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Artificial Intelligence and Chemistry Learning Outcomes of Senior Secondary School Students in Warri Metropolis

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Abstract: *This study investigated artificial intelligence and chemistry learning outcomes of senior secondary school students in Warri Metropolis. The researchers adopted a quasi-experimental design. The population of the study was 800 students. A sample of 80 senior secondary students was selected from two intact classes in two schools. Two research questions and two hypotheses guided the study. The test items were selected from standardized past questions of West Africa Examinations Council (WAEC) which was validated by two lecturers in the department of science education. The instrument used in data collection was Chemistry Performance Test (CPT) developed by the researcher. The reliability coefficient was determined by the Split-half method using Pearson product moment correlation coefficient at 0.78. Mean, standard deviation and Z-test at a 0.05 level of significance were used for data analysis. The result revealed a significant difference in the mean performance scores of students taught using discussion method and those of artificial intelligence. It was then recommended among others that; teachers should include artificial intelligence in teaching methodology content and also make provision to train both teachers and students in the use of artificial intelligence in teaching and learning.*

Keywords: Artificial Intelligence, Chemistry, Learning outcomes

Introduction

The integration of technology into science education has received support from recent curricular advancements, as highlighted by Nicolaou and Petrou (2023). There is an increasing consensus that the incorporation of Artificial Intelligence (AI) technology in education can empower teachers to facilitate students' self-directed learning (Caswell & LaBrie, 2017), influence of Artificial Intelligence (AI) and digital technologies goes beyond particular industries, leading to transformation The establishment of collaborative learning communities encourages the development of creativity in comprehending concepts (Connolly, Logue & Calderon, 2023). The changes brought about by technology are shaping modern societies (Brynjolfsson & McAfee, 2014). The field of education is also affected by these changes, with AI offering new possibilities and difficulties in getting the future workforce ready. With automation and AI becoming more prevalent in various industries, it becomes increasingly important for educational institutions to ensure that students are equipped with the necessary skills (EdSurge, 2018).

The use of AI involves integrating machine learning, deep learning, algorithm development, and natural language processing into various applications (Akgun and Greenhow, 2022). Organizations and individuals stand to benefit from AI due to its potential to enhance efficiency, productivity, time savings, effort reduction, and overall performance improvement (Ali, Abdelbaki, Shrestha, Elbasi, Alryalat, and Dwivedi, 2023; Flavian and Casalo, 2021). However, despite its numerous advantages, AI also presents challenges such as data security, privacy, and its potential to contribute to unemployment (Becue, Praca, and Gama, 2021; Perc, Ozer, and Hojnik, 2019). In summary, the influence of AI is expanding into various aspects of our everyday lives and is increasingly utilized in professional fields such as education (Chen, Chen, and Lin, 2020; Hwang, Xie, Wah, and Gašević, 2020), healthcare provision (Matheny, Whicher, and Israni, 2020), and marketing (Vlačić, Corbo, Silva, and Dabić, 2021). It has emerged as a significant technological force and trend in the 21st century.

Statement of the problem

The learning objectives of chemistry and artificial intelligence for senior secondary students in Warri, Nigeria, are the focus of this study. It appears that the teacher-centered, traditional teaching methods are out of date. There are many computer-based, student-centered teaching strategies in use in today's digital world. Due to their teacher-centered approach, the majority of traditional teaching methods do not allow for student participation in teaching and learning activities. This may be the main cause of the low performance noted in the majority of external exams. Over the years, a lot of stakeholders have expressed serious concern about the low chemistry student performance. The curriculum for this activity-based subject, like that of any other science course, places a strong emphasis on using both problem-solving and activity-based teaching strategies. Sadly, as researchers like Lakpini (2006) have shown, teachers

avoid using student-centered strategies of instruction in favor of easy-going lecture techniques, which are frequently insufficient and inappropriate for meaningful learning to occur. In light of this, the study looked into artificial intelligence and chemistry learning outcomes of senior secondary students in Warri metropolis.

Purpose of the study

The study was carried out to investigate artificial intelligence and chemistry learning outcomes of senior secondary students in Warri metropolis. Specifically, this study tends to:

1. Find out if there is a mean difference in academic learning outcome-performance of students taught chemistry using artificial intelligence technologies and those taught using conventional discussion method of teaching.
2. Find out if there is a mean difference in academic learning outcomes of male and female students taught chemistry using artificial intelligence technologies.

Research Questions

The following questions guided the study:

1. What is the difference in mean learning outcome of students taught chemistry using artificial intelligence technologies and those taught using conventional discussion method?
2. What is the difference in the mean learning outcome of male and female students taught chemistry using artificial intelligence technologies?

Statement of hypotheses

The following hypotheses were tested at a 0.05 level of significance:

1. There is no significant difference in the mean learning outcome of students taught chemistry using artificial intelligence technologies and those taught using the conventional discussion method.
2. There is no significant difference in the mean academic learning outcome performance of male and female chemistry students using artificial intelligence technologies.

Literature review

Artificial Intelligence can be defined as machines that can perform the tasks that humans carry out through their thinking (Dörfler, 2022). The usage of Artificial intelligence is growing at an unprecedented rate and it is rapidly changing the aspects of human life (Xue & Wang, 2022a). One of the significant challenges in teacher education is ensuring that teachers have a strong foundation in the subject matter they teach. AI can automate administrative tasks such as test evaluation, allowing teachers more time to focus on teaching rather than grading tests. decisions, and judge like humans. Buckingham Shum et al. (2016) elaborate on how AI can In conclusion, artificial intelligence refers to the development of systems and machines that can simulate intelligent human behavior and through the use of algorithms and complex mathematical models enable machines to learn, adapt and improve their performance in an autonomous way. The goal for AI is to be able to do things such as recognize patterns, make analyze individual student performance, preferences, and learning styles through machine learning algorithms. Teaching and learning have utilized different technologies as improvement on traditional teaching methods such as discussion, inquiry and demonstration methods. Artificial intelligence (AI) is the simulations of human intelligence in machines that are programmed to think and act like humans. Learning, reasoning, problem-solving, perception, and language comprehension are all examples of cognitive abilities. The application of machines in learning environments is only one variable in a multifaceted equation.

Using AI in education

AI has many uses in the field of education, including support, feedback, assessment, design, and delivery of content. AI can make it possible to create friendly and adaptable content in terms of design. Culican (2024) asserts that AI algorithms can sift through vast amounts of data to fill in the blanks, producing engaging and fashionable content. AI is additionally useful. for creating content that is tailored to the intended audience, such as interactive courses, personalized learning materials, and textbooks. Artificial intelligence (AI) tools facilitate the creation of educational content that leverages natural language processing capabilities, guaranteeing content that is coherent, succinct, and grammatically accurate (Dawes, 2023). Artificial Intelligence (AI) facilitates the efficient and flexible delivery of content by replacing traditional classroom instruction and offering students the ability to learn at any time, from anywhere in the world. AI systems may eventually take the place of lecturers in some subjects. Some educational programs now use artificial intelligence (AI) to scaffold students' acquisition of fundamental skills. Classroom AI systems have, according to Fahimirad and Kotamjani (2018), AI systems in classrooms are highly capable of analyzing data from various sources and comparing it to established patterns. According to Chen et al. (2020), they possess the ability to identify the root cause of issues and provide lecturers with guidance to attain more uniform results in different classes. Stated differently, educators and AI can collaborate to design the most effective teaching strategy that yields the greatest benefits for students. The advantages of implementing AI in the delivery of educational content include universal access for all students, regardless of their language proficiency or disability (Marr, 2024), as well as the ability to provide individualized and customized learning.

Furthermore, according to Dawes (2023), AI can be used to analyze advanced insights about how students are receiving educational delivery and making progress thus enabling a more personalized learning experience. Thus, it can be argued that AI-based education delivery is more learner-centric compared to the traditional method of educational delivery and is beneficial for learners as well as tutors. In terms of assessment, AI can enable automated assessment (Holmes and Tuomi, 2022). For example, AI can automate grading homework and tests usually take a significant amount of time. This time could be used to work on professional development, interact with students, and prepare for class. As AI is also AI systems in classrooms are highly capable of analyzing data from various sources and comparing it to established patterns. According to Chen et al. (2020), they possess the ability to identify the root cause of issues and provide lecturers with guidance to attain more uniform results in different classes. Stated differently, educators and AI can collaborate to design the most effective teaching strategy that yields the greatest benefits for students. The advantages of implementing AI in the delivery of educational content include universal access for all students, regardless of their language proficiency or disability (Marr, 2024), as well as the ability to provide individualized and customized learning.

Artificial intelligence (AI) automated grading can grade almost fill-in-the-blank and all types of multiple-choice tests, eventually replacing human grading. Though it's still in its infancy, essay grading software will advance in the upcoming years. The European School Education Platform (2023), claims that tutors can use AI to tailor assessments and deliver timely feedback that meets each student's unique learning needs. AI in assessment has the advantage of minimizing human subjectivity and assessment time (ibid). Additionally, Sarker (2022) contends that the application of AI to educational assessment improves scalability, personalization, and consistency. Individual consideration, flexibility, and the capacity to analyze large amounts of data from multiple sources are among the advantages of AI in educational assessment that have been reported (Mishra and Deep, 2023). It is widely acknowledged that learners require timely, relevant, and objective feedback in order to receive support and guidance. AI may also be able to offer feedback that satisfies these requirements. AI is already being used to provide feedback to students on their assignments and assessments (Hooda, Rana, Dahiya, Rizwan, and Hossain, 2022). For instance, some educational institutions are using AI systems to track and monitor students' progress and alert tutors to any problems with their performance. Artificial intelligence is used in some tutoring programs to assist students with writing, fundamental math, and other subjects (Leite and Blanco, 2020). These AI systems are limited to teaching students basic subjects; they are not ideal for imparting higher-order thinking skills or creativity.

Furthermore, generative AI tools like ChatGPT or Microsoft Bing can provide customized and quick feedback on students' work. According to Mollick and Mollick (2023), AI is being used in providing feedback to students which is personalized and asks students to take a different perspective. However, the authors noted that AI-based feedback is limited in the sense that it cannot replace human-grounded knowledge that a teacher has about their students. It is widely acknowledged that learners require timely, relevant, and objective feedback in order to receive support and guidance. AI may also be able to offer feedback that satisfies these requirements. AI is already being used to provide feedback to students on their assignments and assessments (Hooda, Rana, Dahiya, Rizwan, and Hossain, 2022). For instance, some educational institutions are using AI systems to track and monitor students' progress and alert tutors to any problems with their performance. Artificial intelligence is used in some tutoring programs to assist students with writing, fundamental math, and other subjects (Leite and Blanco, 2020). These AI systems are limited to teaching students basic subjects; they are not ideal for imparting higher-order thinking skills or creativity.

Discussion method of teaching

Discussion method of teaching on the other hand, is a verbal exchange of views, opinions, or ideas between two or more people involving the students in problem-solving where students carefully consider the problem, argue among themselves in a democratic manner, suggesting solution and draw conclusion (Special Teacher Upgrading Programme, 2007). It is a useful teaching technique for developing higher order thinking skills, communication skills, and enables students to interpret, analyze and manipulate information (Larson, 2000). It is a variety of forms of an opened, collaborative exchange of ideas between a teacher and students for furthering students' thinking, learning, problem-solving, understanding or literary appreciation (Wilkinson, 2009). In discussion method students participate in learning process by coming up with problems, analyzing the factors associated with the problems, developing possible solutions to the problems, putting the solutions into action and evaluating the results of the solutions (Jensen, 2008). The application of student- centred instructional strategies such as inquiry and discussion method are necessary to promote effective teaching of Chemistry to improve Chemistry students' achievement and attitudes in secondary schools in Nigeria.

Learning outcomes are description of the specific knowledge, skills, or expertise that the learner will get from a learning activity, such as training session, coarse, or program. Learning outcomes are measurable achievement that the learner will be able to understand after the learner is complete, which helps learners to understand the importance of the information and what they will gain from their engagement with the learning activity. Creating clear, actionable learning outcomes is an important part of the creation of training programs in organizations. When developing these programs, both management and instructors need to be clear

about what learners should understand after completing their learning part. Learning outcomes also play a key role in assessment and evaluation, making clear what knowledge learners should have upon completion of the learning activity (Valamis, 2022).

Gender performance in AI

The growing importance of AI has opened up debates about fundamental principles and values. Although AI increasingly impacts our everyday lives and economy, AI research and development is still overwhelmingly dominated by men. The "Global Gender Gap Report" indicates that women make up only about 25% of researchers in AI overall, which suggests that they are not sufficiently involved in the development of AI and the associated training datasets (World Economic Forum, 2020). This can lead to a biased and gender-unequal design of AI solutions, exacerbating social disadvantages and inequalities (Hall and Ellis, 2023).
In this context, women and men have different attitudes and perceptions of AI. Men perceive AI applications more positively than women: According to the annual "AI at Work" study, 32% of male participants rate AI in the workplace positively, compared to 23% of female participants (Oracle, 2019). The perception of AI is decisively characterized by the availability of information and knowledge about AI. People who have heard, read, or seen something about AI in the last 12 months tend to have a positive view of AI. Among women, in particular, the less positive basic attitude toward AI is due to a lack of experience with AI and training (Appinio, 2019). Furthermore, men rate their AI skills higher than women (Franken and Mauritz, 2021). Stereotypes continue to significantly influence the self-perception of one's own skills concerning the use of digital technologies and knowledge of technical terms. For example, women rate their understanding of the term AI and their level of knowledge lower than men (Kaspersky, 2020). Previous research has focused on the difference between genders regarding the perception of AI. However, it is recognizable that previous research efforts have focused on the manifestations of the differences while understanding the causes of gender-specific perspectives on the topic has been neglected. There is a lack of comprehensive findings on how women perceive and understand AI, their knowledge about it and what causes their particular approach towards it. However, in-depth insight into women's perspective are crucial to ensure equity in AI development and to derive well-founded recommendations for the education system.

Methodology

This study adopted a quasi-experimental design; specifically, the pre-test and post-test design. A quasi-experiment is an empirical interventional study used to estimate the causal impact of an intervention on the target population without random assignment (Dinardo, 2008). The population of the study consists of 1,450 Senior Secondary 2 students in 20 Senior Secondary Schools in Warri metropolis, Delta State. A total of 80 Senior Secondary Schools Class 2 chemistry students comprising 45 male and 35 female students of intact classes in the selected schools formed the sample. A sample of 39 students was in the experimental group and 41 students in the control group. The selected classes were randomly assigned experimental and control groups in each school. The instrument was a Chemistry Performance Test (CPT) developed by the researcher which contains 25-multiple choice questions based on the contents of the Senior Secondary School Chemistry Curriculum. The items were selected from the West Africa Examinations Council Senior Secondary School Certificate Examination (WASSCE) past question papers. The instrument was given to two lecturers in science education department at the Delta State University, Abraka for face and content validation. Their corrections and suggestions were made before the mass production and administration of the instrument. The reliability coefficient was determined by the split-half method and calculated to be 0.78 using Person Product Moment Correlation Coefficient. Mean, Standard Deviation and t-test independent were statistical tools used for data analysis and hypotheses were tested at a 0.05 level of significance. Students in the experimental group were taught using artificial intelligence technologies and those in the control group were taught using the conventional discussion method. The lesson lasted for two weeks of two units each. Before treatment, the instrument was administered to the experimental and control group as a pre-test and after treatment as a post-test.

Results

Table 1 Mean and standard deviation of performance of students in Chemistry for artificial intelligence

Treatment	N	Pretest		Posttest		
		Mean	SD	Mean	SD	Mean Gain
Artificial-Intelligence	39	14.22	2.58	20.44	4.74	6.22
Conventional discussion method	41	10.10	3.18	13.34	4.63	3.24

Table 1 presents the mean and standard deviation of mean learning outcome for the pre-test and post-test of students exposed to artificial intelligence technologies and those who were exposed to the conventional discussion method. It was observed that the pre-test mean for the two categories were 14.22 and 10.10 respectively. The table also shows that the post-test mean of of the performance of students exposed to artificial intelligence technologies and those exposed to the conventional discussion method had a mean performance of 13.34. It was observed that the mean gain, between pre-test and the post-test mean of the experimental groups was 6.22. That is the mean gain was higher than the control group's mean gain which was 3.24. The experimental group achieved higher than the control group.

Table 2 Mean academic learning outcome performance of male and female students exposed to artificial intelligence technologies

Treatment		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Male	**20**	**13.75**	**3.09**	**21.25**	**5.49**	**7.50**
Female	**19**	**14.47**	**2.04**	**19.58**	**3.79**	**5.11**

Table 2 shows the result of the mean academic learning outcome of male and female students exposed to artificial intelligence technologies. From Table 2, it was observed that students were homogenous academically before treatment (Pre-test) with mean scores of 13.75 and 14.47 for male and female students respectively. The Table also shows the mean gain between the pre-test and post-test mean of the male students was 7.50. This mean gain was higher than the female's mean gain which was 5.11. This gives a mean difference of 2.39 in favour of the males. The male students achieved slightly higher than the female students.

Table 3: Summary of independent sample t-test-test analysis on the mean academic performance of Chemistry students taught Chemistry using artificial intelligence technologies and those taught using conventional discussion method

	N	Mean	SD	df	t-cal	t-crit	Decision
Artificial intelligence technologies	**39**	**20.44**	**4.74**	**78**	**6.77**	**2.00**	**Reject Ho$_1$**
Conventional Discussion method	**41**	**13.34**	**4.63**				

As illustrated in Table 3 above, it can be observed that the calculated value of the t-test is 6.77 while the critical value is 2.00 at degree of freedom (df) of 78 and the level significance of 0.05; because the t-calculated value is greater than the t-critical value, hypothesis one was rejected. That is to say that there is a significant difference in mean academic performance of students taught Chemistry using artificial intelligence technologies and those taught using conventional discussion method.

Table 4: Summary of z-test analysis of the mean academic learning outcome –performance of male and female Chemistry students taught Chemistry using artificial intelligence technologies

Gender	N	Mean	SD	df	t-cal	t-crit	Decision
Male students	**20**	**21.25**	**5.49**	**37**	**1.11**	**2.04**	**Retain Ho$_2$**
Female students	**19**	**19.58**	**3.79**				

As illustrated in Table 4 above, it can be observed that 'that calculated value of t-test is 1.12 while the critical value is 2.04 at df of 37 and the level of significance $P < 0.05$; because the t-calculated value is less than z-critical value, the hypothesis 1 was accepted. That is to say, There is no significant difference in mean academic learning outcome-performance of male and female Chemistry students taught Chemistry using artificial intelligence technologies.

Discussion of findings

The results of the test of hypothesis one have revealed that 'students in the experimental group achieved higher than students in the control group. This means that students taught using the artificial intelligence technologies performed significantly better in Chemistry learning outcome tests than their counterparts who were taught using the conventional discussion. The reason for the better performance may be linked to the fact that method is a significant factor in student performance in basic science. This is because the method provided opportunities for students' interaction with the physical and social environments to explore, ask questions and experience science concepts. By so doing students were actively participating in making discoveries through ill-structured questions and discussing them among their peers in the group. This finding confirms what Afiya (2023) said that AI can play a crucial role in improving the quality of learning generally. Artificial intelligence is becoming an integral part of smart ICT based apps targeted for digital learning. One of the significant challenges in teacher education is ensuring that teachers have a strong foundation in the subject matter they teach.AI can automate administrative tasks such as test evaluation, allowing teachers more time to focus on teaching rather than grading tests.

Based on gender, the study showed that 'male students had a mean performance test score higher than the female students, but the mean difference was statistically insignificant. This indicates that gender has no significant effect on the performance of Chemistry students when exposed to artificial intelligence technologies. This agrees with Abdulrahman (2012) observed that 'gender inequalities are interwoven with social class, ethnicity, sexuality, disability, and other factors identified as influencing attainment''. Also, Adebanjo (2014), also linked gender and academic performance with patterns of behavior. He noted that there are signs of boys being vulnerable to becoming disaffected. He stated further that boys tend to be less careful about rules and are more indifferent to being reprimanded. Also, Oludipe (2012) agreed that 'there was no statistically significant difference in the pre-test, post-test and delayed post-test academic performance mean scores of male and female students.

Conclusion

Based on the findings it can be concluded that the use of artificial intelligence technologies enhance student learning outcomes in Chemistry more than the use of the conventional discussion method of teaching. The result of a non-significant difference in the mean academic performance between male and female students that were exposed to artificial intelligence technologies indicated the efficacy of the artificial intelligence technologies as a medium of instruction for the teaching of Chemistry

without being gender bias. With the use of artificial intelligence technologies, the study revealed no gender disparity in performance. This, therefore, implies that if the right instructional design is used by Chemistry teachers, it is believed that both male and female students will perform equally well in Chemistry.

Recommendations

Based on the findings of the research work, the following recommendations are made

1.Teacher training institutions should include artificial intelligence technologies in the scientific methodology content and make provisions to train pre-service and in-service teachers in the use of artificial intelligence technologies.

2.Chemistry teachers should include activities that will encourage the use of of artificial intelligence technologies by the teachers and students.

3.Chemistry Curriculum developers should make provision for and emphasize the use of artificial intelligence technologies by the curriculum implementers (teachers) because this method has enhanced students' learning outcome-performance in Chemistry.

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