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VIEWS ABOUT ARTIFICIAL INTELLIGENCE IN CHEMISTRY EDUCATION: A QUALITATIVE SURVEY AMONG CHEMISTRY TEACHERS AND STUDENTS IN THE IBADAN METROPOLIS, NIGERIA

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Abstract

Artificial intelligence involves systems that can perform tasks that typically require human intelligence and mimic human intelligence (AI). This technology enhances chemistry education by offering personalized learning experiences through adaptive tutoring systems, improving comprehension and retention. The study investigated the views about artificial intelligence in chemistry education among chemistry teachers and students in the Ibadan metropolis, Nigeria, using ten public secondary schools in Ibadan North and Ibadan South West Local Government Areas. A total of twenty respondents (ten chemistry teachers and ten chemistry students) were sampled for the study. With a phone recorder and semi-structured interview questions, qualitative data were collected and subjected to content analysis. The findings of the study are that teachers are aware of several instructional methods for teaching chemistry. It was also found that both teachers and students have positive and negative views of the use of AI in chemistry. The students feel that AI provides better clarity of concepts and allows them to learn at their own pace. The teachers reported that AI makes teaching easier and that it is a useful source of information. However, they hold the notion that over-dependence could set in. Furthermore, the major challenges identified in the use of AI included no access to data, digital and smart devices, network connection problems, and little or no familiarity with AI tools. In conclusion, despite the hindering factors, most of the teachers and students agreed that AI was a beneficial tool for both instruction delivery and learning. Among others, we have recommended the integration of Artificial Intelligence into the school curriculum as well as teacher training, as this would help students and teachers gain proficiency in its use.

Keywords: *Views, Artificial intelligence, chemistry education*

INTRODUCTION

Innovative and technological advancements facilitate national development, and scientific revolutions largely drive the developing world. It is known that societies that aim at economic

and social growth often recognize and embrace innovations and creations of science (Coccia, 2019). Therefore, it is pertinent for contemporary societies to insist on providing high-quality science education. Science education has evolved with the periodic introduction of products and trends powered by emerging technologies (Almasri, 2024). One of the main purposes of science and education is to raise individuals who can keep up with the rapidly changing and developing scientific age and benefit from the latest technological inventions in every field. Another purpose is to enable individuals to learn that science is necessary for all technological innovations and developments (Güneş and Karaşah, 2016). Chemistry is an integral physical science, and understanding the subject at the senior secondary school level is essential for the acquisition of the fundamental knowledge of matter, its structure, form, behaviors, and interactions. Students who learn chemistry acquire essential scientific skills such as critical thinking, problem-solving, drawing inferences, and creativity.

Due to the nature of chemistry, its teaching and learning are not without many challenges that demand great attention (James, 2018). One of which is the teacher's methodology. There is no doubt that a teacher's approach and pedagogical knowledge, particularly in adopting technology, are determined by many factors, including competence and teaching experience (Ifinedo, Rikala, and Hämäläinen, 2020). In contrast to the traditional methods aimed at imparting knowledge, contemporary perspectives advocate for a more holistic and engaging approach. This is the submission of recent scholarly viewpoints on chemistry education, considering its evolving aims. A few of those proposed are a culturo-techno-contextual approach (Oladejo et al., 2021); Learning Activity Package Instructional Approach (Agwu Udu et al., 2022); Augmented Reality (Wong, Tsang, and Chiu, 2021); Virtual chemical laboratories (Chan et al., 2021). There is a notion that technological inventions have great potential to foster students' learning outcomes in chemistry.

Effective chemistry education should cater to the diverse needs and cognitive styles of students, and technology offers innovative tools to enhance engagement and personalize learning in chemistry education. For instance, Rincon-Flores et al. (2021) explored the potential of "simulations and gamification" to provide virtual laboratories and interactive experiences, allowing students to explore concepts and test hypotheses in a safe and engaging environment. It is no longer solely about conveying facts, but about nurturing inquiry, connecting to real-world contexts, fostering inclusivity, and leveraging technology to empower active learning. The most current is the use of Artificial Intelligence (AI).

The world is currently undergoing what Schwab (2017) has called the Fourth Industrial Revolution, which has been characterized by increased connectivity and automation propagated by technologies including artificial intelligence (AI), machine learning (ML), and digital fabrication. The world has embraced Artificial Intelligence (AI) as a technology that can make our lives easier and stimulate economic development (European Commission, 2020). As such, AI has been widely used in different domains of social systems. Education, specifically chemistry education, is no exception. Artificial intelligence involves the development of computer systems that can perform tasks that typically require human intelligence. These tasks encompass a broad range, from problem-solving and learning to language understanding and perception.

Chen and Li (2022) emphasize the potential of AI in democratizing science education, making it accessible to all regardless of location or resources. Having access to technology, such as AI and digital devices, allows students to connect with their peers, do their homework, and stay up to date with their academics. Automated grading and personalized feedback free up valuable teacher time. AI can analyze student data to identify learning trends and pinpoint areas needing intervention, empowering teachers to personalize instruction and track progress effectively, as demonstrated by Chiu et al. (2020). This fosters a data-driven approach, enabling teachers to tailor their interventions to each student's unique needs. AI tools are incorporated into teaching and learning science for many reasons, such as improving the learning environment, generating quizzes, and predicting learners' academic achievement (Almasri, 2024). While the potential of AI is undeniable, its integration requires careful consideration. Ethical concerns regarding data privacy and teacher displacement need to be addressed.

However, implementing AI in chemistry education may present various challenges, including technical issues like data security and privacy, and human-AI interactions. Many AI systems lack transparency, making it challenging for teachers and students to understand decision-making processes, potentially eroding trust in technology. Moreover, professions like assessment and grading still require human expertise, necessitating ongoing human oversight in AI-powered educational systems.

ARTIFICIAL INTELLIGENCE IN CHEMISTRY EDUCATION

With the continuous pursuit of better and more efficient systems, there is a plethora of AI-based resources and materials that have been developed for educational purposes. These innovations have revolutionized the practice and operations in teaching and learning, including the pedagogy and assessment, which is self-paced, interactive, speedy, and motivating. The comprehensive review done by Chiu (2021) displayed various digitalization and AI systems used in chemistry education. Among them were virtual chemistry laboratories (Almasri, 2024), visualization and interaction with chemical structures, and classroom hands-on activities. In his study, there was clear evidence of the benefits of artificial intelligence and learning analytics in processing students' feedback and academic outcomes, assessment of students' understanding of chemical terms, and investigations related to students' intellectual processes during chemical tasks.

Generative Artificial Intelligence (GAI) text-based systems, including ChatGPT, have been proposed for chemical education among contemporary stakeholders (Emenike and Emenike, 2023). The researchers highlighted a myriad of AI-integrated activities such as writing laboratory reports, constructing essays, doing research, obtaining answers to test questions, and self-learning tutoring; while for teachers, AI can be used to construct lecture notes and plans, generate test items, receive and provide feedback, as well as track learners' progress. Reports that the advent of AI in education could pose an end to formal schooling, as these systems tend to produce better outputs than using human efforts (Gocen and Aydemir, 2020).

Although laced with a bunch of merits, the imperfect nature of AI systems cannot fully replace the human chemistry teacher (Emenike and Emenike, 2023). They further raised their concerns about the accessibility of AI among students and teachers. Clark (2023) submitted that ChatGPT's score for solved problems was

only 44%, which was below the class average of 69%. On open-response questions, ChatGPT presented better responses with generalized information than those requiring specific. The researcher judges that, although useful for students' assessments, the app was ill-equipped to provide consistent answers for many representative exam questions. In a systematic review, Almasri (2024) found that learners' engagement, interest, and willingness for future use were elicited and improved when AI was integrated into their science classrooms. According to the studies reviewed, teachers also described the use of AI-powered pedagogy as useful and somewhat easy to use.

Research Questions

1. What is the prevailing method of instruction among chemistry teachers in selected secondary schools in the Ibadan metropolis?
2. What are the views of chemistry teachers and students about AI in senior secondary schools in the Ibadan metropolis?
3. What are the chemistry teachers' and students' challenges with using AI for chemistry teaching?

METHODOLOGY

The study was a qualitative descriptive survey. Two local governments, Ibadan North and Ibadan Southwest local governments were randomly selected out of the five local governments in the Ibadan metropolis. Out of 60 public schools in the two areas, five schools were randomly selected from each local government area. Using the quota sampling technique, from each of the schools, one chemistry teacher and one chemistry student were interviewed, making a sample size of twenty respondents (ten teachers and ten students). The selected schools were coded as School A to J for the sake of confidentiality. The teachers were tagged as Teachers 1 to 10, while the students were identified based on their schools. Using a semi-structured interview guide, the data were obtained basically in audio form using a phone recorder. The responses were transcribed and analyzed, then reported in written format.

RESULTS

Responses from the respondents are presented and discussed.

Research Question 1: What is the prevailing method of instruction among chemistry teachers in selected secondary schools in the Ibadan metropolis?

Table 1: Prevailing methods of instruction in chemistry teaching

Respondent	Preferred instructional method
Teacher 1	Discussion method
Teacher 2	Laboratory experiment
Teacher 3	Demonstration
Teacher 4	Collaborative Project
Teacher 5	Flipped classroom
Teacher 6	Problem-solving
Teacher 7	Discussion
Teacher 8	Lecture
Teacher 9	Discussion
Teacher 10	Lecture

Table 1 shows the responses provided by the teachers when asked about the most common teaching methods/strategies that they adopt for their chemistry lessons. While some teachers mentioned innovative teaching methods such as flipped classroom, problem-solving and collaborative project, others appeared to remain somewhat conventional by using methods such as lecture, laboratory, demonstration, and discussion. Summarily, the chemistry teachers' responses showed the prevalent use of the discussion method.

Research Question 2. What are the views of chemistry teachers and students about AI in senior secondary schools in the Ibadan metropolis?

Table 2: Results of analysis on the view of chemistry teachers and students about AI students

Respondents	Theme: Positive views	Theme: Negative views
Students	AI brings a clearer understanding of topics being taught in class.	The reason to miss classes and lectures is because of the self-teaching concept AI can bring.
	It helps in knowing topics that had not been taught earlier to the students.	Network problems and inaccessibility to mobile phones.
	AI allows for learning at the student's own pace, even without the input of another person.	At times, AI can bring out negative answers to some questions, most especially the calculation part.
Teachers	It makes the work of the teacher easier in the formation of notes	The teacher may become fully dependent on the use of AI for the formation of lesson notes.
	It makes the work of the teachers seamless.	Teachers may get too lazy to explain some concepts to students in class.
	AI is useful for supplying knowledge on better teaching methods and the students' needs.	
	I develop myself with the information I get from it	

Positive views on the use of Artificial Intelligence (AI)

The majority of the respondents opined that AI has helped in making knowledge outsourcing easier. The student from School A, who was interviewed on his views and opinions on AI, said concerning AI, that:

"*I know about AI. I usually use AI, especially CHATGPT, to learn certain topics I do not understand well in class. It just gives me an explained format of what I want, and I get to read it. I won't say I learn better with AI, but it seems like I understand perfectly after learning with AI".*

The student in School B also gave positive remarks about the use of AI for them in the learning of chemistry:

"*Yes, I know AI. I do not use it often. I use it when I want to understand what I am reading, especially when I was not taught much about it earlier. In my opinion, it has been really helpful for me, and yes, I get to understand well. I would say that if students can get access to technology to use it in learning chemistry, they would easily understand topics like organic chemistry and those difficult topics like Energy changes in a chemical reaction".*

Other responses highlighted that AI allows for learning at the student's own pace, even without the input of another person. For instance, the student in School D stated that:

"Of course, I have heard of AI from my sister, who is currently in a higher institution and used it. My views on AI…. It helps me cover what I am reading with more illustrations and understanding. I love the fact that even when I

want to study ahead of the class and I have not been taught a topic, I can rely on AI and it will deliver in giving understanding of the topic".

The teachers were also interviewed about the integration and the use of AI. They also had positive views of AI. For instance, the chemistry teacher at School E stated thus:

"*AI emergence is a great addition to education. I view it as a tool that helps teachers, or let me just say, myself. There are times it helps me in my note formation. I have the idea, but the layout and putting it down might seem far-fetched, and I get to engage AI for that. It makes my work easier. Also, it helps in knowledge acquisition. There are times, as a teacher, you know what you want to see, but it seems just difficult to place where to see or search for it. So, AI gets to bring and seems like it gives meaning and direction to whatever I have had in my head that I am having difficulty putting down".*

Another set of positive responses was from teachers on their views and opinions on AI. Teachers spoke on the wealth and abundance of knowledge it affords them. The chemistry teacher from School F said:

"*Yes, I know of AI. I do use it. I see it as a major improvement and makes work a little bit seamless in the way we work now. I use it to advance, enhance, and tailor my teachings to the students. It brings the whole concept down easily, and it makes my work less stressful. Also, it helps me develop myself with the information I get from it. I feel that as a teacher, there is some knowledge one should have about better methods of teaching and the needs of the students. So, it helps me to tailor my lessons to the students, well, makes me develop myself with insights and knowledge in dealing with the students, such as the delivery of lessons".*

The responses obtained and analyzed from the respondents of this study on the views and opinions of the teachers and students of AI. The students and the teachers shared their positive experiences.

Negative views on the use of Artificial Intelligence (AI).

The negative views from the teachers and students were from only a few. The student from School C said:

"……. But the only thing that AI presence has done to me is that I don't even understand how it started, but I do not mind missing classes or school, because I know that whether I am in class or not, I can always get a detailed explanation elsewhere through AI, and it makes me lose focus in school. I would call it over-dependence on AI".

The teacher from School G said that:

"……. Though it serves us well as teachers, the only way I feel it could have a side effect is that teachers might get to be very dependent on the use of AI, especially in the area of class notes.

The teacher at School H said:

"Hmmmm……. One of the problems I will encounter in using AI is about network problems, most especially in this school area, where there is poor accessibility to the network."

Research Question. 3: What are the chemistry teachers' and students' challenges with using AI for chemistry teaching?

Table 3: Results of analysis of chemistry teachers and students' challenges with using AI for chemistry teaching and learning

Students	**Teachers**

Limited access to smartphones among students	Many teachers are not familiar with AI, and as such, it affects the usability of AI for the teachers.
Unfamiliarity with how the AI tools work	No access to smartphones or devices to access AI
Data subscription and network connectivity issues	Network issues

Students' Responses

The major challenge the students noted in their interviews was that the use of AI requires some level of literacy in digital and smartphone use. For instance, the student from School A said:

"*I would say that the challenge that students face in the use of this AI for learning chemistry is ……. Okay, without access to phones, such students might not be able to use AI for learning. I would say both access to a phone and enough literacy to use it on the phone".*

The student from School G had a similar view, stating that the absence of a smart device may mean AI would be inaccessible to students.

"*I have friends that I do tell how I use ChatGPT to read Organic chemistry, and I do understand, while they are not able to even get to use it talk less of know how to use it, because they do not have a phone. So it is that without a phone, AI cannot be used for learning".*

The student from School I pointed out the problem of incompetence:

"……. I also saw that not knowing how the AI tool works can also be challenging and frustrating in the use of AI to learn. Another is data connection and subscription to access and use AI, because they are mainly online and need data".

The student from School J who was interviewed said:

"Though I don't have a smartphone yet, I have the opportunity to use my brother's phone when I get back from school. But I know of many students who lack this opportunity, so I would say inaccessible to smartphones will serve as a great challenge in using AI".

Teachers' Responses

The major challenges expressed by teachers did not differ much from those of the students. Although the most prominent challenge was the lack of adequate competencies and skills to use artificial intelligence. This represented the views of the other teachers. For instance, the teacher from School D said:

"*……. I think it will be easy and familiar to use it. Many teachers find textbooks easier and more familiar to use than AI. So, this might be very challenging in use as some teachers might not be able to use it for it is just a new advancement to education".*

The teacher at School E also said:

"Oh, yeah. I see a major challenge in the use. I know of teachers who do not use AI because it is a new thing, and most are not able to acclimatize themselves to it. Not knowing how to use it is the major challenge I see for teachers. Also, if one has no smartphones or access to digital devices, it can serve as a challenge in the use of AI for teachers. Also, network issues can be a hindering factor at the time of usage."

DISCUSSIONS

The respondents provided details on the various methods of instruction in chemistry teaching used in their schools, which included discussion, laboratory experiment, demonstration, collaborative, flipped classroom, and problem-solving methods. The majority of the responses (Teachers 1, 7, and 9)

indicated Discussion as their most-used method. This agrees with the findings of Tufail and Mahmood (2020). Chemistry is often seen as difficult and abstract. Perhaps, this method is perceived to give a clearer and more relatable understanding of topics in chemistry, as it entails active, collaborative participation of learners in explaining and conversing, which consequently promotes the acquisition of scientific skills and achieves better learning outcomes (Ugwu, Jatau, and Gwamna, 2020).

Furthermore, analysis of the responses revealed that students and teachers hold both positive and negative views about the integration and use of AI in chemistry classrooms. Popular among them is that AI brings a clearer understanding to topics being taught in class, and that it helps students locate and study chemistry concepts in advance. This was reflected in the responses from the students in Schools A, B, D, and E. The advantage is seen in the fact that learning can be self-regulated, with little or no input from the teacher. Some other positive views of the use of AI stated by the interviewed students were that AI allows for learning at the student's own pace. The shortcomings of the use of AI amongst the students were also explained by the students from School C, and it was that it allows the students the mind and ability to miss classes and lectures because of the self-teaching concept that AI can bring.

The teachers' views about the use of AI were also obtained during the interviews, the positive responses from the use of AI were that it makes the work of teachers easier as stated by the teachers in Schools, in the formation of notes, it is useful for supplying knowledge on the better methods of teaching, the needs of the students as well as it helps the teachers to develop themselves with the information gotten from it. It also makes the work of the teachers seamless. These were the views of the teachers, particularly in Schools E and F. Similar to those of the chemistry students, the only negative feedback from the teachers, especially in Schools G and H, concerning the use of AI was that teachers could get very dependent on the use of AI for the formation of lesson notes. The challenges students and teachers face in the bid to use AI were also assessed from the interviews in the study. The teachers from Schools A, G, I, and J faced the seeming challenges, including issues of familiarity with AI, and as such, it affects the usability of AI for the teachers as well as limited access to data, smartphones, or other tech devices can hinder the use of AI by the teachers. Also, network issues were stated as a hindrance. For the students, the potential challenges to the use of AI were limited access to smartphones among the students, little or no familiarity with how the AI tool works, data subscription, and network connectivity issues.

CONCLUSION

The majority of the teachers use the Discussion method and are fairly familiar with the use of AI. Despite the fear of over-dependence, chemistry teachers and students hold similar positive views about AI. These include that the use of AI can make teaching and learning chemistry more effective, largely due to its capacity to deepen conceptual understanding, serve as a rich pool of resources, provide self-paced learning, and make work easier. Conversely, limited access to data, smartphones, and network problems, lack of technical know-how on how AI operates, were noted as the common challenges of the use of AI in chemistry education.

RECOMMENDATIONS

The study recommends the following:

1. Teachers should be encouraged to adopt more innovative and contemporary methods into their pedagogical practices in chemistry.

2. The integration of AI into the educational system should be encouraged and sponsored.
3. Chemistry teachers and students should be assisted with access to free, affordable, or subsidized data, gadgets, and smart devices that can support access to Artificial Intelligence tools, hence enriching teaching and learning.
4. Strategic professional development programs, such as training on the effective use of AI, should be organized for chemistry teachers.

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