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EFFECTS OF ARTIFICIAL INTELLIGENCE ON ACADEMIC DEVELOPMENT OF CHEMISTRY STUDENTS IN PUBLIC SENIOR SECONDARY SCHOOLS IN PORT HARCOURT METROPOLIS

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ABSTRACT

This study examined the effect of artificial intelligence on academic development of chemistry students in public senior secondary schools in Port Harcourt Metropolis. To achieve the purpose of the study, the researcher formulated 2 objectives of the study, research questions and null hypotheses that guided the study. Quasi experimental design of non - randomized Pretest, Posttest, Control group design was used for the study. The population for this study consisted of 54,102 Senior secondary schools (SSS1-SSS3) students from Port Harcourt Metropolis. Simple random sampling technique through the use of balloting with replacement was used to select the sample size of 196 SS2 chemistry students. The instrument was ensured through expert review. The data gathered were analyzed using mean and standard deviation for the research questions while the hypotheses where tested using ANCOVA at 0.05 level of significance. Based on the analysis, the findings of the study revealed that using virtual laboratories and personalized learning platforms effectively enhance educational development of public senior secondary school students. Based on the findings of the study, the following recommendations were made, government through the policy makers should implement the uses of virtual laboratories for all secondary school students and government through the school management should promote the use of personalized learning platforms for senior secondary school students.

Key Words: Artificial Intelligence, Effect, Academic Development, Chemistry Students

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INTRODUCTION

Artificial Intelligence (AI) is transforming chemistry education, offering both opportunities and challenges for students' academic development. AI-powered tools can enhance understanding of complex concepts, improve research capabilities, and personalize learning experiences. However, over-reliance on AI could hinder the development of critical thinking and problem-solving

skills. Therefore, a balanced approach is crucial, where AI is integrated to augment learning, while students still engage in independent analysis and exploration. By addressing these challenges and emphasizing a balanced approach, AI can be a powerful tool for enhancing chemistry education and preparing students for the future of scientific research (Holmes & Tuomi, 2022).

The rapid advancement of Artificial Intelligence (AI) is transforming various sectors, and education is no exception. AI plays a significant role in both general and higher education, influencing students' academic development by offering a mix of opportunities and challenges (Edtech, 2020). From personalized learning experiences to intelligent tutoring systems that provide tailored guidance, support, and feedback based on individual learning patterns and knowledge levels. AI has the potential to revolutionize education and address the diverse needs of learners. However, positive educational outcomes are not guaranteed solely by the adoption of advanced AI technologies. The integration of AI in academic environments raises critical questions related to equity, accessibility, and the evolving role of traditional teaching methods.

The influence of AI on education is transformative and multifaceted. AI enables personalized learning by adapting educational content to meet the unique needs of individual students (Johnson & Smith, 2019). Studies have shown that students in personalized learning environments exhibit improved self-efficacy and a more positive attitude toward their education. These experiences are increasingly achievable through AI-driven tools that analyze vast amounts of data to identify learning gaps and tailor interventions accordingly (Baker, 2021). For instance, AI-powered platforms, such as adaptive learning systems, have been shown to enhance student engagement and performance by providing real-time feedback and customized learning pathways (Ju, 2023).

In traditional education, students are encouraged to take an active role in their learning process by developing skills in exploration, analysis, and problem solving. Critical thinking skills are essential for shaping students' overall learning experiences. Educators often rely on questioning techniques, collaborative activities, and assignments to enhance students' ability to evaluate information and develop independent perspectives (Facione, 2020). However, the rapid information processing and insightful responses provided by AI challenge traditional learning methods, raising questions about the distinctions between human learning and machine-based learning. For example, while AI can efficiently process and analyze data, it may lack the nuanced understanding and creativity inherent in human cognition. This underscores the need for a balanced approach to AI integration, ensuring that it complements rather than replaces human interaction and the development of critical thinking skills (Wu, 2023).

The use of AI in education is not without its challenges. The effective integration of artificial intelligence in education requires a thorough understanding of both the technology and the learning process. This complexity is further heightened by ethical concerns, especially in the context of the increasing use of generative artificial intelligence. For instance, Qadir (2023) highlights the risk of students misusing AI tools in dishonest or unauthorized ways, such as using AI-generated content to complete assignments without proper attribution. Additionally, concerns about the application of AI in surveillance, control, and assessment practices could undermine trust and autonomy in educational settings (Williamson, 2017). Higher education institutions must clearly define the role and extent of AI in student education to address these challenges effectively (Holmes & Tuomi, 2022).

As data processing and computing technologies have evolved, artificial intelligence (AI) has been increasingly applied in the educational field, often referred to as Artificial Intelligence in Education (AIED). Applications such as intelligent tutoring systems, educational robots, learning analytics dashboards, adaptive learning platforms, and human computer interactions have demonstrated significant potential for enhancing teaching and learning. For example, intelligent tutoring systems have been shown to provide personalized feedback and support, improving student engagement and learning outcomes. Similarly, adaptive learning platforms leverage AI to tailor educational content to individual learners' needs, promoting more effective and efficient learning experiences (O'Neil, 2016).
Despite advancements, AI integration in education raises critical questions about its alignment with established learning theories. While studies have explored challenges, obstacles and future perspectives (Pinkwart, 2016), few explicitly analyze AI' s diverse functions and their relationship with pedagogical frameworks. For instance, how do AI tools align with constructivist or socio-cultural theories emphasizing collaboration, context, and critical thinking? Additionally, the long-term impact of AI on teaching, learning, and educational equity remains underexplored (Selwyn, 2022).

AI holds immense potential to transform education through personalized learning and adaptive systems. However, its integration requires caution. A deeper understanding of AI' s interplay with educational theories, alongside addressing ethical and pedagogical challenges, is essential. A balanced, human-centered approach prioritizing equitable access can ensure AI empowers rather than excludes (Qadir, 2023).

AI can enhance the academic development of chemistry students in several ways by improving learning efficiency, deepening understanding, and fostering research skills. AI enhances academic development of chemistry students by personalizing learning, providing virtual lab experiences, improving data analysis, speeding up assessment, expanding access to knowledge, strengthening critical thinking, and fostering collaboration (Williamson, 2017).

Artificial Intelligence uses personalized learning and tutoring to enhance development of Chemistry students through adaptive learning platforms. Artificial Intelligence can assess each student's strengths and weaknesses in chemistry and provide customized lessons, practice problems, and feedback (Wu, 2023). Artificial Intelligence tutors like intelligent chatbots can explain complex chemistry concepts (e.g., molecular bonding, reaction mechanisms) in simpler terms and at the student's pace and it can adjust the difficulty level of exercises based on the student's performance.

Castaneda & Selwyn (2018) state that Artificial Intelligence also uses interactive simulations and virtual labs to improve the academic development of Chemistry students. Artificial Intelligence driven virtual laboratories allow students to perform chemical experiments safely in a simulated environment. These tools can mimic real-world conditions and show molecular interactions in 3D, helping students visualize abstract concepts like atomic orbitals or reaction pathways and useful for institutions with limited physical lab resources.

Du Boulay (2020) observed that Artificial Intelligence has data analysis skills for research as another means of enhancing or academic development of Chemistry students. Artificial

Intelligence tools can help students analyze large sets of experimental data faster and more accurately. Artificial Intelligence machine learning models can predict chemical properties or reaction outcomes, teaching students how computational chemistry works in practice and enhances understanding of data-driven problem-solving in modern chemistry research (Castaneda & Selwyn, 2018).

Virtual laboratories enhance student development by providing accessible, safe, and cost-effective environments for practical learning, fostering crucial scientific skills, and boosting motivation and engagement. They offer opportunities to visualize complex concepts, improve understanding of scientific procedures, and develop critical thinking and problem-solving abilities (Braun, & Clarke, 2016). Therefore, virtual laboratories offer a powerful and versatile tool for enhancing student development by providing a safe, accessible, and engaging environment for learning science. They promote critical thinking, improve understanding of complex concepts, and foster a positive attitude towards science, preparing students for future academic and career endeavors.

Personalized learning platforms, particularly those enhanced by artificial intelligence (AI), can significantly enhance student development by tailoring learning experiences to individual needs, fostering engagement, and promoting crucial 21st-century skills ((Williamson, 2017). These platforms adapt to each student's pace, learning style, and preferences, offering customized content and feedback that can lead to improved academic performance and a deeper understanding of concepts. In essence, personalized learning platforms empower students to become active learners, promoting deeper understanding, fostering essential skills, and ultimately enhancing their overall educational development.

AI algorithms analyze student performance and adjust the difficulty and pace of learning materials, ensuring that students are neither overwhelmed nor unchallenged. Personalized platforms cater to different learning styles, incorporating multimedia, interactive simulations, and virtual reality to make learning more engaging and accessible (Williamson, 2017). By making learning relevant and challenging, personalized platforms can boost student motivation and engagement, leading to better participation and knowledge retention. Students are more likely to grasp complex concepts when they are presented in a way that aligns with their individual learning needs and preferences. Research indicates that personalized learning approaches can lead to significant improvements in standardized test scores and overall academic performance.

Statement of the Problem:

In recent years, Artificial Intelligence (AI) has emerged as a transformative tool in the field of education, offering innovative approaches to teaching, learning, and assessment. While developed nations have begun to integrate AI into secondary school science curricula, the application and impact of AI tools on academic development in Nigerian public schools, particularly in subjects like Chemistry, remain largely underexplored. Chemistry, being a core science subject, often poses learning challenges due to its abstract concepts, complex calculations, and need for practical experimentation. In Port Harcourt Metropolis, public senior secondary schools face various limitations such as overcrowded classrooms, inadequate laboratory facilities, and shortage of qualified teachers, all of which hinder effective Chemistry instruction. The integration of AI tools

such as virtual laboratories, intelligent tutoring systems, and personalized learning platforms holds great potential to mitigate these challenges. However, there is a significant gap in understanding the extent to which AI is currently utilized and how it impacts students' academic development in Chemistry.

Moreover, there is limited empirical evidence on whether the adoption of AI technologies enhances student engagement, conceptual understanding, and academic performance in Chemistry among senior secondary school students in the region. Without such data, policymakers and educators may struggle to make informed decisions about the adoption and investment in AI-driven educational tools.

Therefore, this study seeks to examine the effect of Artificial Intelligence on the academic development of Chemistry students in public senior secondary schools in Port Harcourt Metropolis, with a view to identifying the opportunities, challenges, and impact of AI integration in the teaching and learning process.

Purpose of the Study

The main purpose of the study was to examine effect of artificial intelligence on academic development of chemistry students in public senior secondary schools in Port Harcourt Metropolis. Specifically, it sought to:

1. Examine the difference in mean scores of Chemistry students taught using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis.
2. Determine the difference in mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis

Research Questions

The researcher developed the following research questions that guided the study

1 What is the difference in mean scores of Chemistry students taught using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis?
2 What is the difference in mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis?

Hypothesis

The researcher developed the following research questions that guided the study

1 There is no significant difference in the mean scores of students taught Chemistry using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis.

2 There is no significant difference in the mean scores of students taught Chemistry using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis

METHODOLOGY

Quasi experimental design of non - randomized Pretest, Protest, Control group design was used for the study. It employed two separate, non-equivalent, intact senior secondary two (SS2) classes from two schools that met sampling criteria. The population for this study consisted of all Fifty-four thousand one hundred and two (54,102) Senior Secondary School Students (SSS1 to SS3) from Port Harcourt Metropolis. Simple random sampling technique through the use of balloting with replacement was used to select four intact classes from two schools (non-equivalent intact classes) from the target population to obtain one hundred and ninety-six (196) SS2 chemistry students, ninety-nine (99) in the experimental group and ninety-seven (97) in the control group. The researcher constructed Chemistry Performance Test as instrument for data collection which consists of four-point rating scale. The instrument was distributed directly to the respondents by the researcher. The Instrument was ensured through expert review. The data collected were analyzed using descriptive statistics (mean, standard deviation and percentages) which provided answers to the research questions. Inferential statistics (Analysis of Covariance, ANCOVA and Post hoc Analysis) were used to test the hypotheses at 0.05 level of significance.

RESULTS

Research Questions 1: What is the difference in mean scores of Chemistry students taught using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis?

Table 1: Mean and standard deviation analysis on the difference in mean scores of Chemistry students taught using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis

S/No	Group/Method	N	Pre-test		Post-test		Grand Mean
			Mean $\overline{X}$	SD	Mean $\overline{X}$	SD	
1.	Students taught using virtual laboratories (Experimental Group)	99	2.75	0.83	2.90	0.85	2.83
2.	Students taught conventional laboratories (Control Group)	97	2.50	0.79	2.65	0.82	2.56

Source: Field Survey 2025.

The data analysis in table 1 above indicates that the grand mean of 2.83 and 2.56 was achieved between the mean scores of Chemistry students using virtual laboratories and mean scores of

Chemistry students without virtual laboratories. This implies that there is positive and significant effect on the mean scores of Chemistry students using virtual laboratories than those using conventional laboratories.

Research Question 2: What is the difference in mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis?

Table 2: Mean and Standard deviation analysis on the difference in mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis

S/No	Gender	N	Pre-test Mean $\overline{X}$	Pre-test SD	Post-test Mean $\overline{X}$	Post-test SD	Grand Mean
1.	Students taught using personalized learning platforms (Experimental Group)	99	2.70	0.82	2.90	0.85	2.80
2.	Students taught using lecture method (Control Group)	97	2.50	0.79	2.65	0.81	2.58

Source: Field Survey 2025.

The data analysis in table 2 above indicates that the grand mean of 2.80 and 2.58 was achieved between the mean scores of Chemistry students using personalized learning platforms and mean scores of Chemistry students without personalized learning platforms. This implies that there is positive and significant effect on the mean scores of Chemistry students using personalized learning platforms than those using lecture method.

Test of Hypotheses

$H0_1$: There is no significant difference in the mean scores of Chemistry students using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis.

Table 3: Summary of ANCOVA on the significant difference in the mean scores of Chemistry students using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis

Dependent Variable: Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	38.778[a]	2	19.389	2.162	.117
Intercept	6150.132	1	6150.132	685.728	.000
Pretest	28.359	1	28.359	3.162	.077

Virtual Laboratories	36.643	1	36.643	**4.086**	**.024**
Error	2134.566	238	8.969		
Total	121161.000	241			
Corrected Total	2173.344	240			

The data on table 3 showed that there is significant difference in the mean scores of Chemistry students using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis ($F_{1, 238} = 4.086$, Sig.<0.05). This implies that using virtual laboratories effectively enhance educational development of public senior secondary school students in Port Harcourt Metropolis.

$H0_2$: There is no significant difference in the mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis.

Table 4: Summary of ANCOVA on the significant difference in the mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis

Dependent Variable: Post_Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	301.297[a]	2	150.649	14.969	.000
Intercept	779.391	1	779.391	77.443	.000
Posttest	301.238	1	301.238	29.932	.000
Personalized Learning Platforms	89.920	1	89.920	**8.925**	**.000**
Error	2395.259	238	10.064		
Total	116759.000	241			
Corrected Total	2696.556	240			

The data on table 4 showed that there is a significant difference in the mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis ($F_{1, 238} = 8.925$, Sig.<0.05). This implies that using personalized learning platforms effectively improve educational development of public senior secondary school students in Port Harcourt Metropolis.

Discussion of Findings

The findings in research question one revealed that there is positive and significant effect on the mean scores of Chemistry students using virtual laboratories than those using conventional laboratories. This finding is in corroborates with Daramola (2014), who observed that Artificial

Intelligence can enhance the academic development of chemistry students in several ways by improving learning efficiency, deepening understanding, and fostering research skills. Artificial Intelligence enhances academic development of chemistry students by personalizing learning, providing virtual lab experiences, improving data analysis, speeding up assessment, expanding access to knowledge, strengthening critical thinking, and fostering collaboration. Artificial Intelligence driven virtual laboratories allow students to perform chemical experiments safely in a simulated environment. These tools can mimic real-world conditions and show molecular interactions in 3D, helping students visualize abstract concepts like atomic orbitals or reaction pathways and useful for institutions with limited physical lab resources.

The findings in Research Questions two indicated that there is positive and significant effect on the mean scores of Chemistry students using personalized learning platforms than those using lecture method. This finding agrees with the Dover (2015), who noted that Artificial Intelligence uses personalized learning and tutoring to enhance development of Chemistry students through adaptive learning platforms. Artificial Intelligence can assess each student's strengths and weaknesses in chemistry and provide customized lessons, practice problems, and feedback. Artificial Intelligence tutors like intelligent chatbots can explain complex chemistry concepts (e.g., molecular bonding, reaction mechanisms) in simpler terms and at the student's pace and it can adjust the difficulty level of exercises based on the student's performance. Artificial Intelligence also uses interactive simulations and virtual labs to improve the academic development of Chemistry students.

Conclusion

The study concludes that There is positive and significant difference in mean scores of Chemistry students using virtual laboratories and those using conventional laboratories in public senior secondary schools in Port Harcourt Metropolis. And difference in mean scores of Chemistry students using personalized learning platforms and those using lecture method in public senior secondary schools in Port Harcourt Metropolis. The study also deduced that the rapid advancement of Artificial Intelligence (AI) is transforming various sectors, and education is no exception. AI plays a significant role in both general and higher education, influencing students' academic development by offering a mix of opportunities and challenges. From personalized learning experiences to intelligent tutoring systems that provide tailored guidance, support, and feedback based on individual learning patterns and knowledge levels.

Recommendations

The researcher made the following recommendations to achieve the purpose of the study

1 The government through the policy makers should implement the uses of virtual laboratories for all secondary school students
2 Government through the school management should promote the use of personalized learning platforms for senior secondary school students.

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