



## Utilization of AI-Based Tools and Students' Academic Engagement in Secondary School Chemistry Learning

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### Abstract

This study examined the utilization of AI-based tools in secondary school chemistry learning and their impact on students' academic engagement. The study adopted a descriptive survey design. The population of the study consisted of all the chemistry teachers and students in Enugu Education Zone. A sample size of 12 chemistry teachers and 173 chemistry students was drawn using a stratified random sampling technique. The questionnaire on AI-based tools utilization and students' engagement in chemistry (QATUSEC), which was on a four-point Likert scale, was developed by the researchers, which has two clusters. An internal consistency reliability estimate of the instrument was established to be 0.85 and 0.88 for AI utilization and students' engagement, respectively, using Cronbach-alpha method. Mean and standard deviation were used to answer the research questions. Based on the analysis, the following major findings emerged: that AI-based tools are utilized in secondary school chemistry teaching and that AI tools are not frequently integrated into lessons. Moreover, AI tools encourage students to study outside the classroom, while AI also promotes active class participation. The findings suggest that AI tools effectively enhance engagement. Based on the study's findings, it was recommended, among other things, that educational institutions invest in comprehensive professional development programs to equip chemistry teachers with the skills and confidence to effectively integrate AI tools into their pedagogy. Future research should focus on developing assessment frameworks to measure the long-term impact of AI integration on student performance and investigating optimal implementation models for different learning environments.

**Keywords:** AI-based tools, Academic Engagement, Chemistry Learning

### Introduction

Artificial intelligence (AI) is the simulation of human intelligence in machines designed to perform tasks that typically require human cognition, such as problem-solving, decision-making, and learning. In education, AI-based tools, such as virtual labs, intelligent tutoring systems, ChemDraw, and adaptive learning platforms, are transforming traditional teaching methods by offering personalized, interactive, and immersive learning experiences. Despite these advancements, students' academic engagement and performance in chemistry remain a significant challenge, often hindered by conventional teaching approaches that fail to address diverse learning needs or sustain interest. This study seeks to explore the Utilization of AI-Based Tools and Students' Academic Engagement in Secondary School Chemistry Learning.

By doing so, the study provides actionable insights for educators to harness AI technologies effectively, fostering a more engaging, and effective learning environment for chemistry students; generally, science learning.

Chemistry is the scientific study of the reactions, properties and uses of matter. This shows that chemistry is an interdisciplinary subject which the society needs to be acquainted to as it deals with matter and matter is made up of almost everything we can see and interact with in the environment. According to Whitesides (2018), Chemistry serves as the foundation for understanding molecular processes in nature, enabling advancements in medicine, materials science, and sustainable technologies. This branch of science serves as a bridge connecting physics, biology, and

environmental science, playing a crucial role in developing new materials, medicines, and technologies. Anggraeni, Permanasari and Heliawati (2022) emphasize that scientific literacy, including understanding chemical concepts, is essential for students to navigate the complexities of the modern world. Their study highlights the importance of chemistry education in developing critical and creative thinking skills among students. Among the sciences, chemistry is a fundamental discipline that explores the composition, structure, properties, and changes of matter (Chang & Goldsby, 2021). It is a subject that requires both theoretical understanding and practical application, often posing challenges for students due to its abstract concepts and complex calculations. To address these challenges, educators are increasingly adopting innovative tools to enhance the teaching and learning experience which includes artificial intelligence (AI).

Artificial intelligence refers to the simulation of human intelligence in machines that are programmed to perform tasks such as learning, reasoning, and problem-solving (Russell & Norvig, 2021). In education, AI-based tools are designed to personalize learning, provide instant feedback, and create interactive environments that foster student engagement. These tools range from intelligent tutoring systems to virtual laboratories, which are beneficial in science education. For instance, AI-powered platforms can simulate chemical reactions, allowing students to visualize and interact with concepts that are otherwise difficult to grasp in a traditional classroom setting.

Academic engagement, which refers to the level of involvement, enthusiasm, and commitment students demonstrate toward their learning activities, is a critical factor in achieving success in chemistry (Fredricks, Blumenfeld & Paris, 2021). According to Wang and Degol (2016), academic engagement encompasses behavioral, emotional, and cognitive dimensions, all of which are essential for meaningful learning. In the context of chemistry, where abstract concepts and practical experiments are central, maintaining high levels of engagement can be challenging. However, AI-based tools offer a solution by creating interactive and immersive learning experiences. For example, AI-powered virtual reality (VR) simulations allow students to conduct experiments in a risk-free environment, fostering curiosity and deeper understanding. These tools not

only make learning more engaging but also help students connect theoretical knowledge with real-world applications, thereby enhancing their overall academic engagement.

### Research Questions

1. To what extent are AI-based tools utilized in teaching chemistry in secondary schools?
2. What is the extent to which AI-based tools helps in engaging chemistry students in secondary schools?

### Methods

The study adopted a descriptive survey research design. The population of the study comprised all 57 chemistry secondary school teachers and 4737 students within the government schools in Enugu education zone. The study covered 33 government secondary schools across the local government areas; Enugu East 12 schools, Enugu North 9 schools; Isi Uzo 12 schools. Sample size of 173 chemistry students and 12 chemistry teachers was sampled for the study using a stratified random sampling procedure. The stratified random sampling technique was used to ensure adequate representation of both students and teachers across the selected schools based on their local government areas. Two research questions guided the study. The instrument questionnaire on AI-Based Tools Utilization and students' Engagement in Chemistry (QATUSEC) was used for data collection with two clusters which has four Likert scale of Strongly Agree 4 to Strongly Disagree 1. The instrument was subject to face validation by three experts in department of science education, their suggestions were incorporated into the final instrument. To ensure the reliability of the instrument, a small sample of students and teachers outside the study area were used to conduct a pilot study. The internal consistency coefficients of 0.85 (for utilization) and 0.88 (for engagement) were obtained using Cronbach Alpha. The questionnaire was self-administered to the selected respondents and collected back immediately; this was to ensure maximum return of the instrument. Data were analyzed using mean and standard deviation. The real limit of number used for clusters one and two and their decisions are listed as follows: 1.00 – 1.49 stands for Very Low Extent (VLE), 1.50 – 2.49 stands for Low Extent (LE), 2.50 – 3.49 stands for High Extent (HE), and 3.50 – 4.00 stands for Very High Extent (VHE).

## Results

**Table1:** Mean score and standard deviation on the utilization of AI-tools in teaching chemistry in secondary schools

S/N	Items	Mean	Standard Deviation	Remark
1.	AI-based tools (e.g., virtual labs, ChemDraw) are frequently used in my chemistry class.	2.5	0.66	HE
2.	My chemistry teacher integrates AI-based tools during lessons	2.4	1.26	LE
3.	AI-based tools are used to demonstrate complex chemistry concepts.	2.3	0.50	LE
4.	AI-based learning tools help in solving chemistry problems.	2.6	1.09	HE
5.	AI-assisted simulations and animations are used to explain experiments.	2.8	1.05	HE
6.	AI-based tools are used to assess students' understanding in chemistry.	2.7	1.11	HE
7.	AI applications provide feedback on my chemistry assignments.	3.2	0.99	HE
8.	AI tools are accessible and available for use in my school.	3.1	1.12	HE
9.	AI-based tools make chemistry learning easier and more interactive.	3.1	0.57	HE
10.	AI tools are accessible and available for use in my school.	3.2	0.73	HE
11.	AI-based tools help me better understand chemistry concept	3.4	0.76	HE
12.	AI-based platforms (such as ChatGPT, virtual assistants) are used in chemistry learning.	3.2	0.72	HE
<b>Grand Mean</b>		<b>2.87</b>	<b>0.88</b>	<b>HE</b>

Key: LE = Low Extent, HE = High Extent

The results in Table 1 show that AI-based tools are utilized in teaching chemistry in secondary schools. The highest-rated item ( $M = 3.4$ ,  $SD = 0.76$ ) indicates that AI tools help students better understand chemistry concepts. AI tools are also accessible ( $M = 3.2$ ,  $SD = 0.73$ ) and provide feedback on assignments ( $M = 3.2$ ,

$SD = 0.99$ ). However, the lower mean scores ( $M = 2.3$ – $2.4$ ) suggest that AI tools are not frequently utilized in teaching chemistry in secondary schools. This implies that while AI has potential benefits, its actual usage in chemistry teaching remains limited.

## Research Question Two

S/N	Items	Mean	Standard Deviation	Remark
1.	AI-based tools make chemistry lessons more engaging for students.	3.22	0.58	HE
2.	Students actively participate more in chemistry classes when AI tools are used.	3.33	0.37	LE
3.	AI tools encourage students to study chemistry outside the classroom.	3.63	0.48	VHE
4.	AI-based tools make difficult chemistry topics easier to understand	3.25	0.36	HE

5.	AI tools help improve my performance in chemistry tests and assignments.	3.03	0.53	HE
6.	AI-based learning promotes interaction and discussion among students.	3.25	0.34	HE
7.	I feel more motivated to learn chemistry when AI-based tools are used.	2.88	0.57	HE
8.	AI-based simulations make practical chemistry experiments more effective.	3.70	0.75	VHE
9.	AI-based tools improve my confidence in solving chemistry problems.	2.65	0.47	HE
10.	AI-powered tutors help clarify chemistry concepts when I do not understand them.	3.23	0.41	HE
11.	AI-generated chemistry explanations help me understand better than textbooks alone.	3.10	0.37	HE
12.	AI-based interactive chemistry games and quizzes make learning more fun.	3.33	0.43	HE
<b>Grand Mean</b>		<b>3.22</b>	<b>0.47</b>	<b>HE</b>

Key: LE = Low Extent, HE = High Extent, VHE = Very High Extent

The results in Table 2 indicate that AI-based tools significantly enhance student engagement in chemistry learning with mean scores ranging from 2.65 to 3.63. The highest-rated item ( $M = 3.63$ ,  $SD = 0.48$ ) shows that AI tools encourage students to study outside the classroom. AI tools promote active class participation ( $M = 3.33$ ,  $SD = 0.37$ ) and make learning more fun through interactive games and quizzes ( $M = 3.33$ ,  $SD = 0.43$ ). However, AI's impact on students' confidence in solving chemistry problems ( $M = 2.65$ ,  $SD = 0.47$ ) is relatively lower, indicating moderate engagement. Overall, the findings suggest that AI tools effectively enhance engagement, particularly in fostering independent study and interactive learning, though additional support may be needed to boost student confidence.

## Discussion

The results in Table 1 reveal that AI-based tools are utilized in secondary school chemistry teaching. While students acknowledge their benefits (e.g., easier learning, accessibility), actual classroom integration remains inconsistent. This aligns with recent studies, such as Ouyang and Jiao (2023), who found that despite AI's growing presence in education, many teachers still rely on traditional methods due to limited training or infrastructure. Similarly, Smith et al. (2022) observed that AI adoption in science education varies widely, with virtual labs and intelligent tutors being used more infrequently than systematically. The result for frequent AI use in lessons suggest that while some teachers experiment with these tools, they have not yet become

a core part of chemistry teaching. This contrasts with Zhang and Aslan (2023), who reported higher AI integration in STEM subjects where schools had structured digital learning policies. It also revealed further that the uneven adoption, likely due to disparities in resources, teacher confidence, or institutional support. This suggests that despite the growing availability of educational AI applications, systemic barriers continue to limit their integration into regular chemistry instruction.

The results in Table 2 strongly support that AI tools enhance student engagement. Students reported increased participation, engagement, and independent study, a trend corroborated by Wang et al. (2023), who found that AI-driven simulations significantly boost engagement in science subjects. It also revealed that AI encourages studying outside class which mirrors the findings by Li and Wong (2022), where adaptive AI platforms increased self-directed learning. The consistently high engagement metrics demonstrate AI's potential to transform chemistry learning experiences. Particularly noteworthy is the strong performance in promoting independent study and interactive learning suggesting AI tools effectively address engagement challenges in chemistry education. These results support constructivist learning theories, showing how AI-enabled active learning fosters deeper student involvement. However, while AI tools enhance engagement, they may need to be paired with targeted interventions to improve problem-solving skills.

### Conclusion

This study demonstrates that AI-based tools hold significant potential for enhancing student engagement and learning outcomes in secondary school chemistry. The findings reveal that while students perceive these technologies as valuable for improving conceptual understanding, engagement, and independent study, their actual classroom integration remains inconsistent. The gap between AI's demonstrated benefits and its current utilization underscores the need for systemic changes in teacher training, resource allocation, and curriculum development. For AI tools to realize their full educational impact, they must be strategically implemented as part of a comprehensive educational approach rather than as standalone solutions. The results suggest that when properly leveraged, AI technologies can transform chemistry education into a more dynamic, interactive, and student-centered learning experience.

### Limitations of the Study.

While the study provides various insights, there are some limitations to the study. First, the study relied on self-reported data from students, which may be subject to response bias or variations in individual perceptions of AI tool usage. Second, the research was conducted in a specific geographical and educational context, potentially limiting the generalizability of results to other regions with different technological infrastructures or teaching methodologies. Third, the study did not account for variations in teachers' technological proficiency or schools' resource availability, which likely influence AI integration. Finally, the design prevents establishing causal relationships between AI tool usage and learning outcomes. These limitations suggest the need for more comprehensive, longitudinal studies in diverse educational settings.

### Recommendation.

Based on the study's findings, three key recommendations emerge. First, policymakers and school administrators should ensure equitable access to AI technologies by addressing infrastructure gaps and providing ongoing technical support to facilitate consistent integration in chemistry education. Second, educational institutions should invest in comprehensive professional development programs to equip chemistry teachers with the skills and confidence to effectively integrate AI tools into their pedagogy, with a focus on

enhancing student engagement and addressing areas such as problem-solving confidence, where AI's impact was moderate. Third, curriculum developers should create AI-enhanced learning materials tailored to chemistry syllabi, designed to improve both conceptual understanding and problem-solving skills, thereby maximizing engagement and learning outcomes. Future research should focus on developing assessment frameworks to measure the long-term impact of AI integration on student performance and investigating optimal implementation models for diverse learning environments.

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