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Research Article

Leveraging on artificial intelligence in enhancing STEM education: A case study of ChatGPT

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ABSTRACT

The study examined leveraging on artificial intelligence in enhancing STEM education: a case study of ChatGPT. Descriptive survey research design was adopted for the study. All academic staff of the faculty of education, University of Nigeria, Nsukka (UNN) makes up the population while purposive sampling was used to sampled 171 lecturers for the study. Questionnaire on ChatGPT utilization and perception was used for data collection. Three experts, two from the department of science education, and one from department of computer and robotic science all from UNN, validated the questionnaire. The instrument yielded a reliability coefficient of 0.85 using Cronbach's alpha. Research questions were answer using grand mean and standard deviation while t-test was used to test the hypothesis at 0.05 level of significance. The findings of the study revealed thus: that lecturers utilize ChatGPT to a moderate extent and female were found to slightly utilize it more than male. However, the difference was not statistically significant. Also, lecturers were found to have a positive perception toward the use of ChatGPT. Poor power supply, poor internet connectivity, and ICT infrastructure deficit were some of the institutional challenges militating against it use. It was therefore recommended that stable and reliable electricity and upgrade of internet and ICT facilities should be ensured within the institution.

Keywords: artificial intelligence, STEM education, ChatGPT

INTRODUCTION

In this digital era, educators continually seek tools that can transform the classroom experience for both teachers and learners. Information technology has shown great potential in promoting educational transformation needed in 21st century classrooms. It has transformed many aspects of our lives, including; commerce, transportation, communication, governance, and so education cannot be exempted. The incorporation of technology into the education system has been a transformative force, significantly causing a paradigm shift into how we teach and learn. The progress recorded with machine learning (technology) in education has led to the introduction of a more sophisticated innovative digital content generation like generative artificial intelligence (AI) (Hu, 2022). This new set of educational technologies, particularly AI, is directly or indirectly reshaping educational landscape and settings.

AI as an innovative generative language system capable of engaging in sophisticated, human-like conversations (Swargiary, 2024). AI is the simulation of human intelligence in machines that are programmed to think and learn like humans, performing tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. AI refers to the ability of a computer system to mimic the behavior of the human brain. This involves receiving information in the form of external data, learning through training and based on that learning, achieving the goals for which it was designed (Brazdil & Jorge, 2021). AI encompasses a broad range of techniques and approaches, including machine learning, deep learning, natural language processing (NLP), computer vision, and robotics. According to Luckin (2018), the rapid advancement of AI technologies has introduced innovative methodologies for teaching and learning, especially in Science, technology, engineering, and mathematics (STEM) disciplines.

These technologies are used to develop systems that can autonomously analyze data, learn from patterns, make decisions, and adapt to changing environments. The utilization of AI cut across various industries, including but not limited to healthcare, automotive, gaming, finance, education, and lot more. In the education system, AI has the potential to significantly impact how teachers and students

teach and learn by improving efficiency, driving innovation, and transforming institutional operation. AI-powered platforms like ChatGPT have transformed traditional classrooms by offering personalized and adaptive learning experiences (Holmes et al., 2019). Montenegro-Rueda et al. (2023) added that AI such as ChatGPT has settled itself at the central stage of research, ranging from education, computers science, medicine and robotics to social sciences.

ChatGPT is a state-of-the-art language model developed by OpenAI, based on the generative pre-trained transformer architecture. It belongs to a family of models designed to understand and generate human-like text based on the input it receives. ChatGPT has shown great potential in transforming various aspects of education, from personalized learning experiences to intelligent tutoring systems, improvements in the efficiency of the educational process, the promotion of global learning, advanced analytics, instructional automation, creation of more intelligent content and the optimization of effectiveness and efficiency (Jara & Ochoa, 2021). Zhai (2022) opined that ChatGPT serves as an intelligent tutor capable of generating real-time responses, assisting students with complex concepts, and encouraging exploratory learning. ChatGPT in STEM education has the ability to provide personalized learning experiences through NLP capabilities and interact with students in a conversational manner (Chassignol et al., 2018).

STEM is a concept that promote a comprehensive approach to understanding and solving complex problems and encourage interdisciplinary learning, problem solving, innovations and creativity (Stewart, 2015). The use of chatbot like ChatGPT in STEM education not only equips learners with critical thinking skills, problem-solving abilities, and technical knowledge but also help them in chosen career part. The deployment of ChatGPT in STEM learning is essential for innovation and competitiveness in the global economy, to addressing challenges such as climate change, health care, and infrastructure development (Hughes et al., 2022; National Science Foundation, 2021; Wu et al., 2022). It can also adapt explanations, examples, and quizzes based on individual student needs and learning styles to helps them grasp complex STEM concepts more effectively.

Similarly, Baidoo-Anu and Owusu Ansah (2023) opined that ChatGPT is designed to generate human-like text based on a given prompt or context. It can be used for a variety of NLP tasks, such as text completion, conversation generation, and language translation. AI particularly ChatGPT has shifted the mode of learning towards a more self-directed and asynchronous learning, where students are having more autonomy in their learning and are able to complete coursework at their own pace. It allows students to work at a time that is convenient for them, thereby creating time for students who may have other responsibilities or who may have difficulty attending live classes.

However, the shift to machine/technology learning has not come without its own shortfalls. For example, students in low-income or rural areas may not have access to the technology or internet connectivity needed to fully participate in remote learning, lack of motivation, interaction and accountability (Baidoo-Anu & Owusu Ansah, 2023). Other shortfalls include potential misinformation, ethical concerns, and dependency issues (Bender et al., 2021). Similarly, the accuracy of AI-generated responses must be verified to ensure the reliability of learning materials (Zhong et al., 2022). AI's inability to replace human instructors limits its effectiveness in critical thinking development (Selwyn, 2019). Furthermore, educators such as Rudolph et al. (2023) are of the view that relying on ChatGPT could render traditional essay assessments obsolete, allowing students to "outsource" their writing tasks to AI. A chat with students reveals high levels of skepticism towards ChatGPT, with most believing that utilizing the tool may not necessarily lead to improved grades and that overreliance on it could potentially dull their academic outcome (Baidoo-Anu & Owusu Ansah, 2023).

Rudolph et al. (2023) suggested the adoption of approach that ensures that students use ChatGPT not to write their assignments, but as a tool to help outline papers or as an always-available online tutor for pre-test study sessions. Playfoot et al. (2023) are worried that if students adopt AI (ChatGPT) tools for academic writing, the risk of detection will be minimal because of its algorithm. Evidence in literature revealed that ChatGPT would be helpful to numerous professionals, instructors, and students (Gan & Bai, 2023; Rayner, 2023; Stojanov, 2023). Rayner (2023) stated further that stakeholders, including; researchers, scientists, instructors, entrepreneurs and students could employ ChatGPT to improve their creative writing, coding skills, and common-sense reasoning at large. According to Caratiquit and Caratiquit (2023) and Cheng (2023), ChatGPT is an advanced STEM education tool that perform beyond traditional pedagogical methods, providing illustrations and helping learners understand complex ideas, widen their knowledge, and enhance their skill in academic written.

As a readily accessible knowledge repository, ChatGPT facilitates self-directed learning, foster critical thinking, problem-solving abilities, and independent research among scholars (Dai et al., 2023; Mhlanga, 2023). Furthermore, findings revealed that ChatGPT offer an interactive and gamified learning experiences, increases student motivation and participation (Kim et al., 2009), and helps students overcome learning barriers by simplifying complex STEM concepts (Heffernan & Heffernan, 2014). Similarly, ChatGPT help students in brainstorming, generating hypotheses, and improving writing skills in scientific research (Kumar et al., 2021; McNamara et al., 2017), and adapts to individual learning styles, providing customized explanations and problem-solving strategies (Dillenbourg, 2016)

In spite of the existing body of literatures on AI chatbots generally and ChatGPT particularly, to the best of the researchers' knowledge little or no empirical research has been conducted in this area. Similarly, renowned academic publishers in STEM such as Springer Nature, Science, and Routledge have called upon scholars to pay more attention to the impact of ChatGPT on research ethics, authorship, and academic integrity in STEM research and development (Kim, 2023; Thorp, 2023). This substantiates the extent to which technology has change the educational landscape particularly in the developed nations ignoring the developing regions. Developing nations are encouraged to adopt a culturally responsive curriculum that can embrace diversity and

inclusivity in the teaching and learning in variety of subjects, including STEM and AI literacy (Yang, 2022).

To this end, the potential benefit and issues in deploying ChatGPT in academic research in STEM teaching and learning, may be visible among stakeholders in STEM research and higher education development in most parts of the world, but are alien to majority of academics in the developing region such as Nigeria. Chng et al. (2023) stated that although justifications have been made for the integration of emerging technologies' such as ChatGPT for its transformative potential in STEM education, but not much has been done for its eventual implementation in schools. Montenegro-Rueda et al. (2023) added that implementation of ChatGPT in the educational environment has a positive impact but argued that its successful implementation requires teachers to be familiar with the operation ChatGPT. In agreement, Shumiye (2024) added that implementing AI required alterations to instructional strategies. Johnson et al. (2020) theorized that the future of AI in STEM education lies in the integration of ChatGPT with other educational technologies, such as virtual reality and augmented reality.

Given this, the current empirical study focuses on developing a scholarly dialogue to fill the gap in literature and examine the benefits and problems of ChatGPT in mainstream STEM learning. Thereby revealing a more comprehensive understanding of the impact of AI chatbots and perception among STEM educators and the future of human intelligence in higher education, the locality and beyond.

Purpose of the Study

The following purpose guided the study:

1. To determine the extent of use of ChatGPT among STEM lecturers in faculty of education at University of Nigeria, Nsukka (UNN).
2. To determine the perception of lecturers on the use of ChatGPT.
3. To determine institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN.
4. To proffer remedy to the institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN.

Research Questions

The following research questions guided the study:

1. What is the extent of use of ChatGPT among lecturers in faculty of education at UNN?
2. Does gender influence lectures use of ChatGPT in faculty of education at UNN?
3. What is the perception of lecturers on the use of ChatGPT?
4. What are the institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN?
5. What are the remedies to the institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN?

Hypothesis

1. Gender has no influence on the extent of use of ChatGPT among lecturers in faculty of education at UNN.

METHODS

A survey research design was adopted for this study. The study was carried out in UNN in Nsukka LGA of Enugu State. The 343 lecturers in faculty of education, UNN makes up the population for this study while a total of one hundred and seventy lecturers from department of science education, computer and robotic education, and physical and health education was purposively sampled for the study. Purposive sampling was employed because the study focuses on STEM education. Researchers developed an instrument titled lecturers awareness and use of ChatGPT questionnaire (LAUCQ) was used for data collection.

LAUCQ is a 23-item questionnaire structured into four clusters A to D. Cluster A consists of 7 items on extent of use of ChatGPT rated "frequently used = 4, used occasionally = 3, rarely used = 2, not use = 1"; cluster B consists of 5 items on lecturers' perception on the use of ChatGPT, while cluster C and cluster D consist of 6 items each for challenges and remedies, rated on strongly agree = 4, agree = 3, disagree = 2, and strongly disagree = 1.

Three experts two from the department of science education, one from department of computer and robotic science all from UNN, validated the questionnaire. Average reliability coefficient of 0.85 was established for all the clusters using Cronbach's alpha. A total of 232 instruments were administered and retrieved but unfortunately 8 were not filled, leaving only 224 questionnaires valid for analysis. Research questions were answer using percentage, grand mean (M) and standard deviation (SD) while t-test was used to test the hypothesis at 0.05 level of significance. The decision rule for the research question one, real limits were used thus: means ratings between 1.00-2.33 were considered as low extent, 2.34-3.66 (moderate extent), and 3.67-5.00 (high extent). Whereas the decision for research questions three to five were a grand mean score of 2.5 and above as accepted and less than 2.5 was considered rejected.

RESULTS

The result for the study is presented below in charts.

Research question one: What is the extent of use of ChatGPT among lecturers in faculty of education at UNN?

Results in **Table 1** showed that all the items in the cluster had their mean ratings between 2.34-3.66, which implies that these items were being utilized to a moderate extent. Furthermore, the result revealed a grand mean of 3.35 which is also within the mean rating of 2.34-3.66 showing that lecturers in faculty of education utilizes ChatGPT at a moderate extent.

Research question two: Does gender influence lectures use of ChatGPT in faculty of education at UNN?

Table 1. Mean and standard deviation on the extent of use of ChatGPT among lecturers in faculty of education at UNN

S/N	Item on lecturer's use of ChatGPT	N	M	SD	Remark
1	How often do I utilize ChatGPT in my lecture?	171	3.35	.70	Moderate extent
2	I utilized ChatGPT to generate learning materials for my students.	171	3.36	.73	Moderate extent
3	I utilized ChatGPT to generate learning materials for my research.	171	3.20	.94	Moderate extent
4	I utilized ChatGPT mainly for academic activities.	171	3.53	.64	Moderate extent
5	ChatGPT is utilized for other activities other than academic activities.	171	3.32	.75	Moderate extent
Grand mean			**3.35**		**Moderate extent**

Note. Means ratings between 1.00-2.33 (low extent), 2.34-3.66 (moderate extent), 3.67-5.00 (high extent) & N: Number of respondents

Table 2. Mean and standard deviation on the influence of gender on lectures use of ChatGPT in faculty of education at UNN

Gender	N	M	SD
Male	72	16.66	1.89
Female	99	16.87	1.81

Note. N: Number of respondents

Table 3. z-test of significance difference on the influence of gender on the extent of use of ChatGPT among lecturers in faculty of education at UNN

Gender	N	M	SD	df	t	p-value	Decision
Male	72	16.66	1.89	169	.740	.460	Not significant
Female	99	16.87	1.81				

Note. N: Number of respondents

The result in **Table 2** showed that male lecturers had a mean score of 16.66 with an SD of 1.89 while female lecturers had a mean score of 16.87 and an SD of 1.81. the result revealed that female lecturers had slightly higher mean than male lectures in faculty of education, university of Nigeria, Nsukka. In addition, the SD of 1.89 and 1.81 for male and female, respectively revealed that their score is clustered around the mean.

Hypothesis one: Gender has no influence on the extent of use of ChatGPT among lecturers in faculty of education at UNN.

The result in **Table 3** showed a t-value of .740 with a significant p-value of .460 which is greater than 0.05 level of significance for the study. The null hypothesis was therefore not rejected. Thus, there is no significant difference in the mean score of male and female lecturers in faculty of education, university of Nigeria, Nsukka on their extent of use of ChatGPT. Therefore, gender does not influence the use of ChatGPT among lecturers in faculty of Education UNN.

Research question three: What is the perception of lecturers on the use of ChatGPT?

Table 4 shows that seven out of the eight items had a mean score between 3.00-3.60 which is more than the 2.50 grand mean score benchmark for the study except item 8 which had a mean score of 2.28 lesser than the 2.50 mean benchmark for the study. However, with the grand mean of 3.52, it therefore means that the respondents (faculty of education lecturers) agreed to all the eight items in cluster B as their perception toward the use of ChatGPT.

Research question four: What are the institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN?

Table 5 shows that all the seven items on the institutional challenges mitigating against the use of ChatGPT had a mean score between 2.50-4.50 which is more than the 2.50 grand mean score benchmark for the study. With the grand mean of 3.10, it therefore means that the respondents (faculty of education lecturers) agreed to all the seven items in cluster C as their institutional challenges mitigating against the use of ChatGPT.

Research question five: What are the remedies to the institutional challenges mitigating against the use of ChatGPT among lecturers in faculty of education at UNN?

Table 6 shows that all the seven items on the institutional challenges mitigating against the use of ChatGPT had a mean score between 2.50-4.50 which is more than the 2.50 grand mean score benchmark for the study. With the grand mean of 3.04, it therefore means that the respondents (faculty of education lecturers) agreed to all the seven items in cluster D as remediation to their institutional challenges mitigating against the use of ChatGPT.

Table 4. Mean and standard deviation on the perception of lectures on the use of ChatGPT in faculty of education at UNN

S/N	Item	N	M	SD	Remark
1	ChatGPT has helped me stay more organized and manage my academic workload effectively.	171	3.58	.85	Moderate extent
2	ChatGPT always gives accurate and reliability information.	171	3.69	.74	Moderate extent
3	I am satisfied with the responses generated by ChatGPT.	171	3.59	.57	Moderate extent
4	ChatGPT facilitate individualized learning.	171	3.63	.59	Moderate extent
5	ChatGPT offers significant support to lecturers in lesson-planning and academic writing.	171	3.84	.92	Moderate extent
6	Information from ChatGPT is reliable and verifiable.	171	3.76	.80	Moderate extent
7	ChatGPT has the potential to enhance lecturers writing skills.	171	3.85	.90	Moderate extent
8	ChatGPT have the potential of impairing lecturers critical thinking and problem-solving abilities if not moderated.	171	2.28	.88	Moderate extent
Grand mean			**3.52**		**Moderate extent**

Note. Means ratings between 1.00-2.33 (low extent), 2.34-3.66 (moderate extent), 3.67-5.00 (high extent) & N: Number of respondents

Table 5. Mean and standard deviation on the institutional challenges mitigating against the use of ChatGPT in faculty of education at UNN

S/N	Item	N	M	SD	Remark
1	Poor/epileptic power supply in the institution	171	3.39	.92	Moderate extent
2	Limited offices for staff in the institution	171	3.08	.96	Moderate extent
3	Poor internet connectivity within the institution	171	3.14	.96	Moderate extent
4	Lack of incentives and motivation for lecturers	171	3.27	.89	Moderate extent
5	Institutional stand on the use of ChatGPT	171	3.01	1.00	Moderate extent
6	Institution inability to organize service training to equip lecturers with the needed skills	171	3.12	1.06	Moderate extent
7	Inadequate ICT infrastructure within the institution	171	2.71	.92	Moderate extent
Grand mean			**3.10**		**Moderate extent**

Note. Means ratings between 1.00-2.33 (low extent), 2.34-3.66 (moderate extent), 3.67-5.00 (high extent) & N: Number of respondents

Table 6. Mean and standard deviation on the remedies for the institutional challenges mitigating against the use of ChatGPT in faculty of education at UNN

S/N	Item	N	M	SD	Remark
1	Stable and efficient power supply to power	171	2.65	1.04	Moderate extent
2	Ensure enough offices for the staff	171	3.15	.87	Moderate extent
3	Provision of strong internet connection in the school	171	2.57	1.13	Moderate extent
4	Provision of incentives and motivation to the lecturers	171	3.09	.82	Moderate extent
5	Lecturers should be encouraged to use ChatGPT for their academic activities	171	3.19	1.04	Moderate extent
6	In service training should be organized to equip lecturers with the skill needed to effectively use ChatGPT.	171	3.23	1.07	Moderate extent
7	Adequate ICT infrastructure should be installed within the institution.	171	3.42	.70	Moderate extent
Grand mean			**3.04**		**Moderate extent**

Note. Means ratings between 1.00-2.33 (low extent), 2.34-3.66 (moderate extent), 3.67-5.00 (high extent) & N: Number of respondents

DISCUSSION

The result of the study was discussed under this section based on research questions and hypothesis that guided the study.

The findings of the study from research question one and two and hypothesis one revealed thus. That the lecturers in faculty of education, UNN utilizes ChatGPT to a moderate extent. The result further revealed that female had slightly higher mean than their male counterparts. However, in the test significant, it was revealed further that although female lectures had slightly higher mean than male but the difference was not statistically significant. The findings are not surprising considering the environment in which lecturers are subjected to work within university of Nigeria in general and faculty of education in particular where little of no effort are made to help motivate and encourage them. These findings are in sync with the findings of Ziraba et al. (2020) and Ogunjinmi et al. (2021) who also found no significant influence of gender on the use of ChatGPT. However, the findings stand in contrast with the findings of Gregorcic and Pendrill (2023), who concluded that ChatGPT fell short of the required standards to be utilized by lecturers.

The findings on the perception of lecturers on the use of ChatGPT revealed that lecturers have a positive perception toward the use of ChatGPT. They perceived ChatGPT to be helpful in organizing and managing my academic workload effectively and always gives accurate and reliability information. They rejected that ChatGPT have the potential of impairing lecturers critical thinking and problem-solving abilities. The findings are in harmony with the finding of Montenegro-Rueda et al. (2023) but did not resonate well with the findings of Chng et al. (2023) who argued that lectures had negative perception on the use of ChatGPT.

The findings revealed further some institutional challenges mitigating against the use of ChatGPT to include; poor/ epileptic power supply in the institution, poor internet connectivity within the institution and inadequate ICT infrastructure within the institution among others. The findings agree with This result agrees with Oswal (2019), Ja'ashan (2020), and Ukala (2022).

Lastly, the study identified some remediating measures to mitigate institutional challenges against the use of ChatGPT to include stable and efficient power supply to power, ensure enough offices for the staff and provision of strong internet connectivity among others. The findings are in line with the findings of Oswal (2019), Ja'ashan (2020), Ziraba et al. (2020), Ukala (2022), and Montenegro-Rueda et al. (2023). Dumbiri and Nwadiani (2020) and Ukala (2022) therefore recommend thus; the training and retraining of lecturers with 21st century skill needed to effectively utilize the services of ChatGPT and other technological innovations in educational system.

CONCLUSION AND SUMMARY

The researchers therefore conclude based on the findings of the study as thus; that lecturer's utilizes ChatGPT to a moderate extent. Although, female lectures tend to use ChatGPT slightly more than males but the difference is not statistically significant. Similarly, lecturers perceived ChatGPT to be helpful in organizing and managing my academic workload effectively and always gives accurate and reliability information. They, however, rejected the perception that ChatGPT have the potential of impairing lecturers critical thinking and problem-solving abilities. Challenges militating

against the use of ChatGPT and remediation were identified. The researchers therefore conclude that ChatGPT is a vital AI tool for advancing STEM education in the 21st century and lecturers are encouraged to embrace it for optimum output.

Recommendation

The following recommendations were made based on the findings of the study:

1. Stable and reliable electricity should be supplied to the campuses of higher learning to enable lecturers to utilize ChatGPT.
2. The Internet and general ICT facilities on the campuses should be upgraded to enable effective use of ChatGPT.

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Availability of data: All data generated or analyzed during this study are available for sharing upon request. Interested parties are encouraged to direct their inquiries to the corresponding author, who will facilitate the provision of the data in a timely and appropriate manner.

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