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AI IN SENIOR CHEMISTRY EDUCATION: ENHANCING ENGAGEMENT, PERSONALIZATION, AND PEDAGOGICAL PRACTICE

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Abstract
The integration of artificial intelligence (AI) in chemistry education has transformed traditional teaching methodologies, enhancing student engagement and conceptual understanding. This paper explores the impact of AI-driven tools such as adaptive learning systems, virtual laboratories, and intelligent tutoring systems in facilitating personalized learning experiences. AI enables dynamic modeling of atomic interactions, automated assessment mechanisms, and real-time feedback, thereby addressing challenges in chemistry instruction. Using a qualitative research methodology, the study analyzes student interactions with AI tools, focusing on their role in stimulating critical thinking and active learning. Despite its potential, barriers such as accessibility, teacher preparedness, and ethical concerns regarding AI applications in education remain significant. This study is conducted by interviews from teachers and survey from students to explore the types of AI they used and its potential impact on chemistry teaching and learning. It highlights current advancements, potential applications, and challenges in leveraging AI for chemistry education, emphasizing the need for a balanced approach that integrates AI while maintaining pedagogical effectiveness. The findings contribute to a broader understanding of AI's role in shaping the future of science education and provide insights for educators and policymakers in designing AI-integrated curricula.

INTRODUCTION

The rapid integration of digital tools in the educational sector has significantly enhanced learning processes, particularly in disciplines requiring deep conceptual understanding, such as chemistry. In this regard, artificial intelligence (AI) has been leveraged to create engaging learning experiences, facilitate assessments, and enhance education through personalized learning approaches (Iyamuremye, 2024). Within the domain of science education, AI and machine learning systems enable the modeling of atomic interactions, provide instructional support and feedback, and offer adaptive learning modules tailored to students' individual learning paces (Iyamuremye, 2024). Furthermore, the implementation of AI-driven technologies has demonstrated their efficacy in enhancing students' interest and improving the comprehensibility of complex chemical concepts, particularly at the senior secondary level. Despite these advantages, the full-scale adoption of AI in chemistry classrooms remains limited due to constraints such as inadequate resources, insufficient instructor training, and the lack of pedagogical support (Iyamuremye, 2024). This study aims to critically examine the impact of AI on chemistry education in higher secondary institutions, highlighting both its potential benefits and the challenges associated with its practical implementation.

Generative AI is revolutionizing education through new interactive and personalized learning experiences. The learning gap traditionally exists between Chemistry education practices and student engagement and comprehension. The present study argues for innovative approaches based on constructionist learning theory in exploring AI chatbots as agents-to-think-with to engage critical thinking and problem-solving through meaningful dialogues (Araújo & Saúde , 2024). Analyzing student interactions with AI chatbots, how they apply in active learning, and comparative effectiveness of ChatGPT and Bing Chat in Chemistry education is the aim of the research. This would demonstrate that AI has opportunities to alleviate teaching challenges in complex subject areas (Yildirim & Akcan, 2024). Moreover, the educators are unable to take full due to the lack of a well-defined understanding of the contemporary state of the art of AI in chemistry education. Therefore, the objective of this research study is to gather and evaluate the available literature on the introduction and use of artificial intelligence in the field of chemistry education in order to assess the factors facilitating or hindering their use.

1.1 Objectives

At the higher school level of chemistry teaches some unique challenges as the students are asked to understand several complex and abstract principles which require higher order thinking. The use of AI tool in such fields can be the game-changer as they provide personalized learning journeys, forecasting tools or even mock exercises to make the abstract concepts concrete. However, this picture remains blurry as far as the senior school chemistry teaching is concerned since there are many reasons why AI is hardly applied for instance cost issues, lack of structures, and untrained teachers. My aim and objective are to,

- explore the role of AI in senior school chemistry learning among students.
- identify challenges which teachers encounter while using AI in their teaching

1.2 Research Questions

1. What is the current role of artificial intelligence in teaching chemistry to high school students?

2. **What difficulties do teachers experience in the integration of AI tool into chemistry courses?**

This study confirms the need for such innovation by critically analyzing the novel approaches to problems in chemistry education. The fact that AI can offer data-driven insights, adaptive assessment, and personalized learning is fortunate because it raises the prospect of outperforming conventional teaching techniques (Chiu, 2021). In order to inform policymakers and curriculum developers about the benefits and drawbacks of these technologies, this analysis will examine earlier research on AI in chemistry education in order to determine the scope and efficacy of putting these practices into practice. Additionally, this study highlights the opportunities and problems associated with integrating AI, which will probably guide future investigations and the creation of strategies to maximize chemistry education through technology (Lee & Perret, 2022). Furthermore, by tackling these obstacles and possibilities, this study creates pathways for additional research and the creation of focused interventions to optimize AI's beneficial effects on chemistry education.

Although practical and ethical obstacles prevent AI from being widely used, it has the potential to completely transform chemistry education (Brown & Nedungadi,2024). The goal of this research is to give educators, developers, and policymakers useful information so they can create AI interventions in chemistry curricula that are more efficient, approachable, and morally sound. This study intends to optimize the advantages of AI technologies in education by tackling evidence-based issues that educators encounter. Additionally, this study emphasizes how crucial it is to give chemistry students, who will eventually become teachers and scientists, skills that are in line with the latest technological developments (Wilson, 2022). In addition to determining the advantages and difficulties of incorporating AI into education, the survey will investigate the degree of student acceptance, comprehension, and usage of technology. Educational institutions can create more responsive and adaptive curricula with the help of the survey's insights. These programs seek to satisfy the needs of students while encouraging innovation and efficiency in chemistry instruction (Rahmawati etal.,2023). By showing how artificial intelligence (AI) tools, like ChatGPT and other chatbots, can improve the learning and research processes, this study makes a substantial contribution to chemistry education. The study offers important insight into assessing and enhancing the Chemistry Education Curriculum for better AI integration strategies by highlighting the main advantages and difficulties students face when utilizing AI tools. With an emphasis on secondary students between the ages of 15 and 17, this study critically examines the use of AI in senior high school chemistry instruction. The study uses secondary information sources, including industry reports, scholarly journal articles, and expert interviews, to minimize ethical concerns and efficiently manage time (Chiu,2021)). Additionally, rather than focusing on the technical aspects of AI development, this research emphasizes educational outcomes. This study's scope is to assess how artificial intelligence (AI) is affecting chemistry instruction in senior high school, particularly for students between the ages of 15 and 17. It looks at how artificial intelligence (AI) tools improve teaching and learning, highlights opportunities and problems in integrating them, and evaluates how well they work to raise student achievement. The study offers practical suggestions for educators and policymakers based on secondary data from scholarly studies, industry reports, and expert opinions.

2. Literature Review

2.1Constructivist Learning Theory

According to constructivist learning theory, the learner constructs knowledge through experience and interaction with the environment (Piaget& Cook1954 and Piaget,2003). The theory emphasizes the need for active engagement, exploration, and reflection in the learning process. AI tools align well with constructivist approaches by providing interactive, adaptive, and personalized learning environments. For example, virtual chemistry labs and ITSs allow students to conduct simulations and experiments designed to further experiential learning. Through these tools, learners can test hypotheses, visualize chemical reactions, and receive instant feedback under risk-free circumstances (Bada & Olusegun,2015). This helps not only conceptual understanding but also supports critical thinking and problem solving.

The Zone of Proximal Development, as conceptualized by Vygotsky, is the difference between what a learner can do alone and what they can do with support (Vygotsky,1987 &2012). AI systems are mediators in the ZPD because they offer specific support to fill the gap. Virtual tutors, for instance, are tailored to the unique needs of learners by monitoring students' performance in real time and providing them with specific guidance (Luckin , 2018). Such scaffolding allows students to move beyond their current abilities and build confidence and independence. In chemistry education, this may be to guide the learner through concepts involving stoichiometry or chemical kinetics in which an AI tool changes its instructional strategy according to a response from students.

2.2 Artificial Intelligence (AI) in Chemistry teaching and learning

AI-driven tools have brought a significant change in the pedagogies of chemistry education like virtual labs and pedagogies. Such tools eliminate barriers associated with physical labs, such as the high costs of chemicals and equipment or the risks linked to hazardous materials (Rajadhyaksha,2025). Furthermore, AI-based simulations enable students to visualize complex chemical processes, including molecular interactions, reaction mechanisms, and thermodynamics, leading to deeper conceptual understanding.

One of the many trends observed is the use of personalized AI platforms that adapt to individual learning needs. These systems analyze the performance data of students and offer focused guidance on knowledge gaps and areas of strength. This feedback mechanism is made more engaging by tailoring the learning experience for the student. Another trend associated with AI-driven chemistry education involves gamified learning environments.

This concept integrates the gamification model into educational content by incorporating features of games like rewards, leaderboards, and challenges. Applying gamified AI to chemistry makes abstract topics, such as periodic trends or chemical bonding, interactively engaging and interesting for students and motivates better retention (Kabzhalelov etal.,2025).

Moreover, AI tools are increasingly being used to facilitate collaborative learning. Virtual platforms enable students from different locations to work together on chemistry projects, sharing insights and solving problems collectively (Berber etal.,2025). This fosters teamwork and communication skills, which are essential in scientific research and industry contexts. Real-time data sharing, discussion forums, and collaborative simulations create a dynamic learning environment that mirrors professional scientific collaboration. Finally, the integration of augmented reality (AR) and virtual reality (VR) into AI platforms is an emerging frontier in chemistry education. AR/VR tools provide immersive experiences where students can explore atomic structures or simulate chemical reactions in 3D. These technologies make abstract concepts tangible, bridging the gap between theoretical knowledge and practical application (Daher ,2023).

2.3 Personalized learning tools of Artificial Intelligence

AI-based adaptive learning systems adapt educational content according to the individual needs of the students, provide real-time feedback, and give individualized learning pathways. This adaptation assists students in mastering complex chemistry topics more effectively (Tanveer et al., 2024). Adaptive systems rely on algorithms to analyze the performance of students, find gaps in understanding, and dynamically change the curriculum. For instance, students who face difficulties with stoichiometry are given targeted exercises and explanatory content to help strengthen their understanding of the topic. Tools such as ChatGPT and Socratic provide personalized tutoring, helping students understand chemistry topics and solve problems (Al-Tarawneh etal.,2024 and Tanveer et al., 2024). These platforms use natural language processing to interact with students conversationally, making the learning experience more engaging and accessible. They also provide step-by-step explanations, helping students develop critical thinking skills and a deeper understanding of complex chemical principles.

AI-based simulations and virtual labs provide students with hands-on learning experience in a risk-free setting, where they can experiment on chemical reactions and molecular structures without the physical bounds (Tanveer et al., 2024; Sami etal.,2025). These tools model real-life laboratory conditions, giving students the chance to conduct experiments that may not be feasible or safe in regular settings. For example, virtual labs enable students to simulate dangerous chemical reactions, hence making them safe and confident. These tools give students conceptual insights and problem-solving skills by facilitating an engaging, immersive learning process (Bhutoria,2022). Visualizations of molecular interaction, reaction mechanism, and thermodynamic processes show students how an abstract concept takes place, therefore making it clearer. Interactive tools also invite curiosity and experimentation within the students while they work with the tools without much assistance. Virtual labs are more cost-effective and scalable. With the elimination of expensive laboratory equipment and consumables, schools can now provide quality science education to a much wider audience. This is very beneficial in resource-limited environments, where access to a traditional lab may be difficult.

2.4 Challenges in implementation of Artificial Intelligence

Although AI in chemistry education has many advantages, it presents challenges such as ethical concerns, the need for teacher training, and effective implementation (Bhutoria,2022). The ethical considerations involved include data privacy issues since most AI systems collect and analyze a large volume of student data. Schools need to ensure that they are data protection compliant and have measures to protect the students' information.

The digital divide is another significant challenge. Differences in technological infrastructure and internet access may limit the adoption of AI tools(Rosak-Szyrocka, 2024), especially in underprivileged regions. This inequality requires investment in technology and connectivity to ensure that all students benefit from AI-driven educational innovations.

Teacher training will be a major determinant of the effective integration of AI. Teachers will need to be ready to use these tools effectively while aligning them to curriculum goals. Professional development should focus on enhancing teachers' self-efficacy in using technology, thereby maximizing the potential offered by AI in improving student learning outcomes.

Ongoing research and development are critical to addressing these challenges and optimize AI's role in education (Chaturvedi etal.,2025). Collaboration efforts among educators, researchers, and policymakers can help refine AI applications, ensuring they meet the diverse needs of students and teachers alike. AI is transformative in chemistry education, but the broader implications of its integration need to be considered (Yildirim& Akcan ,2021). There are ethical issues such as data privacy and the digital divide, which must be addressed to ensure that access to AI-driven educational tools is equitable. Educators need continuous professional development to effectively harness AI's capabilities in the classroom. By addressing these challenges, AI can play a pivotal role in advancing chemistry education and preparing students for future scientific endeavors.

These components work within an even broader educational system, influenced by school and teacher expertise, technological infrastructure, and curriculum design (Lewis etal.,2021). This framework offers a structured approach to the analysis of how the implementation of AI may change chemistry education and where it needs improvement.

3. Research Methodology

Qualitative methodology was employed for the study to find the perceptions of the teachers and students of using AI in chemistry teaching and learning. The descriptive survey method was also used to investigate whether AI influences and changes O-level chemistry teaching as it relates to 10th and 11th grade students. The study is conducted in two private elite schools in which teachers and students both have access to technology in their courses, 48 chemistry students from a private school and seasoned teachers of the two private institution comprised the study's subjects. Participants were selected through purposive sampling. Two digitized schools of Karachi, Pakistan whose teachers and students are well aware of using AI tools were identified. Students were asked to give feedback using Google Forms. A sample of 48 students and 8 chemistry teachers were purposively selected on the basis of their experience with AI-enhanced teaching methods and their willingness to be interviewed. This will ensure that relevant and meaningful contributions are drawn from both students and teachers.

Table 1: Demographic Table of Students:

Class/ Sections	Number of Boys	Number of Girls	Total Students
11- B/H	08	04	12
10-L	06	05	11
11- I	10	04	14
10-F	04	07	11
Total:	28	20	48

Table 2: Demographic table for Teachers:

School	Males	Females	Total teachers
A	02	03	6
B	01	01	2
Total:	03	04	08

This study follows the code of ethics in research. Respondents were given full information about the purpose of the study, rights as the participant and confidentiality guarantee of the information they gave. The survey was conducted out of willingness and respondents were allowed to cease participation at any time without consequences. The data collection period spans 4–6 weeks, ensuring sufficient time for tool implementation and response gathering.

4. Data Analysis

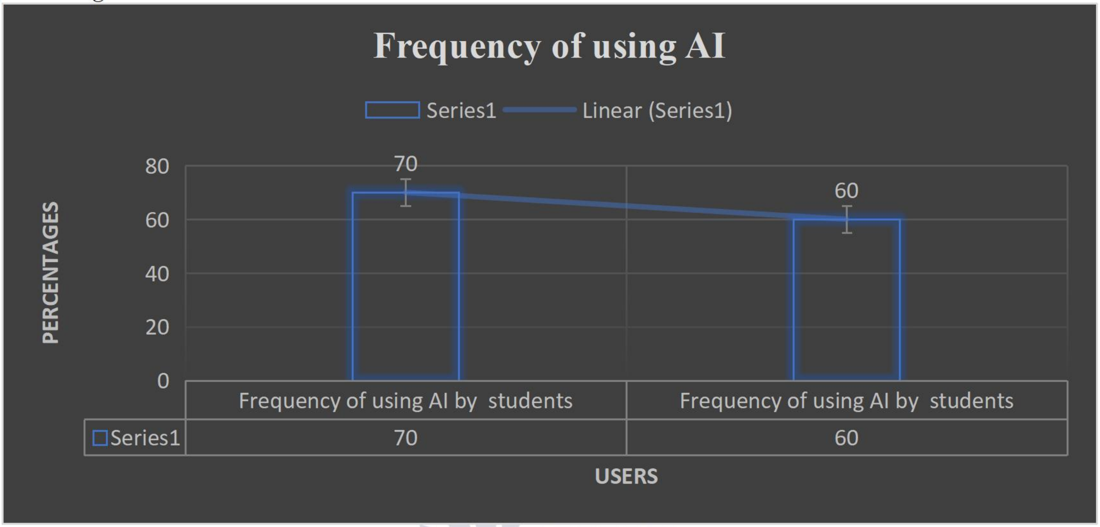
Responses gathered though survey through google form is analyzed through descriptive analysis and it was observed that frequency of AI used by students is slightly higher than of teachers.

Two questions surveyed online were:

- Frequency of AI used in Learning Process
- Types of AI used

Figure: 1

Frequency of using AI



It was observed from the graph that students used AI more frequently as compared to the teachers. This showed the quick absorption of AI in our new generation where teachers still believe to use it limitedly as they are still not equipped and have some resistance for its use.

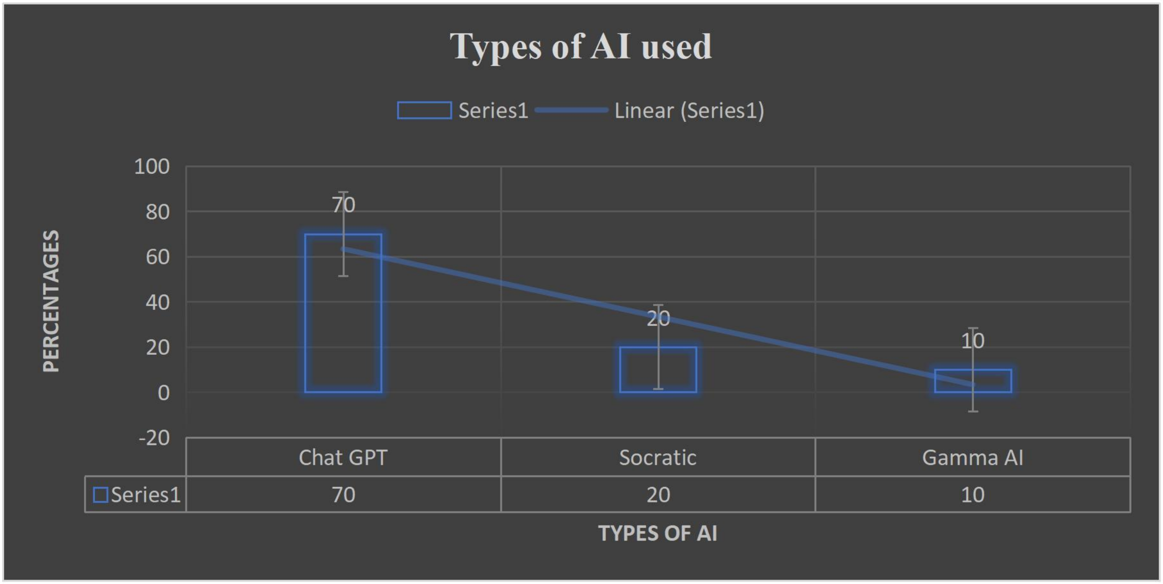


Figure 2
Types of AI used

The survey findings indicate that while the majority of teachers and students actively use ChatGPT, their awareness of other AI-powered tools remains limited. Many rely on ChatGPT primarily for generating text-based responses, answering queries, and assisting with assignments, but they rarely explore additional tools designed for specialized educational or research purposes.

Moreover, the survey reveals that although teachers and students engage with ChatGPT, they often have limited knowledge of its advanced features, such as prompt optimization, customization, or integration with other applications. As a result, they may not be utilizing AI to its full potential for tasks like lesson planning, data analysis, content creation, or enhancing classroom engagement. Additionally, some users face challenges in evaluating the accuracy and reliability of AI-generated content, which may impact its effective and ethical use.

These findings highlight the importance of providing structured training and workshops to help educators and students develop a deeper understanding of AI tools and their effective application in academic and professional settings.

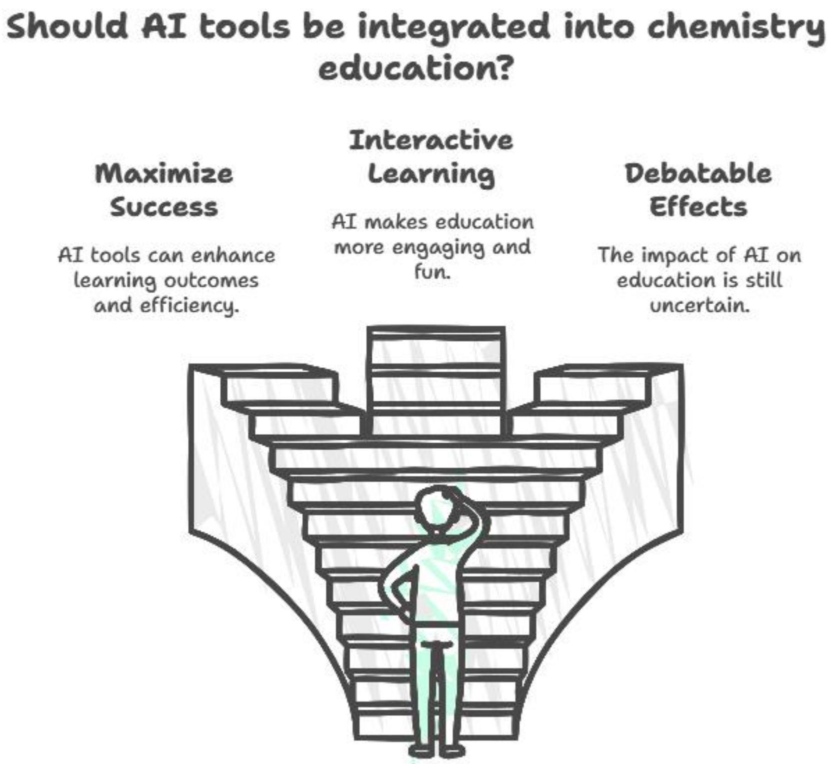
Thematic Analysis

Data collected through interviews were carefully transcribed and analyzed through thematic analysis by finding codes, focal codes and derivation of themes (Clark and Braun, 2017) .

Two major themes emerged from the data:

- Should AI be integrated into Chemistry Education
- Challenges of using AI by Teachers and Students .

Figure 3
1. Should AI tools be integrated into Chemistry Education



Chemistry was highlighted by the outcomes of this survey to be the hardest subject by many senior school students. It is because this subject is composed of diverse, abstract concepts; its complexity, among other factors, lies in concepts such as chemical bonding and mechanisms of chemical reactions, not to mention problems of quantitative kind, which also sometimes require comprehension. The involvement of theoretical aspects in practical use in the lab contributes to increasing its difficulty. As is quoted by one of the teachers:

"Yes, definitely! Chemistry is full of abstract concepts that don't always make sense at first. For example, understanding how chemical bonding works requires a lot of visualization, which is challenging."

One of the interviewees also indicate that there is a significant difference in the interest level between male and female students. Male students generally showed more interest and involvement in chemistry than female students. This may be due to several factors, such as varying levels of self-confidence when dealing with STEM subjects, social influences, or the lack of role models in science-related careers. It may also reflect variations in how male and female students perceive the relevance of chemistry to their future academic and professional goals. These results emphasize the need for targeted interventions to make chemistry appealing and accessible to all students, regardless of gender as proclaimed by another teacher:

"There are multiple reasons. Social conditioning might play a part—boys are often encouraged to explore STEM fields, while girls sometimes receive subtle messages that these subjects aren't for them. Also, the lack of visible female role models in science careers might make it harder for girls to see themselves in this field."

Efforts such as incorporating interactive AI tools, mentorship programs, and diverse role models in chemistry-related fields will be helpful in bridging the gap towards a more inclusive and supportive learning environment. Students are now using AI tools to learn chemistry concepts, whether in class or in preparation for exams. ChatGPT, Khan Academy, Virtual labs, simulation platforms, and gamified quizzes have now become integral part of learning, and it make challenging topics more accessible by offering interactive and dynamic learning experiences. In class, students use AI-powered platforms like Labster and Chem Collective to visualize chemical reactions and processes. Tools like Kahoot, and other platforms for quizzes are often used closer to the examination dates for reviewing and self-evaluation. Through AI, adaptive learning pathways as well as personalized feedback assist students in building their weaknesses into strengths and their knowledge more strongly and efficiently, referring to the interview excerpt:

"Definitely. AI-powered quizzes on platforms like Kahoot help students prepare for exams, offering instant feedback and adaptive learning pathways. Personalized AI tutoring identifies individual weaknesses and helps students strengthen their understanding. This not only boosts confidence but also makes complex topics more manageable for all learners."

It is analyzed that AI will let them learn through their mistakes to enhance deeper comprehension of the main ideas. Interactive platforms like Kahoot are widely used for quizzes and gamified learning sessions, making revision engaging and less stressful. Teachers can create customized quizzes that test students' understanding of key chemistry topics, while the competitive element encourages participation and retention of knowledge. The use of these tools tends to surge significantly as examinations approach. During this period, students often seek efficient and interactive methods to review and consolidate their knowledge. Simulation, quiz solving, and personalized feedback from AI tools make them very necessary for exam preparation. These tools provide real-time insights into what the student does well and where he or she needs to concentrate, thus leading to better performance in exams. Such AI-enabled platforms cater to individual learning needs while encouraging active engagement, critical thinking, and application-based learning, which are crucial for modern education.

Using AI in senior school chemistry education has revolutionized students' ability to capture abstract concepts but also makes learning enjoyable. Generally, abstract topics like molecular structure, chemical reaction, and the principles of thermodynamics that most students are required to understand prove to be unpalatable or even not assimilable under normal teaching circumstances. AI-based platforms such as Socratic, Gamma AI, Phet, Labster and Virtual Labs provide interactive simulations where students can visualize these concepts in a virtual environment, closing the gap between theoretical knowledge and practical understanding. Gamification learning tools, Kahoot, for instance, make this already tough subject a fun and challenging but non-daunting rather illuminating experience.

"Absolutely! Gamification tools like Kahoot turn chemistry into a fun and interactive experience. Instead of feeling overwhelmed, students engage with the subject in a challenging yet enjoyable way. AI also provides adaptive learning experiences, ensuring that students receive personalized feedback to strengthen their weaker areas. Overall, AI is making chemistry more accessible and less intimidating."

These platforms offer quizzes and activities that not only test students' understanding but also reinforce key concepts through repetition and instant feedback. AI tools adapt to individual learning paces, providing tailored explanations and personalized learning pathways to meet diverse student needs.AI tools support interactive learning as learning should not be such a monotonous affair, but rather fully sensory, dynamic, and stimulating. With more fun, interactivity, and personalized attention, this means achieving better conceptual clarity while enhancing students' confidence and interest in the subject, further making chemistry more accessible and delightful.

The introduction of AI in teaching and learning has ensured radical changes in both the teaching method and the pupil learning experience. Its application has also contributed to improvement in teacher advantages in senior school chemistry education. According to the research, the teachers find it very beneficial (Tongtummachat ,2024) .AI-based tools, such as virtual labs, simulations, and interactive platforms, help teachers present complex chemistry concepts in a more effective manner, enabling students to better understand abstract topics such as molecular bonding, chemical reactions, and thermodynamics. Such tools offer dynamic visualizations that make theoretical content more tangible, thus leading to a deeper understanding. Teachers can also utilize AI to generate individualized learning pathways for the students, adjusting content and assessment according to student requirements (Huang et al., 2021).

It is noted that through surveys teachers and students only opted three tools of AI, but upon interviewing, through probing by researcher, teachers named different tools as that were using but not having an exact idea that they are also classified as AI tools.

AI can also help teachers free up their time-consuming administrative tasks. The automation of grading, planning and tracking system like to track the student progress and can free up the teacher's time for more pedagogical approaches and personalized support (Kusmawan,2023). Moreover, AI can identify students who are struggling, allowing teachers to intervene early with targeted interventions (Chaturvedi etal.,2025). For example, AI-driven systems can assess student performance in real time and adjust the difficulty of assignments, thereby providing immediate feedback and optimizing learning outcomes (Huang et al., 2021).

2. Challenges of using AI by Teachers and Students

The constraints that students face in using ChatGPT and other AI technologies point to the need for targeted interventions over barriers to overcome them and maximize their benefits. These include high costs, lack of knowledge, limited access, and operating difficulties. Although AI holds great benefits for learners and teachers, there is a strong need to tackle these constraints to provide equal opportunities for all students. Another considerable challenge is that AI tools tend to be quite expensive to acquire. Many students, especially from low-income areas or institutions, may not be able to afford premium AI services. This may be solved if educational institutions subsidize or team up with technology companies to make the tools available at a discounted price or for free (Iyamuremye etal.,2024). In fact, the availability of AI tools will make sure that every student benefits from them regardless of the background.

"……Despite its benefits, there are significant barriers that prevent many students from fully utilizing AI tools. High costs are a major concern—many AI platforms require paid subscriptions, which students from low-income backgrounds may not afford. Additionally, not all students have the knowledge or access to use AI efficiently, and some struggle with the technical aspects of operating these tools."

The second limitation is that students lack information and awareness about AI. Most students do not know how AI works, its possible applications, or how to apply it in an academic setting. To address this, educational institutions can provide students as well as teachers with comprehensive training programs, including seminars, workshops, and tutorials, on the use of AI in education (Rahmawati eta., 2023). These programs could cover theoretical concepts and practical skills so that students actually understand how AI can support their learning as well as how to use it effectively in studies.

Access issues also pose a significant challenge. In many regions, students face challenges accessing AI tools due to poor technological infrastructure (net connections) or restrictive policies. This can be improved by providing better internet access, devices for the students, and policies supporting the use of AI in education (Kılınç,2023). Governments and educational institutions need to collaborate on ensuring that the students have access to resources. Last but not least, technical problems with the use of AI tools, for example, technical malfunctions or inability to navigate the interfaces, may make students reluctant to fully exploit the tools. Providing friendly interfaces, improved technical support, and instructions on how to use AI tools can help alleviate this problem. Moreover, using AI tools in classroom activities under proper guidance reduces the learning curve and encourages more students to use them effectively (Huang etal.,2021).

"Yes, access issues are another major challenge. In many regions, students struggle with poor technological infrastructure, including weak internet connections or a lack of necessary devices. Additionally, restrictive policies in some schools limit the use of AI tools. Without reliable access, students cannot fully benefit from these advanced learning technologies."

Student response to the survey also reflects that training can play a pivotal role in dealing with these challenges. Most of the respondents believe that workshops and tutorials on the usage of AI and other specific training programs can help enhance students' technical skills (Kusmawan,2023). Educational institutions can therefore enhance students' knowledge of AI by using multiple approaches to training so that students are equipped to reap maximum benefits from AI in their academic endeavors.

The suggestions revealed that AI answers are quite cold, emotionally alienated, and impersonalized but mechanical and unattached. The teaching of subject matter may fail to resonate with students, who most of the time love natural conversation and friendly manner, when it's not presented in a robotic tone. In this respect, AI content should mimic human aspects such as stimulation through encouragement, empathy, and a question-and-answer session with a hint of similarity. For instance, responses can include phrases like "I understand where you're coming from" or "This concept can feel tricky but let me break it down for you."

Teaching is not only the transfer of knowledge but also the emotional connection, patience, and ability to adapt an explanation according to a learner's needs. The human touch seems to be missing, making responses appear transactional without a nurturing environment that inspires confidence and curiosity in students. Including storytelling, real-world analogies, and empathy in answers can mimic the feeling of a supportive teacher guiding their students. AI should be designed to create a two-way interaction, showing it understands the learner's struggles and providing encouragement or validation.

"AI should be designed to mimic human-like interactions by incorporating empathy, encouragement, and conversational elements. Simple phrases like 'I understand where you're coming from' or 'This concept can feel tricky but let me break it down for you' can make a big difference. Additionally, AI responses should include storytelling, real-world analogies, and interactive Q&A formats to make learning feel more natural and engaging. Teaching isn't just about facts—it's about patience, adaptability, and emotional support, and AI should reflect that."

AI tools sometimes generate comprehensive explanations, which, while thorough, may include extraneous information outside the intended curriculum. This can overwhelm learners or shift focus from essential topics they need to master. It's crucial for AI tools to stay syllabus-aligned, presenting information that is directly relevant while avoiding tangents. The answers should be adapted, giving out the main ideas to be learned by students, not using technical terms unless requested and advance information unless necessary. Clarity, brevity, and relevance also succeed in providing students with the guidance they need.

In my survey teachers impose the fact that there is a need to address cost, knowledge gaps, access, and operational difficulties in order to increase the use of AI in educational settings. A multi-faceted approach that includes affordable access, comprehensive training, and improved infrastructure will ensure that all students can take full advantage of AI in their learning journeys

5.Conclusion and Recommendations

Chemistry education students are increasingly relying on AI tools like ChatGPT to enhance their academic experience. Such tools play a very important role in understanding complex chemistry concepts, compiling reports, and conducting research, which is why they are increasingly important in modern education. However, there are a number of barriers that prevent the effective use of AI in education. These include high costs, limited awareness of AI functionalities, restricted access to applications, and operational challenges, such as difficulty navigating or using the tools effectively. Most students and teachers will appreciate the dire need for well-structured training in order to benefit more from AI. Targeted seminars, interactive workshops, and user-friendly tutorials would create confidence and competence in the utilization of AI in educational pursuits. Moreover, this will improve adoption because AI would be incorporated into the curriculum to make it an integral part of learning materials and academic activities. Long-term gains will also come from comprehensive technical support, enhanced accessibility, and regular assessments of AI tools. Variations in AI usage and perceptions along gender and grade level lines imply that teaching pedagogies should be made to accommodate these diverse needs. Addressing the gaps and promoting a supportive environment for AI use will help unlock the full potential of AI to transform chemistry education in ways that enhance students' preparation for academic success and beyond.

Recommendations

Based on the research results obtained, the following important recommendations should be considered as follows:

- Incorporate AI applications like ChatGPT, virtual labs, and simulations into chemistry textbooks, lesson plans, and assignments to align with the curriculum.
- Integrate AI into learning materials to improve students' understanding and analytical skills.
- Organize regular workshops and seminars for students and teachers to familiarize them with AI tools, emphasizing practical applications in chemistry education.
- Equip schools with required digital infrastructure, including high-speed internet, connected devices that are compatible with AI tools.
- Modules for proper use of AI should focus on data privacy, academic honesty, and the avoidance of over-reliance upon AI when exploring learning tasks.
- It ought to set clear expectations of what AI tools are there to supplement learning without impeding skills.

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