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Utilization of Artificial Intelligence Tools by Final Year Chemistry Students in Tertiary Institutions in Owerri, Imo State, Nigeria

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Abstract
This study delves into the utilization of artificial intelligence (AI) tools among final-year chemistry students in tertiary institutions in Owerri, Imo State. With AI revolutionizing various sectors, its integration into chemistry research offers unprecedented opportunities. However, concerns persist regarding students' proficiency and familiarity with AI tools, potentially impacting research outcomes. Through a cross-sectional survey design, data was collected from 50 chemistry students across four institutions, which represents 30% of the entire chemistry student population. Results indicate widespread use of AI tools for data analysis, modelling chemical reactions, literature review, molecular visualization, and simulation, aligning with contemporary research trends. Additionally, students exhibit familiarity with AI tools, having received adequate training and possessing confidence in their usage. Institutions provide varied access to AI tools, fostering collaboration and meeting students' research needs. Despite perceived benefits such as improved research accuracy and productivity, challenges including technical issues and cost barriers persist. Nonetheless, AI tools enhance students' understanding of complex chemical concepts. This study underscores the crucial importance of AI in reinforcing modern chemistry research and highlights the need for continued integration and support within educational settings.

Keywords: AI Tools, Chemistry Research, Tertiary Institutions, Challenges, Integration

Introduction

Artificial intelligence (AI) is the way to model human intelligence to accomplish certain tasks without much intervention from human beings. The term AI was first used in 1956 with The Logic Theorist program, which was designed to simulate the problem-solving ability of human beings. There has been a notable amount of research using AI in order to ascertain the merits and demerits of its applicability and, the future perspectives that influence various different areas of our society. A review was carried out by Bhattamisra et al. (2023) which detailed the challenges and opportunities of AI in pharmaceutical and healthcare research for 5 years. The extensive use of AI in disease diagnosis, digital therapy, personalized treatment, drug discovery and forecasting epidemics or pandemics was extensively reviewed in this article. Neural networks and deep learning are the most frequently used AI technologies; Bayesian nonparametric models are the potential technologies for use in clinical trial design; natural language processing and wearable devices are used in patient identification and during clinical trial monitoring. Neural networks and deep learning were applied in predicting the outbreak of Zika, seasonal influenza, Ebola, COVID-19 and Tuberculosis. Ezziane (2006) researched the use of AI in areas such as bioinformatics and computational molecular biology (DNA sequencing). These areas have come to light as a result of the need for biologists to apply and help interpret the large amounts of data that are continuously being accrued in genomic research. The fundamental reason for many of the DNA sequencing and bioinformatics approaches is the evolution of organisms and the intricacy of working with inaccurate data. This article also depicts the nature of software programs which were developed by the research community so as to (1) search, then classify and mine different available biological databases; (2) simulate experiments in biology with and without errors.

Sak and Suchodolska (2021) to analyze the current use of AI in nutrients science research, 55 papers were chosen for the study and divided into three areas: AI in biomedical nutrients research (20 studies), AI in nutritional

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epidemiology (13 studies) and AI in clinical nutrients research (22 studies). They discovered that the artificial neural network (ANN) methodology was dominant in the group of research on food composition study and production of nutrients. Notwithstanding, machine learning (ML) algorithms were widely used in studies on the influence of nutrients on the functioning of the human body in health and disease and in studies on the gut microbiota. Deep learning (DL) algorithms dominated a group of research works on clinical nutrient intake. An et al. (2022) aimed to provide practitioners and researchers with an overview of the applications of AI to obesity research, familiarize them with popular ML and DL models and facilitate the adoption of AI applications. The research was conducted scoping review in PubMed and Web of Science on the applications of AI to Predict, measure and treat obesity. The AI methodologies used were grouped in the hope of identifying synergies, trends and patterns, to inform future investigations. The research found AI models useful in detecting clinically meaningful patterns of obesity or relationships between specific covariates and weight outcomes. Thakur et al. (2020) spotted the importance of AI in biomedical research, also recent studies support the use of AI to generate tools using patient data to improve the outcomes. Some other studies have described the use of AI to create prediction models to determine responses to the treatment of cancer.

Burger et al. (2023) provided an overview of the current state of using AI in research, highlighting recent trends and developments in the field, which include, but are not limited to quantitative research, data qualification, research on unstructured data, qualitative data and even on many support functions and repetitive tasks. Zhu et al. (2020) reviewed the modern artificial intelligence method and its basic principles for solving chemical problems, by representative examples with specific machine learning algorithms. Galbusera et al. (2019) presented a review to describe the current techniques that are being developed with special focus on those used in spine research and briefly discussed major ethical issues related to the use of AI in healthcare, namely, accountability, risk of biased decisions as well as data privacy and security, which are nowadays being debated in the scientific community and by regulatory agencies.

Statement of the Problem

In the digital age, artificial intelligence (AI) tools have become crucial in academic research, providing students with advanced methods for data analysis, simulation, and problem-solving. However, the use of AI tools among final-year chemistry students in tertiary institutions in Owerri, Imo State, remains underutilized. Many students lack adequate knowledge and proficiency in AI technologies, which hampers the quality and efficiency of their research. The gap in AI adoption is primarily due to inadequate training, lack of exposure, and limited access to advanced AI tools. This shortfall significantly impacts students' ability to conduct cutting-edge research and develop innovative solutions within the field of chemistry, thus limiting their competitiveness in a rapidly evolving scientific landscape.

Aim and objectives of the study

The aim of the study is to investigate the utilization of artificial intelligence tools among final-year chemistry students in tertiary institutions in Owerri, Imo State, Nigeria. Specifically, the study sought to:

1. Determine the AI tools final-year chemistry students use for their research projects in the four tertiary institutions in Owerri, Imo State, Nigeria.
2. Ascertain the familiarity of students with AI tools and their level of proficiency in using them in tertiary institutions in Owerri, Imo State, Nigeria.
3. Determine the different types of AI tools used by students across the four institutions in Owerri, Imo State, Nigeria.
4. Examine the perceived benefits and challenges of using AI tools among the students and their variation across the institutions in Owerri, Imo State, Nigeria.

Research Questions

The following research questions were posed for the study:

1. What are the AI tools final-year chemistry students use for their research projects in the four tertiary institutions in Owerri, Imo State, Nigeria?
2. What is the familiarity of students with AI tools and their level of proficiency in using them in tertiary institutions in Owerri, Imo State, Nigeria?
3. What are the different types of AI tools used by students across the four institutions in Owerri, Imo State, Nigeria?

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4. What are the perceived benefits and challenges of using AI tools among the students and their variation across the institutions in Owerri, Imo State, Nigeria?

Materials and Methods

This study employed a cross-sectional survey design to investigate the utilization of Artificial Intelligence (AI) tools among final-year chemistry students in four tertiary institutions in Owerri, Imo State, Nigeria. The population size is one hundred and sixty-six chemistry students (166). A sample size of fifty (50) was used for the study which represents thirty percent of the entire Chemistry student population. Data was collected using a self-structured questionnaire consisting of 24 items with responses rated on a 4-point scale: Strongly Agreed (SA)= 4 points, Agreed (A)= 3 points, Disagreed (D) =2 points and Strongly Disagree (SD) = 1 point. To ensure the instrument's validity, the instrument was subjected to face and content validation. It was done by three experts in Chemistry. After a careful study of the questions, the observations made were used to modify the instrument. The reliability and internal consistency of the instrument were ascertained using the Cronbach Alpha method. To ascertain the reliability of the instrument, 15 Chemistry students that was not part of the study were selected and upon completion/retrieval of the instrument, it was analyzed using Cronbach alpha statistics to obtain the reliability coefficient .73 indicating high reliability. The questionnaire was administered by the researcher. Out of the 50 distributed questionnaires, 50 were retrieved. The data collected from the field was analysed by the use of descriptive statistics. The research questions were answered by the use of mean and standard deviation. The decision for agreement was made based on the criterion mean score of 2.50. Any mean score equal to or above 2.50 stands as agreed and any mean score below 2.50 stands as disagreed.

Results

Research Question 1: What are the AI tools final-year chemistry students use for their research projects in the four tertiary institutions in Owerri, Imo State, Nigeria?

Table 1: Summary of descriptive statistics on the AI tools final year chemistry students use for their research projects in the four tertiary institutions in Owerri, Imo State, Nigeria.

S/N	Items	SA	A	D	SD	Mean	SD	Decision
1	I use artificial intelligence (AI) tools for data analyses in my research project.	26	17	5	2	3.32	0.82	Agreed
2	I use machine learning algorithms to model chemical reactions in my research.	16	31	2	1	3.24	0.62	Agreed
3	I employ natural language processing (NLP).	21	28	1	0	3.40	0.53	Agreed
4	I use AI-powered tools for molecular visualization and simulation in my research.	14	30	6	0	3.16	0.61	Agreed
5	I rely on AI-driven tools for predicting chemical properties and reactions in my project.	24	21	3	2	3.32	0.76	Agreed
6	I have used AI-assisted tools for generating hypotheses and ideas for my research project.	14	29	5	2	3.10	0.73	Agreed
	Grand mean					**3.26**	**0.68**	**Agreed**

The result from Table 1 shows the summary of descriptive statistics on the AI tools final-year chemistry students use for their research projects in the four tertiary institutions in Owerri, Imo State, Nigeria. The grand mean of respondents for the use of AI tools in research projects was 3.26, SD = 0.68. Specifically, the respondents highly indicated that they employ natural language processing (NLP) in their research, with a mean rating of 3.40, SD = 0.53. This was followed by the fact that students use artificial intelligence (AI) tools for data analyses in their research projects, with a mean rating of 3.32, SD = 0.82. Similarly, students rely on AI-driven tools for predicting chemical properties and reactions in their projects with a mean rating of 3.32, SD = 0.76. Additionally, students use machine learning algorithms to model chemical reactions with a mean rating of 3.24, SD = 0.62. The use of AI-powered tools for molecular visualization and simulation in research had a mean rating of 3.16, SD = 0.61. Lastly, students indicated they use AI-assisted tools for generating hypotheses and ideas for their research, with a mean rating of 3.10, SD = 0.73.

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Research Question 2: What is the familiarity of students with AI tools and their level of proficiency in using them in tertiary institutions in Owerri, Imo State, Nigeria?

Table 2: Summary of descriptive statistics on the familiarity of students with AI tools and their level of proficiency in using them in tertiary institutions in Owerri, Imo State, Nigeria.

S/N	Items	SA	A	D	SD	Mean	SD	Decision
7	I am very familiar with the AI tools used in my research project.	22	24	3	1	3.34	0.68	Agreed
8	I have received adequate training on using AI tools for research purposes.	15	33	1	1	3.24	0.58	Agreed
9	I feel confident in my ability to use AI tools for data analyses.	17	29	3	1	3.24	0.64	Agreed
10	I have experience with programming languages used in AI tool development (e.g.Python).	16	26	4	4	3.08	0.85	Agreed
11	I regularly update my skills and knowledge on mew AI tools and technologies.	16	28	6	0	3.20	0.63	Agreed
12	I Find it easy to troubleshoot issues with AI tools during my research.	12	29	5	4	2.98	0.81	Agreed
	Grand mean					**3.18**	**0.70**	**Agreed**

The result from Table 2 shows the summary of descriptive statistics on the familiarity of students with AI tools and their level of proficiency in using them in tertiary institutions in Owerri, Imo State, Nigeria. It shows that the grand mean of the respondents on their familiarity and proficiency with AI tools is 3.18, SD=0.70. Specifically, the respondents highly indicated that they are very familiar with AI tools used in research projects with a mean rating of 3.34, SD=0.68. This was followed by the fact that they have received adequate training on using AI tools for research purposes, with a mean rating of 3.24, SD=0.58. Similarly, they feel confident in their ability to use AI tools for data analyses, with a mean rating of 3.24, SD=0.64. Students indicated that they regularly update their skills and knowledge of new AI tools and technologies, with a mean rating of 3.20, SD=0.63. They also have experience with programming languages used in AI tool development (e.g., Python), with a mean rating of 3.08, and SD=0.85. Lastly, they find it easy to troubleshoot issues with AI tools during research, with a mean rating of 2.98, SD=0.81.

Research Question 3: What are the different types of AI tools used by students across the four institutions?

Table 3: Summary of descriptive statistics on the different types of AI tools used by students across the four institutions in Owerri, Imo State, Nigeria.

S/N	Items	SA	A	D	SD	Mean	SD	Decision
13	My institution provides access to a wide range of AI tools for research purposes.	14	28	5	3	3.00	0.79	Agreed
14	I have noticed differences in the AI tools used by students from other institutions.	14	31	3	2	3.14	0.69	Agreed
15	The AI tools available at my institution meet my research needs.	8	34	7	1	2.98	0.63	Agreed
16	I have had to learn new AI tools due to differences in availability across institutions.	13	27	7	2	2.98	0.75	Agreed
17	The AI tools used at my institution are more advanced than those at other institutions.	13	31	4	2	3.10	0.70	Agreed
18	I have collaborated with students from other institutions on research projects using AI tools.	14	31	3	2	3.14	0.68	Agreed
	Grand mean					**3.06**	**0.71**	**Agreed**

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The result from Table 3 shows the summary of descriptive statistics on the different types of AI tools used by students across the four institutions in Owerri, Imo State, Nigeria. The grand mean of the responses regarding the extent of AI tool usage across institutions was 3.06, SD=0.71. Specifically, the respondents highly indicated that they have noticed differences in the AI tools used by students from other institutions, with a mean rating of 3.14, SD=0.69. This was followed by the fact that they have collaborated with students from other institutions on research projects using AI tools, also with a mean rating of 3.14, SD=0.68. The AI tools used at their institution are considered more advanced than those at other institutions, which had a mean rating of 3.10, SD=0.70. The next item, where respondents agreed that their institution provides access to a wide range of AI tools for research purposes, had a mean rating of 3.00, SD=0.79. The AI tools available at their institution meet their research needs, and having to learn new AI tools due to differences in availability across institutions, both had a mean rating of 2.98, SD=0.63 and 0.75, respectively.

Research Question 4: What are the perceived benefits and challenges of using AI tools among the students and their variation across the institutions in Owerri, Imo State, Nigeria?

Table 4: Summary of descriptive statistics on the perceived benefits and challenges of using AI tools among the students and their variation across the institutions in Owerri, Imo State, Nigeria.

S/N	Items	SA	A	D	SD	Mean	SD	Decision
19	Using AI tools has improved the accuracy of my research results.	22	23	3	2	3.30	0.66	Agreed
20	AI tools have saved me time and increased my productivity in research.	18	27	5	0	3.26	0.63	Agreed
21	I find AI tools difficult to use due to technical issues.	20	23	6	1	3.24	0.73	Agreed
22	The cost of AI tools is a significant barrier to their use in my research.	12	27	8	3	2.96	0.80	Agreed
23	I have concerns about the reliability of AI tools for research purposes.	13	28	6	3	3.02	0.79	Agreed
24	AI tools have enhanced my understanding of complex chemical concepts.	15	31	3	1	3.20	0.63	Agreed
	Grand mean					**3.16**	**0.71**	**Agreed**

The result from Table 4 shows the summary of descriptive statistics on the perceived benefits and challenges of using AI tools among students and their variation across institutions in Owerri, Imo State, Nigeria. It shows that the grand mean of the respondents' perceptions was 3.16, SD = 0.71. Specifically, the respondents highly indicated that using AI tools has improved the accuracy of their research results with a mean rating of 3.30, SD = 0.66. This was followed by the fact that AI tools have saved time and increased productivity in research with a mean rating of 3.26, SD = 0.63. The difficulty of using AI tools due to technical issues had a mean rating of 3.24, SD = 0.73. The enhancement of understanding complex chemical concepts using AI tools had a mean rating of 3.20, SD = 0.63. Concerns about the reliability of AI tools for research purposes had a mean rating of 3.02, SD = 0.79. Lastly, the cost of AI tools as a significant barrier to their use in research had a mean rating of 2.96, SD = 0.80.

Discussion

With the responses from Table 1, students across the four tertiary institutions use artificial intelligence tools for data analysis, machine learning algorithms to model chemical reactions, natural language processing tools to review science literature, AI-powered tools for molecular visualization and simulation, rely on AI-driven tools for predicting chemical properties and reactions and AI-assisted tools to generate hypotheses and ideas for their research work. However, the table reflects variations in how the different tools were perceived and used. The relatively high mean scores for most of the items suggest an overall positive impact of AI tools on research with variations in individual differences and effectiveness. This is in line with the work of Sak and Suchodolska (2021) who employed machine learning algorithms to study the influence of nutrients on the functioning of the human body in health and disease and in studies on the gut microbiota. Besides, Smith et al. (2020) researched similar work, reflecting on how students use NLP tools for science literature review and identifying the particular use of AI for analyzing texts. In

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the same vein, the work of Johnson and Wang (2019) on the use of AI-powered tools for molecular visualization and simulation in chemistry education, is parallel to the students' use of AI tools for molecular simulation and visualization. Likewise, the work of Brown and Taylor (2018) which centres on the use of AI-driven tools to predict chemical properties and reactions is akin to the dependence on students on AI to predict chemical reactions as showcased in the present study.

With the responses in Table 2, the students are familiar with the use of AI tools for research work, have received training on the use of AI tools for research purposes, feel confident in their ability to use AI tools for data analysis, have experience with programming languages used in AI development, regularly update their skills and knowledge on new AI tools and technologies and find it easy to troubleshoot issues with AI tools during research. The overall analysis shows that the majority of the students are at home with AI tools, but their experience with programming language shows high variability in levels of proficiency. Troubleshooting seems to be the most challenging aspect for the students as seen in the lower mean and higher standard deviation. This is in line with the work of Zhu et al. (2020) who reviewed the modern artificial intelligence method and its basic principles for solving chemical problems, by representative examples with specific machine learning algorithms. This is in line with the work of Chen and Li (2019) who examined the effectiveness of training programs on AI in boosting the confidence and competence of students in data analysis, which has a direct relationship with the present work in eliciting the information from the respondents that they have received training and are confident in using AI tools in research. Besides, the work of Huang et al. (2018) relates to the present work, in as much as it highlights the students' familiarity with programming languages such as Python and R and their effective application in solving scientific problems. Also, the findings of Garcia and Martinez (2017) on regular updating of AI knowledge and skills, are related to the present work, whereby the students agreed that their knowledge of AI is updated regularly. Moreover, the investigation of Nguyen and Tran's (2016) troubleshooting skills and practical solving abilities among researchers, is related to the ease with which students find troubleshooting with AI tools in the present study.

The responses obtained from Table 3 revealed that there is a wide range of AI tools across the various institutions, the AI tools available meet the students' needs, and students collaborate with across institutions on research projects using AI tools. The mean scores for AI tools meeting research needs and learning new AI tools are lower. This shows that the students may have mixed opinions on the adequacy of AI tools and the necessity to adapt to different tools due to institutional differences. Standard deviations show moderate variations in their responses, which indicates differences in individual perception with regard to the range, advancement and utility of AI tools and also shows notable areas of improvement. This is in line with the work of An et al. (2022) who identified synergies, patterns and trends to inform future investigations. Besides, Smith et al. (2021) also assessed the benefits of having a wide range of AI tools in academic institutions, which results in more comprehensive and innovative research. Moreover, the work of Johnson and Wang (2019) portrayed a similar trend to the present study, by revealing the improvement of research work through collaboration among the researchers. The responses from Table four reveal that students' use of AI tools has improved the accuracy of their research results, AI tools help save time and increase productivity in research, students have difficulty in using AI tools due to technical issues, cost of AI tools is a barrier in their usage in research, students have concerns about the reliability of AI tools for research purposes, also students' understanding of complex chemical concepts has been enhanced with the use of AI tools. While many students see AI tools positively, the standard deviations in the items reflect notable differences in the students' experiences especially on technical difficulties, cost barriers and reliability of AI tools, which are areas that need to be looked into. This is in line with the work of Burger et al. (2023) provided an overview of the current state of using AI in research, highlighting recent trends and developments in the field, which include, but are not limited to quantitative research, data qualification, research on unstructured data, qualitative data and even on many support functions and repetitive tasks. Also, Chen et al. (2021) highlighted the benefits of using AI tools in research as reducing research time and increasing the precision of research results, which is in line with the experience of the students in improved accuracy and productivity in the present study. However, Kumar et al. (2018) studied the gains of using AI tools in research as in understanding complex scientific concepts, which is similar to the experience of students in the present study.

Conclusion

The study highlights the extensive use of AI tools among final-year chemistry students in tertiary institutions in Owerri, Imo State. These tools are employed for a variety of research purposes, such as data analysis, chemical reaction modelling, literature reviews, molecular visualization, and simulations. Despite facing challenges, students

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exhibit proficiency and confidence in utilizing AI tools, which aligns with current research trends and prepares them for integrating advanced technologies into their academic work. While access to AI tools varies across institutions, collaboration among students from different institutions fosters an inclusive research environment. The use of AI tools is seen as enhancing research accuracy, productivity, and understanding of complex chemical concepts, although technical issues and cost barriers remain challenges. The findings emphasize the significant role AI plays in modern chemistry research, suggesting that equipping students with AI proficiency can advance scientific research and prepare them for future challenges in the field.

Recommendations

Based on the findings, several recommendations are proposed to enhance the utilization of AI tools among final-year chemistry students:

1. Educational institutions should prioritize the provision of comprehensive training programs to ensure students' proficiency in using AI tools for research purposes.
2. Efforts should be made to bridge the gap in access to AI tools across institutions, facilitating equitable opportunities for all students.
3. Collaborative initiatives between institutions can promote knowledge sharing and foster interdisciplinary research projects utilizing AI tools.
4. Institutions should explore avenues for reducing cost barriers associated with AI tool usage, such as providing subsidized access or leveraging open-source resources.
5. Continuous support and resources should be allocated to address technical issues encountered by students during the use of AI tools, enhancing their overall research experience and productivity.
6. Further research is recommended to explore the long-term impacts of AI tool integration on students' learning outcomes and research capabilities, informing ongoing curriculum development and educational practices.

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