

Assessing the Role of Generative Artificial Intelligence in Enhancing Algebra Performance among Senior Secondary School Students in Funtua Educational Zone, Katsina State

¹Zaharaddeen Aliyu, ²Rabiu Ahmed Tijjani, ²Muawiya Haruna Usman

¹Department of Science Education, Ahmadu Bello University, Zaria,

²Department of Mathematics, Federal University of Education Zaria, Kaduna State

ABSTRACT

This study assessed the role of Generative Artificial Intelligence (GenAI) in enhancing algebra performance among senior secondary school students in Funtua Educational Zone, Katsina State, Nigeria. A pretest-posttest, quasi-experimental control group design was adopted. The study population comprised 5,245 SS2 Mathematics students from 22 public Senior Secondary Schools in the zone. A sample of 124 students was selected from two randomly chosen schools out of 22 available schools. The students were divided into two groups: an experimental group taught Algebra using GENAI-based instructional methods and a control group taught using the conventional method. The Algebra Performance Test (APT) was used for data collection, with validity established by experts at Ahmadu Bello University, Zaria, and a reliability coefficient of 0.75 determined through Pearson Product-Moment Correlation (PPMC). One research questions and one null hypothesis guided the study. Research question was analyzed using Mean, Standard Deviation, and Mean Difference statistics, while hypothesis was tested using an Independent Sample t-test at a 0.05 level of significance. Findings revealed a significant improvement in algebra performance among students exposed to GENAI-based instruction compared to their counterparts in the control group. The study concludes that GENAI is an effective tool for enhancing algebra learning among secondary school students. It is recommended that Mathematics teachers integrate Generative Artificial Intelligence into instructional strategies to improve students' understanding of complex mathematical concepts like Algebra.

ARTICLE INFO

Article History

Received: September, 2024

Received in revised form: December, 2024

Accepted: January, 2025

Published online: March, 2025

KEYWORDS

Generative Artificial Intelligence (GenAI),
Algebra, Academic Performance

INTRODUCTION

Mathematics is a fundamental subject taught at the basic, secondary, and tertiary levels of education in Nigeria. Olanrewaju (2023) emphasized its significance in various fields of life. According to De Vera and Balgua (2023), mathematics serves as the foundation and essence of science and technology. The formal education system, particularly in Nigeria, is responsible for imparting mathematical and scientific knowledge, fostering positive attitudes, developing essential skills, and shaping critical

thinking, especially in mathematics. Blåsjö (2021) asserted that mathematics is the cornerstone of all scientific disciplines, as no scientific endeavor can thrive without mathematical validation.

Highlighting the deep connection between mathematics, science, and technology, Agah (2020) argued that without mathematics, science would not exist; without science, technology would not develop; and without technology, modern society would be unattainable. Consequently, mathematics remains a universally core and compulsory

Corresponding author: Zaharaddeen Aliyu

✉ zaliyu@abu.edu.ng

Department of Science Education, Ahmadu Bello University, Zaria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved



subject taught across all nations, although the language of instruction varies depending on each country's official medium (Acharya et al., 2021).

Hillmayr et al. (2020) described mathematics as an essential tool for advancing science and technology. No nation can achieve scientific and technological development without prioritizing the teaching and learning of mathematics, as it enables learners to develop a comprehensive understanding and interpretation of scientific and technological concepts. The National Policy on Education of the Federal Republic of Nigeria (FRN, 2013) identifies mathematics as a core subject that all students, regardless of discipline, gender, or ability, must study and pass at the credit level, particularly at the secondary school level. To meet the objectives of mathematics education, Nigeria, as a developing country, must adopt modern innovations in teaching and learning. This requires skilled mathematicians who can facilitate the early and effective realization of educational goals.

Despite the significant role of mathematics, research findings by Ndidi and Effiong (2020) as well as Eyong et al. (2020) indicate that students in Nigeria continue to exhibit poor academic performance in the subject. This challenge has been linked to several factors, including a lack of teaching materials, mathematics anxiety, ineffective teaching methods, and inadequate instructional facilities. In response, researchers such as Pattier (2021) and Nabayra (2022) have proposed various modern teaching strategies, including the integration of GENAI as an instructional tool.

Generative Artificial Intelligence (GenAI) has emerged as a transformative force in various sectors, notably in education, healthcare, and creative industries. Recent systematic reviews have delved into its applications and implications, providing a comprehensive understanding of its current state and future directions. In the educational sphere, a systematic review by Ogunleye et al. (2024) examined the integration of GenAI in higher education. The study analyzed 355 relevant papers and identified a significant gap in the development of guidelines for effectively incorporating GenAI into teaching

and learning practices. The authors emphasized the need for interdisciplinary research to formulate frameworks and policies that can guide educators and stakeholders in leveraging GenAI for educational enhancement. Sengar et al. (2024) conducted a comprehensive review focusing on the advancements and applications of GenAI across various domains. Their findings highlighted the pivotal role of GenAI in language generation, image translation, and interdisciplinary applications. The study also underscored the importance of adhering to Responsible AI principles, advocating for ethical considerations to ensure the sustainable growth of generative models.

McIntosh et al. (2023) explored the evolving landscape of GenAI, with a particular focus on innovations like Google's Gemini and the anticipated OpenAI Q* project. Their survey assessed the computational challenges, scalability, and real-world implications of these technologies, highlighting their potential to drive significant progress in fields such as healthcare, finance, and education. The authors also addressed the emerging academic challenges posed by the proliferation of AI-generated content, emphasizing the need for ethical and human-centric approaches in AI development. When effectively utilized, GenAI can significantly enhance students' academic performance.

Academic performance refers to the level of achievement demonstrated by students in tests or examinations, often assessed by comparing their scores with those of their peers at the same educational level. According to Jomud and Paclipan (2020), academic performance represents a student's scholastic standing at a particular time. Wang et al (2020) described it as the quality of outcomes attained by students, as evidenced by their examination scores. Similarly, Ariastuti and Wahyudin (2022) emphasized that academic performance reflects the extent of students' learning progress.

The research study delves into the Technology Acceptance Model (TAM), developed by Davis (1989), is a widely used framework for understanding how users come to accept and adopt new technologies. The model is grounded

in the idea that the likelihood of technology being accepted and effectively used depends on two key factors: perceived usefulness and perceived ease of use. Perceived usefulness refers to the degree to which a user believes that using a particular technology will enhance their performance or provide a benefit, such as improving learning outcomes, efficiency, or productivity. For instance, in an educational context, students might accept and adopt a technology like Generative Artificial Intelligence (GenAI) if they believe it will help them learn better or improve their academic performance.

On the other hand, perceived ease of use concerns the degree to which a technology is perceived as free from effort. If users find a technology intuitive, user-friendly, and easy to integrate into their routine, they are more likely to accept and use it consistently. TAM posits that both perceived usefulness and ease of use are influenced by external factors, such as prior experiences, technical support, or the design of the technology itself. The model also suggests that these perceptions lead to attitude formation, which in turn affects the behavioral intention to use the technology, ultimately determining whether or not the technology will be adopted. Additionally, TAM has been extended over time to account for other variables, such as social influence, facilitating conditions, and trust, which further shape how individuals interact with technology. In education, TAM provides valuable insights into how students, educators, and administrators evaluate and embrace technological tools. When applied to the adoption of Generative AI in teaching and learning, TAM suggests that students will be more likely to engage with AI-based educational tools if they perceive them as both useful for improving their learning outcomes and easy to use.

Statement of the Problem

The persistent underperformance of senior secondary school students in Algebra within the Funtua Educational Zone of Katsina State, Nigeria, has raised significant concerns among educators and policymakers. Despite various interventions, students continue to exhibit

challenges in grasping fundamental algebraic concepts, leading to suboptimal academic outcomes. This issue is not unique to the region; similar patterns have been observed nationwide, with reports indicating a high incidence of student weaknesses and poor performance in Algebra, as highlighted in the West African Examinations Council (WAEC) Chief Examiners' Reports from 2015 to 2023.

In response to these challenges, there is a growing interest in leveraging technological advancements, particularly Generative Artificial Intelligence (GenAI), to enhance the teaching and learning of Algebra. GenAI has demonstrated transformative potential in educational settings, offering personalized learning experiences and interactive problem-solving opportunities. Studies have shown that integrating GenAI into educational practices can lead to improved academic performance and foster a more engaging learning environment.

However, the application of GenAI in the context of Algebra education within the Funtua Educational Zone remains underexplored. There is a lack of empirical evidence assessing the effectiveness of GenAI tools in enhancing Algebra performance among senior secondary school students in this specific region. This gap in research hinders the development of targeted strategies to address the unique educational challenges faced by students in the Funtua Educational Zone. Therefore, this study seeks to assess the role of Generative Artificial Intelligence in enhancing Algebra performance among senior secondary school students in the Funtua Educational Zone, Katsina State. The research aims to provide valuable insights that can inform educational practices and policy decisions, ultimately contributing to improved academic outcomes in the region by investigating the impact of GenAI on students' understanding and application of Algebraic concepts.

Objectives of the Study

The objectives of this study are to:

1. ascertain the effect of Generative Artificial Intelligence (GenAI) on SS II Mathematics students' performance in algebra.



Research Questions

The following research questions guided the study;

1. What is the difference between the mean performance scores of SS II mathematics students taught algebra using Generative Artificial Intelligence (GenAI) and those taught using Conventional Method?

Null Hypotheses

The following null hypotheses were formulated and tested at $p \leq 0.05$ level of significance:

HO₁: There is no significant difference between the mean performance scores of SSII mathematics students taught algebra using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional Method.

METHODOLOGY

This study employs a quasi-experimental design, incorporating pre-test and post-test assessments, along with control and experimental groups, utilizing intact classes. The research focuses on two groups: an experimental group and a control group. Two intact classes—one serving as the experimental group and the other as the control group—were selected for the study.

The target population comprises all Senior Secondary School II (SSII) students from twenty-two public senior secondary schools in the Funtua Educational Zone of Katsina State, totaling 5,245 students. The twenty-two schools consist of 18 co-educational institutions and 4 single-sex schools, with 2 exclusively for males and 2 exclusively for females. All schools are owned by the Katsina State Government and operate as either day or boarding schools.

For sampling, simple random sampling through balloting was employed to select the sample schools. Four schools were randomly chosen from the eighteen co-educational senior secondary schools in the study area. A total of 212 SSII students were selected as the sample for the study from these two public co-educational senior

secondary schools in the Funtua Educational Zone. Pre-tests were administered to the SSII Mathematics students in each of the four randomly selected schools to assess their equivalence in terms of academic performance. This was achieved by analyzing the pre-test results using One-Way Analysis of Variance (ANOVA) and Scheffe's test. Two intact classes—one from the experimental school and one from the control school—were selected through balloting without replacement.

The researcher developed the Algebra Performance Test (APT), a 40-item multiple-choice objective assessment, to evaluate students' proficiency in Algebra. The test was constructed using a table of specifications adapted from Bloom's Taxonomy (1970) to ensure comprehensive coverage of the subject matter. To establish the test's validity, it underwent evaluations for construct, criterion, and content validity by a panel of professors from the Department of Science Education at Ahmadu Bello University, Zaria. This expert review process ensured that the APT accurately measures the intended constructs and aligns with the curriculum's objectives. A pilot test was conducted at Kurami Government Senior Secondary School, which is part of the study's population but not included in the sample. A group of 30 students participated in this pilot testing phase.

Following the pilot testing, the APT's reliability was assessed using Pearson Product Moment Correlation statistics, facilitated by the SPSS software (Version 20.0). The analysis yielded a reliability coefficient of $r = 0.75$, indicating a strong positive correlation between the initial and subsequent administrations of the test. This result signifies that the APT is a reliable instrument for measuring students' Algebra performance.

RESULTS

Results obtained from the data collected were analyzed as follows:

Research Question One What is the difference between mean performance scores of mathematics students taught algebra using

Generative Artificial Intelligence (GenAI) and those taught using Conventional method?
To answer the research question one post test scores from APT for experimental and control

groups were subjected to mean and SD. Summary of the findings is in Table I.

Table 1: Mean, Standard Deviation Statistics of Posttest APT scores for Experimental and Control Groups

Group	N	Mean	STD	Mean difference
EXP (Generative Artificial Intelligence (GenAI))	61	33.02	1.78	13.95
Control (Conventional method)	63	19.06	3.03	

Result of the Descriptive Mean t statistics showed that huge difference exist between the mean performance scores of SSII Secondary school Mathematics students taught Algebra Concept using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional method. Their computed mean performances are 33.02 and 19.06 of SSII Secondary school Mathematics students taught Algebra Concept using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional method respectively with a mean performance difference of 13.95 in favour of students taught Algebra Concept using Generative Artificial Intelligence (GenAI).

Testing Null Hypotheses

H0₁: There is no significant difference between the mean performance scores of SSII mathematics students taught algebra using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional method.

To test null hypothesis one, the post test scores from APT for experimental and control groups were subjected to independent sample t-test. The summary is presented in Table 3

Table 2: Summary of Independent Sample t-test of Mean Posttest APT Scores for Experimental and Control Groups.

Group	N	Mean	STD	Mean diff.	Df	t. comp.	t crit.	p
EXP (GenAI)	61	33.02	1.78	13.95	122	31.1	1.96	0.000
Control	63	19.06	3.03					

$p < 0.05$, $t_{\text{computed}} > 1.96$ at $df = 122$

Result of the independent t-test statistics showed that significant difference between the mean performance scores of SSII Secondary school Mathematics students taught Algebra Concept using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional method. Reasons being that the calculated p-value of 0.00 is lower than the 0.05 alpha level of significance and the computed t-value of 31.1 is greater than 1.96 t-critical value at $df = 122$. Their computed mean performances are 33.02 and 19.06 of SSII Secondary school

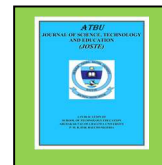
Mathematics students taught Algebra Concept using Generative Artificial Intelligence (GenAI) and their counterparts taught using Conventional method respectively, with a mean performance difference of 13.95 in favour of students taught Algebra Concept using Generative Artificial Intelligence (GenAI). Therefore, the null hypothesis which states that There is no significant difference between the mean performance scores of SSII Secondary school Mathematics students taught Algebra Concept using Generative Artificial Intelligence (GenAI)

Corresponding author: Zaharaddeen Aliyu

✉ zaliyu@abu.edu.ng

Department of Science Education, Ahmadu Bello University, Zaria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved



and their counterparts taught using Conventional method, is hereby rejected.

DISCUSSION OF RESULTS

The study's findings indicate that students in the experimental group, who were taught Algebra concepts using Generative Artificial Intelligence (GenAI), achieved significantly higher mean performance scores compared to those taught through conventional methods. This result was statistically significant, as evidenced by the t-test analysis, leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis. Consequently, the null hypothesis, which posited no significant difference in the mean performance scores of Senior Secondary School II (SSII) students taught Algebra using GenAI versus those taught via conventional methods, was rejected. This significant difference underscores the effectiveness of GenAI in enhancing students' performance in Algebra.

These findings align with previous research by Abd Algani and Shine (2025), who reported that students exhibited notable improvements in performance when taught using GenAI compared to traditional teaching methods. Similarly, studies by Sun and Zhou (2024), Mellado et al. (2024), and Alier et al. (2024) support the notion that GenAI can significantly enhance educational outcomes. Furthermore, Orhan et al. (2024) emphasized the importance of effectively integrating GenAI tools in teaching to improve student performance. Additionally, Wachira (2025) found that students demonstrated significant performance improvements when taught with GenAI as opposed to conventional methods.

CONCLUSION

This study concludes that the integration of Generative Artificial Intelligence (GenAI) significantly enhances students' academic performance in Algebra. The findings indicate that students taught using GenAI achieved higher mean performance scores compared to those taught through conventional methods. These results suggest that GenAI serves as a powerful

tool in education, capable of enhancing learning outcomes and promoting equitable academic achievement

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

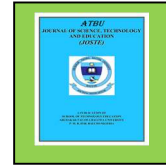
1. Secondary school Mathematics teachers should frequently employ the Generative Artificial Intelligence (GenAI) in teaching difficult and abstract concepts in Mathematics like Algebra.
2. Mathematics teachers should consistently encourage students to actively participate in classroom explorations, discussions and elaboration of learnt concepts for better acquisition performance.
3. Professional bodies like MAN in collaboration with the Federal and State Ministries of Education should embark on nationwide re-training of Mathematics teachers to design and implement classroom instructions based on the Generative Artificial Intelligence (GenAI) through regular national, state and local seminars, workshops and conferences.

REFERENCES

- Abd Algani, Y., & Shine, M. (2025). Using Generative Artificial Intelligence Models (GAIM) as digital assistants for enhancing motivation and retention proficiency of mathematics undergraduates. *Research Journal in Translation, Literature, Linguistics, and Education (RJTLLE)*, 1(1), 39-55.
- Acharya, B. R., Kshetree, M. P., Khanal, B., Panthi, R. K., & Belbase, S. (2021). Mathematics Educators' Perspectives on Cultural Relevance of Basic Level Mathematics in Nepal. *Journal on Mathematics Education*, 12(1), 17-48.
- Agah, M. P. (2020). Challenges of mathematics in economic development in the twenty-first century: Implications for tertiary education. *Journal of Education, Society and Behavioural Science*, 33(3), 20-25.



- Alier, M., Garcia-Peñalvo, F., & Camba, J. D. (2024). Generative Artificial Intelligence in Education: From Deceptive to Disruptive.
- Ariastuti, M. D., & Wahyudin, A. Y. (2022). Exploring academic performance and learning style of undergraduate students in English Education program. *Journal of English Language Teaching and Learning*, 3(1), 67-73.
- Blåsjö, V. (2021). Galileo, Ignoramus: Mathematics versus Philosophy in the Scientific Revolution. *arXiv preprint arXiv:2102.06595*.
- Bloom B. S. (1970). Taxonomy of Educational Objectives, *Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340. <https://doi.org/10.2307/249008>
- De Vera, M. C., & Balgua, B. L. O. (2023, May). Utilization of technologies in teaching mathematics in a flexible learning environment. In *AIP Conference Proceedings* (Vol. 2602, No. 1). AIP Publishing.
- Eyong, E. I., Ugada, C., & Aminu, A. (2020). Indicators of Improved Achievement of Students in Mathematics. *The Universal Academic Research Journal*, 2(1), 29-37.
- Hillmayr, D., Zierwald, L., Reinhold, F., Hofer, S. I., & Reiss, K. M. (2020). The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis. *Computers & Education*, 153, 103897.
- Jomud, P. D., & Paclipan, M. O. (2020). Relationship between family and school factors and the students' academic performance in mathematics. *International Journal of Educational Policy Research and Review*.
- McIntosh, A., Huang, Z., & Gupta, P. (2023). *The evolving landscape of Generative AI: Computational challenges and interdisciplinary applications*. arXiv preprint. Retrieved from <https://arxiv.org/abs/2312.10868>
- Mellado, R., Cubillos, C., & Ahumada, G. (2024, October). Effectiveness of Generative Artificial Intelligence in learning programming to higher education students. In *2024 IEEE International Conference on Automation/XXVI Congress of the Chilean Association of Automatic Control (ICA-ACCA)* (pp. 1-7). IEEE.
- Nabayra, J. (2022). Mathematics learning in the new normal through teacher-created videos: The freshmen university students' experience. *International Journal of Arts and Humanities Studies*, 2(1), 22-27.
- Ndidi, M. A., & Effiong, I. E. (2020). Influence of Classroom Environment on Senior Secondary School Students' Academic Achievement in Mathematics in Calabar Nigeria. *Educational Research and Reviews*, 15(8), 495-503.
- Ogunleye, A. I., Sharma, S., & Patel, H. (2024). *Generative Artificial Intelligence in higher education: A systematic review and future directions*. arXiv preprint. Retrieved from <https://arxiv.org/abs/2406.09520>
- Olanrewaju, S. S. (2023). Mathematics Education in Nigeria: Problems and Prospects. *Rethinking the Teaching and Learning of Mathematics in the Pandemic Era*, 176.
- Orhan, A., Aydın Yıldız, T., & Çınar Yağcı, Ş. (2024). Assessing EFL learners' attitudes on Generative Artificial Intelligence: Development and validation of Generative Artificial Intelligence attitude scale for EFL learners (GenAIAS). *Journal of Research on Technology in Education*, 1-21.



- Pattier, D. (2021). Teachers and YouTube: The use of video as an educational resource. *Ricerche di Pedagogia e Didattica. Journal of theories and research in Education*, 16(1), 59-77.
- Sengar, C., Kumar, A., & Singh, R. (2024). *Advancements and applications of Generative Artificial Intelligence: A systematic review*. arXiv preprint. Retrieved from <https://arxiv.org/abs/2405.11029>
- Sharma, G. (2024). Investigating the Influence of YouTube Educators on Academic Achievement: A Study of Teenagers Preparing for Competitive Exams. *Journal of Informatics Education and Research*, 4(2).
- Sun, L., & Zhou, L. (2024). Does generative artificial intelligence improve the academic achievement of college students? A meta-analysis. *Journal of Educational Computing Research*, 62(7), 1896-1933.
- Wachira, P. W. (2025). Mathematics Teaching and Assessment in the Age of Generative AI. In *Educational Assessments in the Age of Generative AI* (pp. 315-342). IGI Global Scientific Publishing.
- Wang, M. T., Hofkens, T., & Ye, F. (2020). Classroom quality and adolescent student engagement and performance in mathematics: A multi-method and multi-informant approach. *Journal of youth and adolescence*, 49, 1987-2002.