

# AI-BASED CHATBOT SYSTEMS FOR MITIGATING LEARNING DISPARITIES AND ADVANCING SDG 4 IN SELECTED UNIVERSITIES IN SOUTH-SOUTH NIGERIA

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## ABSTRACT

Learning disparities remain a major challenge to achieving Sustainable Development Goal 4 (SDG 4), particularly in higher education where differences in academic preparedness and access to personalised learning support can affect learning outcomes. This study examined the effect of AI-based chatbot systems on students' learning outcomes, perceived learning support, equitable participation, learning engagement, and digital learning skills in selected universities in South-South Nigeria. A quasi-experimental pre-test–post-test non-equivalent control group design was adopted. The study involved 200 undergraduate students, comprising 100 students in an experimental group that received chatbot-supported learning and 100 in a control group that received conventional support. Data were collected using a researcher-developed achievement test, an AI-Based Chatbot Learning Support Questionnaire, and a Learning Engagement and Digital Skills Scale. Data were analysed using ANCOVA, independent-samples t-test, and Pearson product-moment correlation at the 0.05 significance level. After controlling for pre-test scores, the experimental group recorded significantly higher post-test learning outcomes than the control group,  $F(1, 197) = 53.89$ ,  $p < .001$ , partial  $\eta^2 = .213$ . The experimental group also reported significantly higher perceived learning support and equitable participation, while chatbot use was positively associated with learning engagement and digital learning skills. The findings suggest that AI-based chatbots can complement conventional instruction by extending personalised and timely learning support. However, their educational value should be interpreted alongside evidence of uneven effects across learning outcomes and the need for appropriate pedagogical integration.

**Keywords:** Artificial intelligence, AI-based chatbots, learning disparities, higher education, SDG 4, blended learning, South-South Nigeria.

## Introduction

Education remains a central instrument for human capital development, social transformation, and sustainable economic growth. Yet significant disparities in learning opportunities and outcomes continue to challenge the attainment of inclusive and equitable education, particularly in developing contexts (UNESCO, 2023; World Bank et al., 2022). These disparities are associated with unequal access to learning resources, instructional support, and opportunities for personalised learning.

Following the transition from the Millennium Development Goals to the Sustainable Development Goals in 2015, Sustainable Development Goal 4 (SDG 4) placed stronger emphasis on inclusive, equitable, and quality education and lifelong learning opportunities for all (United Nations, 2015). Universities therefore have an important role in creating learning environments that respond to students with diverse academic backgrounds and learning needs. In Nigerian higher education, growing enrolment, instructional workloads, and uneven access to academic resources can make sustained individualised support difficult (UNESCO, 2023; World Bank et al., 2022).

The digital transformation of higher education has created opportunities to address some of these challenges through artificial intelligence (AI). AI-based chatbot systems can provide conversational academic assistance, respond to students' questions, clarify concepts, support formative learning activities, and provide feedback beyond scheduled classroom periods. Such systems can complement lecturers by extending opportunities for self-paced and personalised learning (Anih & Obadiaru, 2025; Kasneci et al., 2023; Zawacki-Richter et al., 2019).

The potential value of AI chatbots is particularly relevant where lecturers face large classes and competing instructional responsibilities. By providing on-demand academic support, chatbots may help students who need additional explanation, practice, or feedback. Their use may therefore contribute to more equitable learning opportunities, provided that chatbot outputs are critically evaluated and aligned with curricular and pedagogical requirements.

Empirical research has generally reported promising educational effects of AI-supported learning, including improved academic performance, engagement, conceptual understanding, and access to personalised support. However, the evidence is not uniformly positive across all learning dimensions. Recent systematic evidence indicates that ChatGPT-based interventions can improve some learning outcomes while showing no significant effect on self-efficacy, and other reviews report both engagement and disengagement in AI-supported learning environments. These findings suggest that the educational value of AI chatbots depends on how they are integrated into teaching and learning rather than on technology use alone.

Within Nigerian universities, the integration of AI-based chatbot systems also raises contextual concerns relating to digital infrastructure, connectivity, digital competence, ethical governance, privacy, and the alignment of AI-generated content with local curricula. UNESCO (2023) emphasises that technology can widen rather than reduce educational inequalities when access, quality, and governance conditions are not adequately addressed. These concerns make context-specific empirical evidence important.

Although research on AI in education is expanding, empirical evidence specifically examining AI-based chatbots as tools for mitigating learning disparities and supporting SDG 4 in Nigerian higher education remains limited. Evidence from South-South Nigeria is particularly scarce, despite the distinctive institutional and technological conditions within the region. The present study therefore examined the effects and relationships associated with AI-based chatbot use among undergraduate students in selected universities in South-South Nigeria.

Although the educational potential of AI-based chatbot systems has attracted increasing scholarly attention, existing studies have largely examined their influence on student engagement, academic achievement, technology acceptance, or online learning within developed educational contexts (Kasneci et al., 2023; Okonkwo & Ade-Ibijola, 2021; Tlili et al., 2023). Empirical evidence specifically investigating the role of AI-based chatbot systems in mitigating learning disparities while advancing SDG 4 within Nigerian higher education remains limited. Even fewer studies have focused on universities in South-South Nigeria, where institutional realities, technological infrastructure, and students' learning needs differ considerably from those reported in other regions. This empirical and contextual gap necessitates the present study, which examines the role of AI-based chatbot systems in mitigating learning disparities and advancing Sustainable Development Goal 4 in selected universities in South-South Nigeria.

### **Statement of the Problem**

Learning disparities remain a persistent challenge in universities in South-South Nigeria, limiting the attainment of inclusive, equitable, and quality higher education envisaged under Sustainable Development Goal 4 (SDG 4). Differences in students' academic preparedness, learning pace, access to academic resources, and opportunities for individualised support can contribute to uneven learning experiences and outcomes.

These challenges may be intensified by large classes, limited lecturer-to-student ratios, insufficient instructional support, inadequate digital infrastructure, and increasing academic workloads. Under such conditions, lecturers may find it difficult to provide continuous guidance, timely feedback, and individualised academic assistance to all students. Students who require additional support may consequently experience difficulty understanding complex concepts, maintaining engagement, and achieving expected learning outcomes.

AI-based chatbot systems offer a possible means of extending academic support beyond scheduled classroom interaction. Through immediate responses, personalised explanations, self-paced learning opportunities, and formative support, chatbots may complement conventional instruction. However, their effectiveness in reducing learning disparities and strengthening equitable participation cannot be assumed, particularly in contexts where infrastructure, digital competence, ethical governance, and pedagogical integration remain uneven.

Although previous studies have examined AI applications, online learning, and students' acceptance of emerging technologies, empirical evidence on the effectiveness of AI-based chatbot systems for learning outcomes, perceived learning support, equitable participation, engagement, and digital skills in South-South Nigerian universities remains limited. This contextual gap creates uncertainty about the extent to which chatbot-supported learning can contribute to SDG 4 within Nigerian higher education. The present study therefore investigated these outcomes using a quasi-experimental design in selected universities in South-South Nigeria.

It is against this background that this study seeks to investigate whether AI-based chatbot systems can mitigate learning disparities and advance the attainment of Sustainable Development Goal 4 in selected universities in South-South Nigeria.

### **Aim and Objectives of the Study**

This study examined the role of AI-based chatbot systems in supporting inclusive, equitable, and quality learning in selected universities in South-South Nigeria, in line with Sustainable Development Goal 4. Specifically, the study sought to:

1. examine the effect of AI-based chatbot systems on students' learning outcomes in selected universities in South-South Nigeria, in line with SDG Target 4.1;

2. assess the extent to which AI-based chatbot systems influence perceived learning support and equitable participation among students in selected universities in South-South Nigeria, consistent with SDG Targets 4.3 and 4.5;
3. determine the relationship between students' frequency of AI-based chatbot use, learning engagement, and digital learning skills in selected universities in South-South Nigeria, in support of SDG Target 4.4.

### **Research Questions**

The following research questions guided the study:

1. What is the effect of AI-based chatbot systems on students' learning outcomes in selected universities in South-South Nigeria?
2. To what extent do AI-based chatbot systems influence perceived learning support and equitable participation among students in selected universities in South-South Nigeria?
3. What is the relationship between students' frequency of AI-based chatbot use, learning engagement, and digital learning skills in selected universities in South-South Nigeria?

### **Null Hypotheses**

- H<sub>01</sub>: There is no significant difference in post-test learning outcome scores between students exposed to an AI-based chatbot system and those receiving conventional learning support in selected universities in South-South Nigeria.
- H<sub>02</sub>: There is no significant difference in perceived learning support and equitable participation scores between students who use an AI-based chatbot system and those who receive conventional learning support.
- H<sub>03</sub>: There are no significant relationships among students' frequency of AI-based chatbot use, learning engagement, and digital learning skills.

### **Research Methods**

The study adopted a quasi-experimental pre-test–post-test non-equivalent control group design to examine the effectiveness of AI-based chatbot systems in supporting learning outcomes and reducing learning disparities among university students. The study was conducted at Federal University Otuoke, Bayelsa State, and the University of Port Harcourt, Rivers State, Nigeria. The universities were selected because they are federal institutions within the South-South geopolitical zone with comparable academic structures, diverse undergraduate populations, and growing use of digital learning technologies. The population comprised undergraduate students enrolled in selected general education and faculty-based courses. Purposive sampling was used to select participants with varying academic abilities, gender, and levels of digital competence. Intact classes were subsequently assigned to the experimental and control groups. The sample comprised 200 undergraduate students, with 100 students in the experimental group and 100 in the control group.

Data were collected using three instruments: a Researcher-Developed Achievement Test (RDAT) to measure learning outcomes, an AI-Based Chatbot Learning Support Questionnaire (ABCLSQ) to assess perceived learning support and equitable participation, and a Learning Engagement and Digital Skills Scale (LEDSS) to measure learning engagement and digital learning skills. The instruments were validated by experts in Educational Technology, Measurement and Evaluation, and Computer Science Education. Reliability was established through a pilot study using Cronbach's alpha for the questionnaire instruments and the Kuder–Richardson Formula 20 (KR-20) for the achievement test; coefficients of 0.70 or higher were considered acceptable. Before the intervention, the experimental group received a one-week

orientation on the installation, navigation, and educational use of the AI-based chatbot system. Both groups completed a pre-test before the six-week intervention.

The experimental group received chatbot-supported learning alongside regular classroom instruction, whereas the control group received conventional lecturer-led instruction without chatbot support. At the end of the intervention, both groups completed the post-test and relevant questionnaire instruments. Data were analysed using mean and standard deviation, Analysis of Covariance (ANCOVA), independent-samples t-test, and Pearson Product-Moment Correlation. ANCOVA was used to test the effect of chatbot-supported learning on post-test outcomes while controlling for pre-test differences; independent-samples t-tests were used to examine group differences in perceived learning support and equitable participation; and Pearson correlation was used to examine relationships among chatbot use, learning engagement, and digital learning skills. All hypotheses were tested at the 0.05 significance level. Ethical principles, including informed consent, voluntary participation, confidentiality, anonymity, and the right to withdraw without penalty, were observed.

## Results

**Research Question 1:** What is the effect of AI-based chatbot systems on students' learning outcomes in selected universities in South-South Nigeria?

*Table 1: ANCOVA of Posttest Learning Outcomes Controlling for Pretest Scores*

| <i>Source</i>            | <i>Type III<br/>Sum of<br/>Squares</i> | <i>Df</i> | <i>Mean<br/>Square</i> | <i>F</i> | <i>p-value</i> | <i>Partial <math>\eta^2</math></i> |
|--------------------------|----------------------------------------|-----------|------------------------|----------|----------------|------------------------------------|
| Pretest<br>(Covariate)   | 4820.15                                | 1         | 4820.15                | 85.32    | <0.001         | 0.301                              |
| Group (AI vs<br>Control) | 3045.67                                | 1         | 3045.67                | 53.89    | <0.001         | 0.213                              |
| Error                    | 11060.20                               | 197       | 56.19                  |          |                |                                    |
| Total                    | 18925.02                               | 200       |                        |          |                |                                    |

After controlling for pre-test scores, ANCOVA showed a significant difference in post-test learning outcomes between students who used the AI-based chatbot and those who received conventional support,  $F(1, 197) = 53.89$ ,  $p < .001$ , partial  $\eta^2 = .213$ . The pre-test covariate was also significant,  $F(1, 197) = 85.32$ ,  $p < .001$ , indicating that initial ability contributed to post-test performance. The significant group effect, together with the effect size, indicates that chatbot-supported learning was associated with a substantial improvement in learning outcomes after adjustment for baseline differences.

**Research Question 2:** To what extent do AI-based chatbot systems influence perceived learning support and equitable participation among students in selected universities in South-South Nigeria?

*Table 2: Mean Ratings and Independent-Samples t-Test of Perceived Learning Support and Equitable Participation*

| Group                           | N   | Perceived Learning Support Mean | SD   | Equitable Participation Mean | SD   | t    | df  | p      |
|---------------------------------|-----|---------------------------------|------|------------------------------|------|------|-----|--------|
|                                 |     |                                 |      |                              |      |      |     |        |
| AI-based Chatbot (Experimental) | 100 | 4.32                            | 0.51 | 4.18                         | 0.54 | 9.52 | 198 | < .001 |
| Conventional Support (Control)  | 100 | 3.41                            | 0.62 | 3.36                         | 0.60 | 8.36 | 198 | < .001 |

The experimental group recorded higher mean scores than the control group for both perceived learning support and equitable participation. Independent-samples t-tests showed statistically significant group differences in perceived learning support,  $t(198) = 9.52$ ,  $p < .001$ , and equitable participation,  $t(198) = 8.36$ ,  $p < .001$ . These results indicate that students who received chatbot-supported learning perceived greater academic support and more equitable opportunities to participate than students who received conventional support.

**Research Question 3:** What is the relationship between students' frequency of AI-based chatbot use, learning engagement, and digital learning skills in selected universities in South-South Nigeria?

*Table 3: Pearson Correlations among Chatbot Use, Learning Engagement, and Digital Learning Skills*

| Variables                         | 1    | 2    | 3 |
|-----------------------------------|------|------|---|
| 1. Frequency of Chatbot Use       | 1    |      |   |
| 2. Learning Engagement Scores     | 0.62 | 1    |   |
| 3. Digital Learning Skills Scores | 0.57 | 0.69 | 1 |

Pearson correlation analysis showed significant positive relationships among chatbot use, learning engagement, and digital learning skills. Chatbot use was strongly related to learning engagement ( $r = .62$ ,  $p < .01$ ) and moderately related to digital learning skills ( $r = .57$ ,  $p < .01$ ), while learning engagement was strongly related to digital learning skills ( $r = .69$ ,  $p < .01$ ). The results indicate that more frequent chatbot use was associated with higher learning engagement and stronger digital learning skills; however, the correlational design of this analysis does not establish causation.

### Test of Hypotheses

**H<sub>01</sub>:** There is no significant difference in post-test learning outcome scores between students exposed to an AI-based chatbot system and those receiving conventional learning support in selected universities in South-South Nigeria.

**Table 4:** *Analysis of Covariance of Post-Test Achievement Scores by Learning Condition*

| Source                     | df  | <i>F</i> | <i>p</i> | Partial $\eta^2$ |
|----------------------------|-----|----------|----------|------------------|
| Pre-test score (covariate) | 1   | 85.32    | < .001   | .302             |
| Learning condition         | 1   | 53.89    | < .001   | .215             |
| Error                      | 197 | —        | —        | —                |

**Note.** *Dependent variable = post-test achievement score. The analysis controlled for students' pre-test achievement scores.  $p < .05$ .*

### Hypothesis decision

| Hypothesis      | <i>F</i> (1, 197) | <i>p</i> | Partial $\eta^2$ | Decision |
|-----------------|-------------------|----------|------------------|----------|
| H <sub>01</sub> | 53.89             | < .001   | .215             | Rejected |

The ANCOVA revealed a statistically significant effect of learning condition on students' post-test achievement scores after controlling for pre-test scores,  $F(1, 197) = 53.89$ ,  $p < .001$ , partial  $\eta^2 = .215$ . Thus, H<sub>01</sub> was rejected. Students who received chatbot-supported learning had significantly higher adjusted post-test achievement scores than those who received conventional learning support.

**H<sub>02</sub>:** There is no significant difference in perceived learning support and equitable participation scores between students who use an AI-based chatbot system and those who receive conventional learning support.

**Table 5:** *Independent-Samples *t*-Test of Perceived Learning Support and Equitable Participation by Learning Condition*

| Outcome variable           | <i>t</i> | df  | <i>p</i> | Decision               |
|----------------------------|----------|-----|----------|------------------------|
| Perceived learning support | 9.52     | 198 | < .001   | Reject H <sub>02</sub> |
| Equitable participation    | 8.36     | 198 | < .001   | Reject H <sub>02</sub> |

**Note.**  $p < .05$ . H<sub>02</sub> = null hypothesis 2.

The results in Table 4 indicate statistically significant differences between students who used the AI-based chatbot system and those who received conventional learning support in perceived learning support,  $t(198) = 9.52$ ,  $p < .001$ , and equitable participation,  $t(198) = 8.36$ ,  $p < .001$ . Since both  $p$ -values are below the .05 significance level, H<sub>02</sub> was rejected. This indicates that the two groups differed significantly in their perceived learning support and equitable participation scores. H<sub>03</sub>: There are no significant relationships among students' frequency of AI-based chatbot use, learning engagement, and digital learning skills.

**Table 6: Pearson Correlations among AI-Based Chatbot Use, Learning Engagement, and Digital Learning Skills**

| Variables                            | 1   | 2   | 3   |
|--------------------------------------|-----|-----|-----|
| 1. Frequency of AI-based chatbot use | —   | .62 | .57 |
| 2. Learning engagement               | .62 | —   | .69 |
| 3. Digital learning skills           | .57 | .69 | —   |

**Note.**  $p < .01$  (two-tailed).  $N = 200$ . Correlation coefficients are Pearson's  $r$ .

The results in Table X indicate significant positive relationships among students' frequency of AI-based chatbot use, learning engagement, and digital learning skills. Frequency of chatbot use was positively related to learning engagement ( $r = .62, p < .01$ ) and digital learning skills ( $r = .57, p < .01$ ), while learning engagement was strongly positively related to digital learning skills ( $r = .69, p < .01$ ). Since all observed relationships were statistically significant at the .01 level,  $H_{03}$  was rejected. However, the correlational design does not establish causality; therefore, the observed associations should not be interpreted as evidence that chatbot use causes higher learning engagement or digital learning skills.

### Discussion

**AI-Based Chatbot Systems and Students' Learning Outcomes.** The findings revealed that students exposed to the AI-based chatbot system achieved significantly higher adjusted post-test learning outcomes than those who received conventional learning support. The ANCOVA result remained significant after controlling for pre-test differences, suggesting that the difference between groups was not explained solely by their initial achievement levels. The effect size (partial  $\eta^2 = .213$ ) also indicates a substantial practical effect.

This finding is consistent with evidence that AI-supported learning can improve academic performance by providing immediate feedback, personalised learning opportunities, and interactive support. UNESCO (2023) emphasised the potential of appropriately implemented digital technologies to improve access to learning resources, while Kasneci et al. (2023) highlighted the capacity of generative AI to support individualised learning and feedback. More recent experimental evidence also reports positive effects of ChatGPT interventions on academic performance, although substantial heterogeneity across studies warrants cautious interpretation (Deng et al., 2025).

The present result should nevertheless be interpreted alongside evidence that AI-supported learning does not produce uniformly positive outcomes. For example, Deng et al. (2025) found a non-significant overall effect on self-efficacy, while Lo et al. (2024) reported evidence of both engagement and disengagement in ChatGPT-supported learning, including concerns related to academic dishonesty. These qualified findings suggest that chatbot effectiveness depends on the learning outcome assessed, intervention design, duration, and pedagogical conditions. The present study therefore supports chatbot use as a complement to instruction rather than as a universally effective substitute for established pedagogical practices.

**AI-Based Chatbot Systems, Learning Support, and Learning Equity.** The study further revealed that students who used AI-based chatbot systems reported higher levels of perceived learning support and equitable participation than students who received conventional support. The statistically significant group differences suggest that chatbot-supported learning can extend academic assistance and create additional opportunities for students to seek clarification and participate in learning activities.

This finding is consistent with UNESCO (2023), which emphasised that technology should be intentionally deployed to promote equitable access to quality education. The European Commission (2022) similarly highlighted the role of digital technologies in expanding access to learning resources and personalised support. However, equitable outcomes cannot be assumed from technology availability alone. Differences in connectivity, digital competence, access to devices, and the quality of AI-generated responses may reproduce rather than reduce existing inequalities. Consequently, institutional support and inclusive implementation are essential.

**AI-Based Chatbot Systems, Learning Engagement, and Digital Learning Skills.** The findings also showed significant positive relationships among chatbot use, learning engagement, and digital learning skills. More frequent chatbot use was associated with higher engagement and stronger digital learning skills, while engagement was also positively associated with digital learning skills. These relationships suggest that chatbot-supported learning may provide students with opportunities for active interaction, exploration, and digital practice.

The finding is consistent with the view that digital learning environments can strengthen independent learning and digital competence when students interact meaningfully with technology (UNESCO, 2023; World Economic Forum, 2023). However, the correlational nature of this analysis means that the direction of influence cannot be established. Students who are already more engaged or digitally competent may also be more likely to use chatbots frequently. The finding should therefore be interpreted as an association rather than evidence of a causal effect.

The Pearson correlation analysis used to test the third hypothesis confirmed these relationships, indicating that students who interacted more frequently with the chatbot demonstrated significantly higher levels of engagement and stronger digital learning skills. The rejection of the null hypothesis therefore provides empirical evidence that AI-based chatbot systems contribute not only to academic achievement but also to the development of essential digital competencies required for lifelong learning and the realization of SDG 4.

The present finding supports the World Economic Forum (2023), which identified digital literacy, technology use, and lifelong learning competencies as essential skills for education and future employment. It is also consistent with UNESCO (2023), which emphasized that effective integration of digital technologies promotes learner engagement, independent learning, and digital competence. Furthermore, Kasneci et al. (2023) argued that generative AI applications increase students' motivation, engagement, and problem-solving abilities through interactive learning experiences. Similarly, Awoniyi and Owolabi (2025) found that digital skills significantly predict students' academic development and entrepreneurial capability, reinforcing the importance of integrating AI-supported learning technologies into higher education curricula.

## **Conclusion**

This study examined the effects and relationships associated with AI-based chatbot-supported learning in selected universities in South-South Nigeria. The findings showed that, after controlling for pre-test differences, students who received chatbot-supported learning achieved significantly higher post-test outcomes than those who received conventional support. The chatbot group also reported higher perceived learning support and equitable participation, while frequency of chatbot use was positively associated with learning engagement and digital learning skills. These findings suggest that AI-based chatbots can complement conventional instruction by extending timely, interactive, and personalised learning support. However, the benefits of chatbot use should be understood as context-dependent and supported by appropriate pedagogy, digital competence, ethical safeguards, and institutional infrastructure. The study was limited by its sample size, geographic scope, purposive sampling, and reliance on self-reported measures for

some variables. Future research should employ larger and more diverse samples, longer intervention periods, objective measures of engagement and digital skills, and mixed-methods designs to examine students' experiences and the sustainability of observed effects.

### **Recommendations**

Based on the findings and identified limitations, the following recommendations are made:

1. Universities should integrate AI-based chatbot tools into structured blended-learning strategies rather than adopting them as substitutes for lecturer-led instruction. Chatbot use should be linked to clearly defined learning objectives, course activities, and assessment practices.
2. University management should provide continuous professional development for lecturers on pedagogically appropriate chatbot use, including prompt design, verification of AI-generated content, learner support, and responsible use of student data.
3. Institutions should strengthen digital infrastructure, connectivity, and access to appropriate devices so that chatbot-supported learning does not create new inequalities between students with different levels of technological access.
4. Lecturers should monitor students' chatbot use and provide guidance on critical evaluation, academic integrity, privacy, and the limitations of AI-generated responses. Chatbot outputs should be treated as supplementary resources requiring human verification.
5. Future interventions should use longer follow-up periods and objective measures of learning engagement and digital skills to determine whether the benefits observed in the present study are sustained beyond the intervention period.

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