprehensive chemistry database to accurately answer complex questions, creating an all-inclusive AI chemistry application, and devising methods to calculate chemical problems using mathematical formulas. This would involve integrating these methods into AI to generate tasks with different formulas and calculations but identical final meanings. Implementing these suggestions could significantly improve students' chemistry skills and promote academic integrity. This study underlines the transformative potential of AI in education, particularly in the domain of chemistry, offering new avenues for enhancing learning outcomes and teaching efficiency.

Key words: Artificial intelligence, Chemistry education, AI in chemistry education

Introduction

As Stephen Haking say, "Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks."

Due to the infinity of the human thinking system, new innovative and technological changes are happening and developing in every century. One such technological innovation is artificial intelligence.

Artificial intelligence(AI) is an intelligent machine or software technology that can think at a human level thanks to a large database. Artificial intelligence (AI) is the basis of many service sectors that have adopted new information technologies (S. J. Russell, P. Norvig, 2016). People can use AI for different sides, like finding the answers of unclear questions; help to write assignments; editing the photos by writing details. Although the roots of artificial intelligence date back several decades, there is now a clear consensus that intelligent machines with learning, reasoning and adaptive capabilities are particularly important (Arrieta, A. B., Díaz-Rodríguez,2020). It is thanks to these features that AI methods are achieving unprecedented levels of performance when learning to solve increasingly complex computational tasks, which makes them crucial for the future development of human society (D. M. West, 2018). Recently, the complexity of AI-powered systems has grown so much that they do not require human intervention to design and deploy. When decisions from such systems ultimately affect people's lives, such as medicine, law or defense, there is a need to understand how such decisions can be supported by AI techniques.

Artificial intelligence (AI) is a field of research that combines applications of machine learning, algorithmic generation, and natural language processing Artificial intelligence applications are changing educational tools. AI has various educational applications such as personalized learning platforms that promote student learning, developed virtual labs, and bots that help with homework and projects. Although artificial intelligence has many benefits and advantages in improving student knowledge and teacher experience, it has not been properly applied at the ethical level (Akgun, S., & Greenhow, C., 2022).

Theoretical part

In the age of advanced science and technology, students and teachers are using artificial intelligence positively in the field of education and benefiting from it. As a chemistry teacher, I researched articles on the use of artificial intelligence in chemistry education.

Russian scientists Vladimir L. Kodkin, Ekaterina V. Artemeva (2024) described the progress and uses of neural networks, especially ChatGPT, in different areas like chemistry education and research in the article “ChatGPT: Application in Chemistry Education and Challenges”. It explains the advantages of artificial intelligence and ChatGPT, like their ability to handle large amounts of data, make personalized learning systems, and give suggestions for solving problems. It shows real-life examples of how ChatGPT can help improve learning in chemistry, like making tests, generating multiple-choice questions, studying chemistry topics, and writing scientific ideas in chemistry. It ends by discussing the exciting possibilities of AI to solve complex problems that might be beyond human abilities, opening doors for more research and collaboration between humans and intelligent machines.

From Ohio State University, scientist Ted M. Clark (2023) studied how well an artificial intelligence chatbot called ChatGPT could answer chemistry exam questions in “Investigating the Use of an Artificial Intelligence Chatbot with General Chemistry Exam Questions” article. They tested ChatGPT on exams from two chemistry classes. ChatGPT did a good job at understanding the main ideas in questions that had multiple-choice answers, even when there were lots of chemical symbols. However, it only got 44% of the answers right, which was lower than what most students got. When it came to questions where students had to write out their answers, ChatGPT was good at understanding language, especially for questions that needed general knowledge. But it had trouble with questions that needed specific skills, especially if those skills were taught in lectures. Even though some of its wrong answers

sounded convincing, ChatGPT isn't yet good at giving reliable answers or explanations for many exam questions. However, it could be useful for making assignments where students work on improving ChatGPT's answers.

Researchers Margarida Figueiredo and M. Lurdes Esteves (2014) from Portugal looked into how lab classes in Chemistry learning are taught using artificial intelligence in “Lab Classes in Chemistry Learning an Artificial Intelligence View” article. They studied 702 students in 10th grade in Portuguese Secondary Schools. They used a method called k-Means clustering to group the data into different segments. Also used decision trees to create models explaining the segmentation. The findings revealed that most students think doing experiments is very important for learning Chemistry. They also found that how much importance students place on research in chemistry learning depends a lot on how much they participate in lab work.

In the article "Artificial intelligence in chemistry" by N.A.B Gray (1988), it's mentioned that they review the methods and tools of artificial intelligence. Chemical problems are seen as good areas to test new artificial intelligence methods. Artificial intelligence techniques can be used to solve real-life chemistry problems. In chemistry, these techniques can help with tasks that need chemical knowledge, as well as tasks where chemistry is just one part of the problem. Programs that use encoded chemical knowledge can help solve problems like figuring out chemical structures, planning synthesis, and designing experiments. Robotics methods that use artificial intelligence and expert systems can make chemical instruments work better. Systems that understand human language could make it easier to deal with chemical information, and artificial intelligence techniques could make computer-based teaching even better.

In their paper titled "Artificial Intelligence Generative Tools and Conceptual Knowledge in Problem Solving in Chemistry" Wajeeh Daher, Hussam Diab, and Anwar Rayan (2023) discuss how artificial intelligence (AI) has become increasingly important in education and problem-solving. They focus on the use of ChatGPT, an AI tool, to support learning in chemistry. The researchers examined the challenges ChatGPT faces in understanding and responding to chemistry problems related to “Introduction to Material Science”. Using a framework proposed by Holme et al., which covers areas like transfer, depth, prediction/explanation, problem-solving, and translation, they assessed ChatGPT's understanding of concepts. The scientists presented ChatGPT with thirty chemistry problems from the Introduction to Material Science field and asked it to provide solutions. They concluded that ChatGPT struggled with understanding conceptual knowledge, particularly in areas like representations and depth, which hindered its ability to effectively transfer knowledge.

In their article "Evaluating Academic Answers Generated Using ChatGPT" American scientists Suzanne Fergus, Michelle Botha, and Mehrnoosh Ostovar (2023) explore the use of technology in education, especially amid the COVID-19 pandemic. They focus on Chat Generative Pre-Trained Transformer (ChatGPT), an AI technology that generates conversational responses based on user prompts. This study aims to understand how ChatGPT performs in answering chemistry assessment questions and its potential impact on learning and assessment. The researchers examined two chemistry modules in a pharmaceutical science program's first and second years, comparing ChatGPT-generated responses to end-of-year exam assessments. They found that ChatGPT performed well in answering questions that required knowledge and understanding but faced limitations in questions that demanded application of knowledge and interpretation of non-textual information. The study also assesses the

quality of ChatGPT responses and concludes that it poses a low risk of cheating. Additionally, the researchers suggest that ChatGPT discussions could prompt conversations about academic integrity and assessment design, similar to the educational discussions sparked by the COVID-19 pandemic.

Wajeeh Daher, Hussam Diab, and Anwar Rayan (2024) explored the growing use of generative artificial intelligence tools in different fields, especially education, in their article "Generative Artificial Intelligence in Chemistry Problem Solving across Versions and Languages". They focused on ChatGPT versions 3.5 and 4.0, which are known for their ability to understand multiple languages, aiding both students and teachers. Their research aimed to compare the performance of these versions, specifically looking at how accurately ChatGPT answered questions in English compared to Arabic. They tested ChatGPT with 39 chemistry problems typically found in 6th-7th grade curriculum, consisting of both open-ended and multiple-choice questions. They categorized each response as accurate, partially accurate, or inaccurate. Their analysis revealed significant improvements in version 4.0, especially in handling Arabic. However, despite these enhancements, the study found that ChatGPT's responses in English were consistently more accurate than those in Arabic. To address this issue, they proposed either including more Arabic data during training or implementing a method where questions are first translated from Arabic to English, answered, and then translated back into Arabic for users. This approach leverages the higher accuracy of English responses to benefit Arabic-speaking users and potentially improves outcomes for users in other languages, especially in science education contexts like chemistry.

The next research work is Mary E. Emenike and Bright U. Emenike (2023) article " Was This Title Generated by ChatGPT? Considerations for Artificial Intelligence Text-Generation Software Programs for Chemists and Chemistry Educators". They discuss the concerns raised by the release of ChatGPT, a free text-based system developed by OpenAI, especially regarding honesty in academics and how students are evaluated across different levels of education. However, they believe that these systems can have a bigger impact beyond just teaching and learning chemistry. According to their research, artificial intelligence systems like ChatGPT can be useful for students, teachers, and school administrators in various ways such as teaching, research, and professional activities. They explore different ways students and teachers might use ChatGPT, highlighting both the advantages and potential problems, and also considering fairness and accessibility issues. For example, students can use ChatGPT to get help with tasks like answering questions on assignments, writing lab reports, doing research, studying, and getting tutoring assistance. Meanwhile, teachers can use it for teaching purposes such as creating assessment items, preparing class materials, conducting research, and managing professional aspects like their career and speaking engagements. They aim to encourage productive discussions on how to make the best use of artificial intelligence technology while being aware of its limitations.

The same thing in the article “Proposal to integrate artificial intelligence tools in chemistry teaching in higher education” by the authors R. Perezzan, S. Montalvo-Quirós, R. Rama-Ballesteros, D. Herráez-Aguilar(2024). In today's education, Artificial Intelligence (AI) is becoming increasingly important, especially in Natural Sciences like Chemistry. This study proposes using AI tools such as ChatGPT 3.5, Microsoft Bing, and Wolfram Alpha to enhance learning in Chemistry. These tools help students understand complex concepts and improve their ability to learn independently. Students can ask the AI questions and discuss the answers with their teacher to improve critical thinking skills. This approach not only improves Chemistry learning but also prepares students for academic and professional challenges. By integrating AI into teaching, education becomes more modern and adaptable to current

demands. AI tools facilitate a more interactive and effective learning experience, allowing students to explore concepts independently and creatively. Ultimately, the integration of AI in higher education offers new opportunities for deeper learning and better preparation for the modern world.

The upcoming paper, "The Limitations and Potential of ChatGPT in Chemistry Education " by Thu Nguyen and Yanika Sirichokcharoenkun (2023), delves into the drawbacks and potential of using ChatGPT in chemistry education. It explores how ChatGPT, a type of chatbot powered by language processing technology, has become popular in various educational fields, including chemistry. The authors analyze its limitations, such as its struggle with understanding context, inability to interpret visuals, and lack of specialized training data. They also highlight its benefits, including providing personalized help, fostering critical thinking, and supporting self-paced learning. However, they also acknowledge challenges like accuracy issues and ethical concerns. The paper concludes by offering suggestions for educators and developers to maximize ChatGPT's benefits while minimizing its drawbacks in chemistry education.

Summarizing the above information, the impact of artificial intelligence in teaching chemistry was discussed and literature research was conducted. The purpose of this study is to search for the use of AI in chemistry education. The research question is “which activities with AI are used in chemistry instruction”.

Methodology

A literature review research method was used to carry out the research. About 10 works of foreign and domestic scientists written on AI in chemistry education were studied. These articles were about the AI in chemistry education, the advantages and disadvantages of AI and impact to the study. Research works of scientists were taken from the Google Scholar platform. Keywords such as AI, chemistry education and AI in chemistry education were used to search for the article. The scientific articles were shown in the following table (Table 1). Each activity with frequency and percentage calculation as analysis method.

Article	Number
Vladimir L. Kodkin & Ekaterina V. Artemeva(2024); Ted M. Clark(2023); Margarida Figueiredo & M. Lurdes Esteves(2014); N.A.B Gray (1988); Wajeeh Daher, Hussam Diab & Anwar Rayan (2023); Suzanne Fergus, Michelle Botha & Mehrnoosh Ostovar(2023); Wajeeh Daher, Hussam Diab & Anwar Rayan(2024); Mary E. Emenike & Bright U. Emenike(2023); R. Perezzan, S. Montalvo-Quirós, R. Rama-Ballesteros & D. Herráez-Aguilar(2024); Thu Nguyen and Yanika Sirichokcharoenkun(2023)	10 articles

Table 1. Presentation name of the searched articles

Result

After extensive data collection, it was determined that artificial intelligence can be applied to 4 types of activities in chemistry education. The results of the research are shown in Table 2. The table provides a list of types of activity that can be created by artificial intelligence and research articles, frequency and percentage in the literature.

The most common activities identified were answering questions and solving problems (70%). This indicates that students use artificial intelligence to assist with learning chemistry through these methods. The least common activities included laboratory work (20%) and making scientific predictions (20%), such as writing research papers. These tasks tend to be more interesting to college and university students.

Activity name	Article (author, Year)	Frequency	Percentage
Creating and solving open-ended and multiple-choise questions	Vladimir L. Kodkin, Ekaterina V. Artem'eva(2024); Ted M. Clark(2023); Wajeeh Daher, Hussam Diab, and Anwar Rayan(2024); Mary E. Emenike and Bright U. Emenike(2023)	4	40%
For Studying Chemistry(answering questions, solving problems)	Vladimir L. Kodkin, Ekaterina V. Artem'eva(2024); N.A.B Gray (1988); Wajeeh Daher, Hussam Diab, and Anwar Rayan (2023); Suzanne Fergus, Michelle Botha, and Mehrnoosh Ostovar(2023); Mary E. Emenike and Bright U. Emenike(2023); R. Perezzan, S. Montalvo-Quirós, R. Rama-Ballesteros, D. Herráez-Aguilar(2024); Thu Nguyen and Yanika Sirichokcharoenkun(2023)	7	70%
For Scientific Assumptions	Vladimir L. Kodkin, Ekaterina V. Artem'eva(2024); Mary E. Emenike and Bright U. Emenike(2023)	2	20%
Laboratory works	Margarida Figueiredo, M. Lurdes Esteves, José Neves and Henrique Vicente(2014); Mary E. Emenike and Bright U. Emenike(2023)	2	20%

Table 2. Activities with frequency and percentage

Conclusion

At the end of the study, 10 different articles on "AI in chemistry education" were analyzed, identifying four types of activities. The main activities include creating and solving both open-ended and multiple-choice questions (40%), and answering questions and solving problems (70%). As suggestions for further research, I recommend developing a chemistry database for AI to help answer complex questions accurately; creating a chemistry AI app that consolidates all necessary information; and developing methods to calculate chemical problems using mathematical formulas. This should also include inputting these methods into AI to create tasks that are different in formula and calculation but

have the same final meaning. Implementing these recommendations could significantly enhance students' chemistry skills and academic integrity.

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