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Artificial Intelligence Use and Critical Thinking Practices among Senior Secondary Students in Ekiti State, Nigeria: A Mixed-Methods Study

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ABSTRACT

The growing integration of artificial intelligence (AI) into secondary education has generated increasing interest in its potential to support students' critical thinking, while concerns remain about overreliance on AI-generated information and its implications for independent reasoning. However, empirical evidence on the relationship between AI use and critical thinking among secondary school students in Nigeria remains limited, particularly regarding how students and teachers perceive the cognitive benefits and risks of AI use. This study examined the association between AI use and students' self-reported critical-thinking practices and explored students' and teachers' perceptions of how AI influences critical thinking. An explanatory sequential mixed-methods design was adopted. Quantitative data were collected from 150 secondary school students selected through a multistage sampling procedure from five secondary schools in Ekiti State, Nigeria. Data were collected using five-point Likert scales measuring AI use and self-reported critical-thinking practices with 10 items each, and analysed using Pearson product–moment correlation. Qualitative data were subsequently obtained through semi-structured interviews with ten students and five teachers and analysed thematically to explain the quantitative findings. The results showed a statistically significant moderate positive association between AI use and students' self-reported critical-thinking practices ($r(148) = .523$, $p < .001$). Interview findings indicated that students and teachers perceived AI as useful for accessing alternative perspectives, obtaining detailed explanations, and deepening understanding, but expressed concerns about excessive reliance on AI-generated responses and reduced independent cognitive engagement. The findings suggest that the educational value of AI for critical thinking depends on how it is used, particularly students' capacity to evaluate, verify, and reflect on AI-generated information. The study contributes context-specific evidence to the emerging literature on AI and critical thinking in Nigerian secondary education and highlights the need for AI literacy and guided pedagogical practices that promote evaluative and responsible AI use. The study is limited by its restricted geographical scope and reliance on self-reported measures.

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1. INTRODUCTION

The integration of Artificial Intelligence into education is one of the most consequential shifts in teaching and learning. The public release of large language model (LLM)-based applications such as ChatGPT in late 2022 accelerated the visibility and accessibility of AI tools among teachers and students, with applications ranging from information retrieval and content generation to problem solving, explanation, and learning support [1],[2], [3]. In education, however, the growing accessibility of AI raises an important question: whether these technologies strengthen students' capacity to think critically or encourage reliance on externally generated responses. Critical thinking remains a central educational goal and an important 21st-century competence because it involves the ability to interpret, analyse, evaluate, and draw reasoned inferences from information [4], [5], [6]. The increasing interaction between AI-assisted learning and these cognitive processes therefore presents an important issue for secondary education systems, particularly in developing contexts such as Nigeria, where digital access, teacher preparedness, and patterns of technology use vary considerably [7], [8], [9].

It is important to distinguish artificial intelligence as a broad technological field from generative AI, large language models, and specific applications such as ChatGPT and Meta AI. AI encompasses computational systems designed to perform tasks that ordinarily require aspects of human intelligence, whereas generative AI refers more specifically to systems capable of producing new content in response to user prompts [10], [11]. LLMs constitute one category of generative AI designed primarily to process and generate human-like language, while applications such as ChatGPT are user-facing tools built on such models [12]. These distinctions are important because the educational implications of AI may vary according to the technology used and the purpose for which it is employed. In this study, AI use refers to students' reported frequency of engaging with AI-enabled tools for academic and learning-related activities, including obtaining explanations, finding information, generating ideas, checking answers, exploring alternative solutions, and preparing for assessments.

Recent empirical research suggests that the relationship between the use of AI and critical thinking is complex and may involve both cognitive benefits and risks. Overdependence on AI dialogue systems has been associated with reduced analytical engagement and greater cognitive offloading [1]. These concerns suggest that frequent reliance on AI may encourage cognitive offloading when learners accept generated responses without independently examining their accuracy, logic, or evidence. A systematic review of empirical studies conducted between 2022 and 2025 revealed that ChatGPT can support higher-order thinking when incorporated into inquiry-based and scaffolded learning environments [5]. Conversely, other studies have argued that AI can function as a "thinking partner" when learners are encouraged to question, evaluate, and critically engage with AI-generated responses [6]. Similarly, [13] emphasised the importance of explicitly developing students' competencies for constructive and responsible AI use. Collectively, these findings suggest that the cognitive consequences of AI use depend substantially on how learners engage with AI and the pedagogical conditions within which such use occurs, rather than on the technology alone.

These concerns are also relevant to secondary education in Nigeria, where AI adoption is emerging alongside longstanding challenges in students' higher-order cognitive engagement. Although mathematics provides an important context for examining reasoning and problem solving, the present study does not measure mathematics-specific critical thinking. Rather, it examines students' general self-reported critical-thinking practices in relation to their use of AI for academic and learning-related activities. Existing Nigerian studies nevertheless provide useful contextual evidence regarding the emerging use of AI in education. For example, one study reported limited familiarity with ChatGPT among mathematics teachers in Nigeria [14], while another found that students valued AI for understanding mathematical concepts but expressed concerns about excessive dependence on AI-generated responses [15]. These findings illustrate both the emerging opportunities associated with AI use and the need to understand its implications for students' independent cognitive engagement.

Critical thinking is particularly important within secondary education because it involves purposeful and self-regulatory processes of interpretation, analysis, evaluation, and inference [16]. In Nigeria, concerns have been raised about instructional practices that rely heavily on teacher-centred approaches and rote learning, which may provide limited opportunities for students to develop higher-order cognitive processes [17], [18]. Empirical studies have also reported positive associations between students' critical-thinking skills and academic outcomes, including mathematics and quantitative reasoning [17], [19], [20]. These findings reinforce the importance of critical thinking as an educational outcome while also demonstrating the need to distinguish critical-thinking ability from subject-specific academic achievement. Accordingly, evidence of poor mathematics examination performance should not, in itself, be interpreted as evidence of inadequate critical-thinking ability.

Despite the rapidly expanding international literature on AI in education, important empirical gaps remain regarding its relationship with higher-order cognitive outcomes among secondary school students in Nigeria. Existing studies in Africa have largely focused on AI awareness, access, adoption, perceptions, or general educational applications, with comparatively limited attention to students' critical-thinking practices [8], [9], [21], [22], [23], [24]. More specifically, there is limited empirical evidence examining the association between students' reported AI use and their self-reported critical-thinking practices in Nigerian secondary schools. There is also limited mixed-methods evidence that combines quantitative evidence of this association with qualitative accounts of how students and teachers understand the influence of AI on critical thinking. Consequently, it remains unclear whether students perceive AI primarily as a resource that stimulates evaluation, reflection, and consideration of alternative perspectives or as a convenient source of answers that may reduce independent cognitive engagement.

The present study addresses these gaps by examining the relationship between AI use and students' self-reported critical-thinking practices in Nigerian secondary schools and by exploring students' and teachers' perceptions of this relationship. An explanatory sequential mixed-methods design is employed, with qualitative evidence used to provide contextual explanations of the quantitative findings. The study therefore moves beyond

examining AI adoption or general perceptions of AI by bringing together students' reported AI use, their self-reported critical-thinking practices, and the perspectives of both students and teachers. This integrated approach provides context-specific evidence on the conditions and perceptions surrounding AI-supported learning in Nigerian secondary education.

Accordingly, the study addresses the following research questions:

1. What relationship exists between AI use and students' self-reported critical-thinking practices in Nigerian secondary schools?
2. How do Nigerian secondary-school students perceive the influence of AI use on their critical-thinking practices?
3. What are Nigerian secondary-school teachers' perceptions of the influence of AI use on students' critical-thinking practices?

By addressing these questions, the study contributes context-specific mixed-methods evidence to the emerging literature on AI and critical thinking in Nigerian secondary education. It also provides practical evidence for the development of AI-literacy initiatives and guided pedagogical practices that encourage students to question, evaluate, verify, and reflect on AI-generated information rather than use AI as a substitute for independent reasoning.

2. METHODOLOGY

Research Design

The study adopted an explanatory sequential mixed-methods design. The quantitative phase was conducted first to examine the association between students' AI use and their self-reported critical-thinking practices, followed by a qualitative phase involving interviews with selected students and mathematics teachers. The qualitative phase was designed to explain and contextualise the quantitative findings by exploring participants' experiences and perceptions of how AI may support or hinder critical thinking. This design was appropriate because statistical associations alone provide limited insight into how students understand and experience AI-supported learning. Integration of the two strands occurred during interpretation, where qualitative themes were used to contextualise the quantitative findings.

Research Location, Participants and Sample Procedure

The study was conducted in selected secondary schools in Ekiti State, Nigeria. The quantitative sample comprised 150 students from five secondary schools. Participants were drawn from Senior Secondary School 1 (SSS1), Senior Secondary School 2 (SSS2), and Senior Secondary School 3 (SSS3). The qualitative component involved 10 students and five mathematics teachers from the participating schools. The study focused specifically on the selected schools in Ekiti State; consequently, the findings should be interpreted within this geographical and institutional context rather than generalised to all secondary-school students in Nigeria. A multistage sampling procedure was employed. First, five local government areas (LGAs) were randomly selected from the 16 LGAs in Ekiti State.

Second, one secondary school was randomly selected from each of the five selected LGAs. Third, 30 students were selected from each participating school, comprising 10 students each from SSS1, SSS2, and SSS3. Students were selected to provide representation across the three grade levels and by gender. For the qualitative phase, two students and one mathematics teacher were purposively selected from each participating school, resulting in 10 students and five teachers. The student participants comprised one male and one female student with relatively high reported levels of AI use from each school. All interviewed students had prior experience using AI for academic purposes. Mathematics teachers were selected because of their direct involvement in teaching the participating students and their ability to provide classroom-based perspectives on AI use and students' critical-thinking practices. The qualitative sample was deliberately structured to ensure representation across the five participating schools and to capture both student and teacher perspectives. Given the predetermined sample, the study does not claim theoretical saturation; rather, the qualitative component was used to obtain contextual and explanatory evidence relevant to the quantitative findings.

Instruments for Data Collection

The study relied on primary quantitative and qualitative data. Quantitative data were collected using a structured questionnaire comprising three sections. This questionnaire had three parts. Section A obtained demographic information, including age, gender, and class. Section B contained a 10-item AI Use Scale, while Section C contained a 10-item Self-Reported Critical-Thinking Practices Scale (*See Appendix*). The AI Use Scale assessed the frequency with which students engaged in AI-related academic activities, including obtaining explanations, generating ideas, finding information, checking answers, exploring alternative solutions, and preparing for academic tasks. Responses were recorded on a five-point frequency scale ranging from 1 (Never) to 5 (Very Often). Possible scores ranged from 10 to 50, with higher scores indicating more frequent AI use. The Self-Reported Critical-Thinking Practices Scale assessed students' reported engagement in behaviours such as evaluating AI-generated information, examining the logic of responses, considering alternative perspectives, checking the credibility of information, identifying potential bias, and reflecting on their reasoning. Items were rated from 1 (Strongly Disagree) to 5 (Strongly Agree), producing possible scores from 10 to 50, with higher scores indicating greater self-reported engagement in critical-thinking practices. No items were reverse-coded.

The scales were adapted from relevant frameworks and previous studies [25], [26], [27]. During adaptation, terminology and item wording were modified to make the instruments appropriate for Nigerian secondary-school students and to contextualise AI use within academic learning. The instruments were subsequently reviewed by experts in educational technology, educational psychology, and measurement and evaluation. The qualitative data were collected using a semi-structured interview guide developed in line with the research questions and quantitative findings. The interview questions explored participants' experiences of AI use, perceived benefits and limitations, verification of AI-generated information, independent thinking, cognitive engagement, and potential over-reliance on AI. The interview guide was piloted before the main study.

Validity and Reliability of Instrument

The questionnaire was subjected to expert review to establish content and face validity. Experts in educational technology, educational psychology, and measurement and evaluation examined the items for clarity, relevance, completeness, developmental appropriateness, and contextual suitability. Their recommendations were incorporated before the final administration. A pilot test involving 30 students outside the study area was conducted to determine the internal consistency of the scales. Cronbach's alpha coefficients were 0.801 for the AI Use Scale and 0.791 for the Self-Reported Critical-Thinking Practices Scale, indicating acceptable internal consistency. The interview guide was also piloted to assess the clarity, sequence, and relevance of the questions.

Data Collection Procedure

Data collection occurred in two sequential phases. The quantitative phase was conducted first, after which the findings informed the selection of participants for the qualitative phase. After obtaining approval from the appropriate educational and school authorities, data were collected. Written informed consent was obtained from the parents or legal guardians of all participating secondary school students before data collection, while assent was obtained from the students. The questionnaires were administered to the selected students in the respective schools by the researchers. Participation was voluntary, and participants were assured that their responses would remain anonymous, confidential, and used solely for research purposes. After the survey, qualitative interviews were conducted with purposively selected students and teachers from the respondents. Interviews were conducted individually and face-to-face by the researcher in a secluded setting within the participating schools. Each interview lasted approximately 10 minutes and was conducted in English. All interviews were audio-recorded with participants' permission and transcribed verbatim. Translation was therefore not required. The transcripts were checked against the recordings to ensure transcription accuracy.

Data Analysis

The quantitative data were analysed using descriptive statistics and the Pearson product–moment correlation coefficient. Pearson correlation was used to determine the direction and strength of the association between AI use and students' self-reported critical-thinking practices. Statistical significance was assessed at the 0.05 level. Qualitative data were analysed thematically. The analysis involved repeated reading of the transcripts, identification of meaningful units, initial coding, grouping of related codes, development and refinement of themes, and interpretation of the resulting themes in relation to the research questions and quantitative findings. Particular attention was given to AI as a learning aid, independent thinking, verification of AI-generated information, alternative perspectives, cognitive engagement, and potential over-reliance on AI. The two datasets were integrated at the interpretation stage. Specifically, qualitative findings were used to explain, elaborate, and contextualise the quantitative association between AI use and self-reported critical-thinking practices. The mixed-methods integration therefore provided

complementary evidence rather than treating the qualitative findings as evidence of causality.

Ethical Considerations

Ethical guidelines governing research involving minors were adhered to throughout the study. Approval was obtained from the relevant educational and school authorities. Appropriate parental/guardian consent and student assent were obtained before participating in the study. Participation was voluntary, and participants were informed of their right to decline participation or withdraw without penalty. No personally identifying information was included in the dataset. Participant codes were used instead of names, while interview recordings and transcripts were securely stored and accessed only for research purposes. Interviews were conducted in a private setting with the support of the teachers to minimize interruptions and protect participants' confidentiality.

Methodological Limitation

Because the quantitative participants were drawn from five schools, students were naturally clustered within schools. The use of Pearson correlation does not explicitly model this nested structure and therefore assumes independence of observations. Consequently, the reported association should be interpreted as an individual-level association within the study sample, rather than as evidence that applies uniformly across schools or the broader Nigerian secondary-school population. Future studies involving larger numbers of schools could employ multilevel or hierarchical analytical approaches to account explicitly for school-level clustering.

3. RESULTS AND DISCUSSION

3.1 Results

This section presents the findings of the study based on the quantitative and qualitative data collected. It reports the participants' characteristics, the descriptive and inferential analysis of the quantitative data, and the key themes emerging from the qualitative interviews. The findings are presented in accordance with the research questions and are reported objectively without interpretation, which is reserved for the Discussion section.

Research Question 1: What relationship exists between AI use and students' self-reported critical-thinking practices in Nigerian secondary schools?

To address the first research question, a Pearson product–moment correlation analysis was used to examine the relationship between artificial intelligence (AI) use and students' self-reported critical-thinking practices, as presented in Table 1.

Table 1: Pearson Correlation between Artificial Intelligence Use and Self-Reported Critical-Thinking Practices

Variables	Mean	SD	r	p	Remark
Artificial Intelligence Use	33.37	6.42	0.523	0.000	Significant
Critical-Thinking Practices	37.76	3.92			

Table 1 shows the Pearson correlation between AI use and self-reported critical-thinking practices among secondary school students. A mean AI use score of 33.37 (*SD* = 6.42) and a mean critical thinking practices score of 37.76 (*SD* = 3.92) were recorded. The analysis revealed a statistically significant, moderate positive correlation between AI use and self-reported critical-thinking practices, $r(148) = .523$, $p < .001$. Thus, students who reported higher levels of AI use also tended to demonstrate higher levels of self-reported critical-thinking practices. The finding provides evidence of a meaningful positive association between AI use and self-reported critical-thinking practices among Nigerian secondary school students. However, the correlational design does not permit a causal interpretation; therefore, the result should not be taken to mean that increased AI use directly improves students' critical thinking. Rather, it indicates that the two variables are positively related within the study sample.

Research Question 2: How do Nigerian secondary-school students perceive the influence of AI use on their critical-thinking practices?

The qualitative findings revealed that students perceived the influence of artificial intelligence (AI) on their critical-thinking practices as multifaceted and context-dependent. Although the quantitative analysis demonstrated a statistically significant, moderate positive relationship between AI use and critical thinking, $r(148) = .523$, $p < .001$, the interview data provide a more nuanced understanding of this association. Three interconnected themes emerged from the interviews: AI as a resource for expanding perspectives and understanding; perceived risks of over-reliance and reduced independent thinking; and verification and evaluation of AI-generated information.

AI as a Resource for Expanding Perspectives and Deepening Understanding

A prominent dimension of students' accounts was the perception that AI could extend their understanding of academic issues by exposing them to perspectives and explanations that might not be immediately available through classroom instruction or their existing learning materials. Rather than simply providing answers, some students reported using AI to explore a problem beyond their initial understanding. This suggests that, when used as an exploratory resource, AI may provide opportunities for students to encounter alternative interpretations and reconsider their initial understanding of a topic.
Student 005 (Female, SS3, 15 years), for example, explained:

> *"If we're given a particular problem to solve, we only see our own view about the topic, but if we consult the AI, it helps us get deeper into the topic."*

This account illustrates how the student perceived AI as a means of moving beyond a single or initially held perspective. The phrase "get deeper into the topic" suggests that AI was not necessarily being used merely to obtain a final answer, but to extend the student's engagement with a problem. From the student's perspective, AI can introduce additional information that encourages consideration of a topic from perspectives that may not have

emerged through an initial classroom discussion or individual attempt at problem solving. Such use positions AI as a supplementary source of information that can potentially stimulate comparison, questioning, and further exploration.

A similar perception was expressed by Student 004 (Male, SS3, 15 years), who stated:

> "*Explanations that are not in my notes will be provided by the AI. Meta* AI brings some information fully detailed."

The student's account emphasizes the perceived value of AI in supplementing existing learning resources. The reference to explanations that are "not in my notes" indicates that students may use AI to fill perceived gaps in their classroom materials and obtain additional explanations of concepts. The perceived availability of more detailed information may provide students with opportunities to reconsider concepts, connect new information with prior knowledge, and explore issues beyond the immediate content presented by the teacher or textbook. Taken together, these accounts suggest that some students perceive AI as a cognitive extension of existing learning resources, rather than merely an answer-generating tool. This interpretation provides qualitative context for the significant positive correlation between AI use and critical thinking. The quantitative finding indicates that higher AI use was associated with higher critical-thinking scores, while these student accounts suggest that one possible context for this association is the use of AI to access additional perspectives and explanations. However, because the quantitative finding is correlational, the qualitative evidence should not be interpreted as demonstrating that such AI use causes improvements in critical thinking.

Perceived Risks of Over-Reliance and Reduced Independent Thinking

Despite recognizing potential benefits, students also identified circumstances in which AI could undermine rather than support critical thinking. A particularly important concern was the tendency of AI tools to provide immediate answers, which students perceived as potentially reducing the need to reason through a problem independently. This theme introduces an important qualification to the positive quantitative relationship observed between AI use and critical thinking.

Student 002 (Female, SS3, 14 years) expressed this concern explicitly:

> *"No, I don't think AI helps me think critically... after it gives me the answers, I'll still go and do my research because it does make mistakes sometimes."*

The response is particularly revealing because it simultaneously identifies a limitation of AI and demonstrates a critical response to that limitation. The student's initial assessment was that AI did not necessarily promote critical thinking because it provided answers directly. However, the student also reported conducting additional research after receiving an AI-generated response because of the possibility of error. Thus, the account illustrates the tension between cognitive convenience and critical engagement. AI may reduce the immediate need for students to work through a problem independently, but awareness of the possibility of inaccurate responses may prompt students to question and investigate the information provided.

Student 003 (Female, SS3, 15 years) similarly reported:

> *"Not really... I noticed that when I use the AI, it makes some mistakes, then I'll correct it."*

This response further illustrates students' awareness that AI-generated information cannot necessarily be accepted without scrutiny. The student's recognition of errors and subsequent attempt to correct them suggests that AI use can involve an evaluative process in which students assess the credibility and accuracy of generated information. At the same time, the statement reinforces the concern that simply receiving an AI-generated answer does not necessarily constitute critical thinking. The critical-thinking value may emerge from what the student does after receiving the answer, whether the response is accepted unquestioningly, investigated further, challenged, or corrected. The two accounts therefore provide an important counterpoint to the positive correlation observed quantitatively. Although AI use was positively associated with critical thinking in the student sample, students themselves recognized that AI could discourage deeper thinking when used primarily to obtain immediate solutions. The qualitative evidence consequently suggests that frequency of AI use alone does not fully capture the cognitive quality of AI-supported learning. Students' engagement with, and response to, AI-generated information appears important in understanding how they perceive its relationship with their thinking.

Verification and Evaluation of AI-Generated Information

A third theme concerned students' reported practice of verifying AI-generated responses using other sources of information. This was particularly significant because verification involves questioning the accuracy and credibility of information rather than accepting it automatically. Students described using textbooks, online searches, and teachers as sources against which AI-generated responses could be evaluated.

Student 001 (Female, SS3, 14 years) explained:

> *"I verify it by cross-checking with my textbooks, and if it's for research purposes, I check Google for more information."*

This account demonstrates that the student did not regard AI as an unquestionable authority. Instead, the student described a process of cross-referencing and information comparison. The use of textbooks and online searches to assess AI-generated information suggests an awareness that AI responses require independent verification. Such behaviour is particularly relevant to critical thinking because it involves examining information from multiple sources and making judgments about its reliability.

Student 004 (Male, SS3, 15 years) similarly stated:

> *"When I get an answer, I go to my teacher to check if it's truly correct."*

Here, teacher verification serves as an additional mechanism for evaluating AI-generated information. The response suggests that students may recognize the limitations of AI and consequently seek human expertise before accepting an answer as accurate. The teacher is therefore perceived not merely as a source of information but also as a point of

validation for information generated by AI. These accounts suggest that some students perceive AI use as initiating rather than completing the thinking process. AI may provide an initial explanation or answer, after which students compare, verify, question, and evaluate the information. Such practices are consistent with the positive association identified in the quantitative analysis and help explain how AI use may coexist with relatively stronger critical-thinking performance among some students. At the same time, the findings do not establish that all students engage with AI in this manner; rather, they demonstrate that verification and evaluation form an important aspect of some students' reported experiences.

Integration of the Quantitative and Qualitative Findings from Students' Perspective

The qualitative findings provide important context for interpreting the statistically significant positive relationship identified between AI use and students' critical thinking, $r(148) = .523$, $p < .001$. The quantitative result indicates that students who reported higher levels of AI use also tended to demonstrate higher levels of critical thinking. However, the student interviews reveal that this relationship should not be interpreted as evidence that AI use inherently enhances critical thinking. Instead, the qualitative data reveal different ways in which students experience and engage with AI. On the positive side, students described AI as a means of accessing alternative perspectives, obtaining more detailed explanations, and extending their understanding beyond their existing notes and classroom experiences. These forms of engagement may provide opportunities for students to explore information more broadly and reconsider their initial understanding of academic problems. The interviews also revealed that students sometimes questioned the reliability of AI-generated responses and cross-checked them using textbooks, online sources, and teachers. Such practices indicate that some students do not simply accept AI-generated information but engage in processes of comparison, verification, and evaluation.

Conversely, students recognized that AI can provide quick and convenient answers that may reduce the need for independent reasoning. The accounts of Students 002 and 003 demonstrate that students are aware of the possibility that AI can make errors and that uncritical acceptance of AI-generated responses may be problematic. Their responses also illustrate an important distinction between using AI to obtain an answer and using AI as an object of critical evaluation. In the former case, AI may reduce the cognitive effort required to solve a problem; in the latter, the AI response becomes information that the student must interrogate, verify, and potentially correct. Thus, the qualitative findings do not contradict the positive correlation; rather, they contextualize and qualify it. The statistical evidence establishes an association between AI use and critical thinking, while the interviews suggest that students perceive both opportunities and risks associated with AI-supported learning. AI can provide additional perspectives and explanations and can serve as a starting point for information evaluation. However, students also perceive a risk that immediate AI-generated answers may encourage passive acceptance and reduce independent reasoning when the technology is used without adequate scrutiny.

Research Question 3: What are Nigerian secondary-school teachers' perceptions of the influence of AI use on students' critical-thinking practices?

The interviews with secondary school mathematics teachers revealed a nuanced but predominantly cautious perception of the influence of artificial intelligence on students' critical thinking. Three interrelated issues emerged from the teacher interviews: dependence on AI and the erosion of independent thinking, AI as a support rather than a substitute for reasoning, and the need for ethical and purposeful use of AI.

AI Dependence and the Risk of Reduced Independent Thinking

A prominent concern among teachers was that unrestricted use of AI could encourage students to outsource their thinking to technology. Teachers perceived that when students routinely turn to AI for immediate solutions, they may become less willing to engage independently with academic problems, explore alternative solutions, or draw on their existing knowledge before seeking external assistance. This concern was particularly evident in the account of Teacher 1 (Male, 8years teaching experience), who associated excessive AI use with students' growing dependence on technology:

> *"Using AI is not advisable because they need to explore their own personal knowledge to make things better... they'll feel dependent on it for any little problem, and that will hinder their smooth learning."*

The teacher's account suggests that the concern is not AI use itself, but the extent to which students transfer cognitive responsibility to the technology. When AI becomes the immediate solution to academic difficulties, students may have fewer opportunities to reason independently, formulate explanations, evaluate alternatives, and reach conclusions. Thus, excessive dependence on AI may undermine the development of intellectual independence. This concern provides an important qualitative qualification to the significant positive relationship between AI use and critical thinking, suggesting that how students engage with AI is important in interpreting the observed association**.**

Teacher 2 (Male, 6years teaching experience) expressed a similar concern, emphasizing the possibility that students may delegate substantial portions of their thinking to AI because of the convenience of obtaining immediate solutions:

> *"They put all their thinking on the AI, saying it will solve the problems easily... I don't think they demonstrate improved critical thinking."*

This account highlights the tension between technological convenience and cognitive engagement. Although AI may make academic tasks easier and faster, obtaining an answer does not necessarily involve the reasoning required to evaluate, justify, or apply it. The teacher therefore suggests that AI may facilitate task completion without necessarily promoting deeper critical-thinking processes. This perspective qualifies the significant positive correlation between AI use and critical thinking, which indicates an association rather than a causal effect, while emphasizing that how students use AI may be important to understanding this relationship**.**

AI as an Aid Rather Than a Substitute for Thinking

Despite these concerns, the teachers did not uniformly reject the use of AI in education. Some participants adopted a more balanced position, recognizing that AI can have

educational value when it complements rather than replaces students' own reasoning. Teacher 5 (Female, 3years teaching experience) captured this position by acknowledging the usefulness of AI while simultaneously emphasizing the continued importance of students' independent cognitive engagement:

> *"It's very okay, but it shouldn't be that they leave their brain without thinking critically... AI should be like an aid."*

This perspective indicates that teachers' concerns center on uncritical or excessive AI use rather than AI technology itself. Describing AI as an "aid" implies that students should remain cognitively active by interpreting, questioning, and evaluating AI-generated information while retaining responsibility for their own reasoning. Teacher 5 therefore presents AI use and critical thinking as potentially compatible when students remain actively engaged in learning. This aligns with students' reports of using AI for additional explanations and alternative perspectives rather than simply accepting its responses, providing qualitative context for the significant positive correlation between AI use and critical thinking.

Ethical and Purposeful Use of AI

Another important dimension of the teachers' accounts concerned the manner in which students should use AI. Teacher 4 (Male, 3years teaching experience) emphasized that AI should be used ethically and purposefully, rather than becoming a substitute for students' own effort:

> *"Students should make use of it ethically… not as a dependent tool but as a tool to make use of their work easily."*

The teacher's statement extends concerns about dependence to the need for responsible and ethical AI use. While teachers recognized AI as a legitimate learning aid, they emphasized that students should retain ownership of their academic work and responsibility for thinking, evaluating information, and completing tasks. This perspective contextualizes the significant positive correlation between AI use and critical thinking, which indicates association rather than causation and does not imply that all forms of AI use have similar cognitive implications. Overall, the teachers' accounts suggest that the educational value of AI depends less on its presence than on how it is used: reliance on ready-made answers may reduce independent reasoning, whereas purposeful use as a learning aid may support cognitive engagement without displacing students' responsibility.

Integration of Teachers' and Students' Perspectives

The qualitative findings provide important context for the positive relationship identified between AI use and students' critical thinking. The interviews suggest that this relationship is closely linked to how students engage with AI. Some students reported using AI to access alternative perspectives and detailed explanations while verifying its outputs through textbooks, online sources, and teachers. These practices involve comparison, evaluation, and verification, providing qualitative context for the positive association observed quantitatively. Conversely, both students and teachers acknowledged that AI can

provide immediate answers and encourage dependence when students rely on it to perform cognitive tasks they could otherwise undertake independently. Teachers particularly emphasized that AI should function as an aid rather than a substitute for students' reasoning. Thus, the qualitative findings complement rather than contradict the quantitative result: AI use was positively associated with critical thinking, but its perceived educational value depends on whether students use it to support or replace their thinking. Overall, the convergence of the findings suggests a positive but nuanced relationship between AI use and critical thinking in Nigerian secondary schools. AI may serve as a useful cognitive resource when students actively question, evaluate, and verify its outputs, whereas excessive reliance may undermine independent thinking. The findings therefore highlight the importance of purposeful and evaluative AI engagement rather than AI use alone.

3.2 Discussion

This study examined the relationship between artificial intelligence (AI) use and students' self-reported critical thinking practices in Nigerian secondary schools, while also exploring students' and teachers' perceptions of AI's influence on critical thinking. Overall, the findings suggest that AI has the potential to function as a valuable cognitive resource for learning, but its educational value depends largely on how students engage with it. The convergence of the quantitative and qualitative findings supports the view that AI should be understood as a pedagogical tool whose influence on critical thinking is shaped by learners' cognitive engagement, AI literacy, and teachers' instructional guidance rather than by technology alone [6], [21], [28]. This interpretation should, however, be treated cautiously because the quantitative component was cross-sectional and both AI use and critical thinking were self-reported. Thus, the findings demonstrate an association rather than a causal effect of AI use on critical thinking.

AI Use and Self-Reported Critical-Thinking Practices

The first finding revealed a significant positive relationship between AI use and students' self-reported critical-thinking practices. Specifically, AI use was moderately and positively associated with self-reported critical-thinking practices. This indicates that students reporting more frequent academic use of AI also tended to report greater engagement in behaviours such as evaluating information, considering alternative perspectives, and questioning AI-generated responses. Although this relationship should not be interpreted causally, it supports the growing body of evidence that AI can facilitate higher-order cognitive processes when learners actively interact with AI-generated information rather than merely accepting it. Generative AI has been shown to support analysis, evaluation, comparison of ideas, and knowledge construction by exposing learners to multiple explanations and perspectives [4], [29], [30]. Similarly, AI literacy frameworks emphasize that meaningful learning with AI requires learners to critically interrogate AI-generated responses, formulate effective prompts, and evaluate the quality of generated information [6], [21]. Systematic evidence further indicates that AI has the potential to improve higher-order cognitive outcomes when integrated appropriately into learning activities, although these benefits depend substantially on learners' level of engagement and

instructional context [5], [13]. From the perspective of Cognitive Offloading Theory, this finding can be understood in two contrasting ways. AI may serve as an external cognitive resource when students use it to obtain explanations, generate alternative perspectives, or explore possible solutions and then independently evaluate those outputs. Conversely, AI may substitute for reasoning when students simply accept generated answers without questioning or verification [28], [33]. The positive association observed in this study may therefore reflect productive or evaluative AI engagement rather than AI use itself being inherently beneficial to critical thinking.

The finding also aligns with broader educational research demonstrating that critical thinking develops through active engagement with learning tasks rather than passive reception of information. Previous studies have consistently reported positive relationships between critical thinking and students' academic performance, mathematical reasoning, and problem-solving abilities [17], [19], [20]. Likewise, learner-centred instructional approaches such as project-based learning, inquiry-based learning, STEM education, and flipped classrooms have been shown to promote analytical reasoning and reflective thinking by encouraging students to construct and evaluate knowledge independently [7], [18], [31], [32]. The present finding extends this literature by indicating that AI use is associated with self-reported critical-thinking practices, although it does not establish that AI produces such practices. Several alternative explanations could also be considered. Students with stronger critical-thinking abilities may be more likely to use AI productively because they may be better able to formulate questions, identify weaknesses in generated responses, and verify information. Similarly, digitally advantaged students may have both greater access to AI tools and stronger academic support. Prior achievement, school quality, digital access, and AI literacy may therefore influence both AI use and critical-thinking practices. Reverse causality is also possible: rather than AI use strengthening critical thinking, students who already possess stronger critical-thinking dispositions may be more inclined to use AI because they are better equipped to evaluate its outputs. The cross-sectional design does not permit these competing explanations to be disentangled.

Students' Perceptions of AI Use and Critical Thinking

The second finding revealed that students perceived AI as both a supportive and potentially problematic learning resource. Participants reported that AI provided alternative perspectives, detailed explanations, and deeper understanding of academic concepts, suggesting that they viewed AI as an accessible learning companion capable of enriching classroom learning. These perceptions corroborate previous findings showing that students appreciate generative AI for its capacity to provide personalized explanations, immediate feedback, improved access to information, and enhanced learning efficiency [2], [3], [15]. Similarly, research on AI-supported mathematics learning has demonstrated that AI can broaden students' conceptual understanding and facilitate inquiry by exposing learners to multiple approaches for solving problems [14], [30]. These findings collectively suggest that AI may promote critical thinking by encouraging learners to explore alternative viewpoints rather than relying solely on conventional instructional materials.

An important part of the findings, however, is that students did not perceive AI as an unquestionable authority. Many participants reported verifying AI-generated responses through textbooks, online resources, and consultation with teachers before accepting the information. Such practices indicate that students engaged in comparison, evaluation, and validation of AI outputs, which represent important components of critical thinking. This finding supports recommendations that AI literacy should emphasize the ability to evaluate AI-generated information critically rather than simply learning how to operate AI tools [6], [21]. It also agrees with stakeholder-based studies suggesting that effective AI integration requires learners to understand the strengths, limitations, and potential biases of AI systems before relying on their outputs [9], [13]. These accounts provide one possible explanation for the quantitative association: students who use AI as a starting point for inquiry, verification, and comparison may also be more likely to report critical-thinking behaviours. However, because these behaviours were self-reported, the extent to which reported practices correspond to actual critical-thinking performance remains uncertain.

Nevertheless, students also acknowledged that unrestricted AI use could encourage dependence by providing immediate answers that reduce opportunities for independent thinking. This concern closely reflects the propositions of Cognitive Offloading Theory, which suggests that learners may transfer cognitive processes to external technologies to reduce mental effort. Although cognitive offloading may increase efficiency, excessive reliance on external cognitive supports can reduce opportunities for analysis, reflection, and metacognitive regulation [28], [33]. Recent systematic reviews similarly caution that prolonged dependence on AI dialogue systems may weaken cognitive engagement and diminish learners' motivation to perform intellectually demanding tasks independently [1], [5]. Thus, the students' accounts highlight an important distinction between using AI to stimulate further inquiry and using it to avoid cognitive effort.

Teachers' Perceptions of AI Use and Critical Thinking

The third finding demonstrated that teachers similarly perceived AI as a potentially valuable but cognitively ambivalent educational resource. Although teachers acknowledged the instructional benefits of AI, they consistently emphasized that AI should support rather than replace students' reasoning. This finding is consistent with previous studies reporting that teachers generally recognize AI's capacity to improve teaching and learning while simultaneously expressing concerns about learner dependence, ethical use, academic integrity, and diminished cognitive engagement [9], [22], [23], [24]. Teachers therefore appear to perceive AI not as an educational threat but as a tool whose effectiveness depends largely on pedagogical guidance and students' responsible engagement.

There was, however, an important difference in emphasis between students and teachers. Students tended to focus on the immediate learning benefits of AI, including explanations, alternative perspectives, and access to information, whereas teachers placed greater emphasis on the possibility that these conveniences could reduce students' independent cognitive effort. This divergence suggests that students and teachers may evaluate AI from different positions: students primarily experience its accessibility and

responsiveness, while teachers are more concerned with whether AI-supported activities preserve the learning processes that education seeks to develop.

The teachers' emphasis on purposeful and ethical AI use also agrees with evidence that educators consider AI most beneficial when learners remain actively involved in analysing, questioning, and evaluating information rather than outsourcing cognitive tasks to technology [6], [34]. Similar conclusions were reached by [14], who argued that teachers' instructional practices play a critical role in determining whether AI enhances or constrains meaningful learning. These concerns reinforce the importance of equipping teachers with the pedagogical competencies needed to design AI-supported tasks that require students to question, verify, explain, and justify their reasoning rather than merely reproduce AI-generated answers.

Theoretical and Practical Implications

The findings provide a nuanced application of Cognitive Offloading Theory to AI-supported learning. The theory helps explain why the same technology may have contrasting cognitive consequences. AI can operate as an external cognitive resource when students use it to access information, explore alternative explanations, and test ideas while retaining responsibility for evaluating the outputs. Conversely, it may function as a substitute for reasoning when students outsource problem solving and accept generated responses without verification. The present findings therefore suggest that the cognitive consequences of AI use depend not simply on whether students use AI, but on the nature and quality of their engagement with it. The findings have practical implications for several stakeholders. For students, AI literacy activities should emphasise verification, source evaluation, comparison of alternative answers, identification of inaccuracies, and reflection before accepting AI-generated information. For mathematics teachers, AI-supported tasks should require students to explain and defend their reasoning, for example, by identifying errors in AI-generated mathematical solutions, comparing alternative solution methods, and justifying whether an AI response is valid. For school administrators, professional development should extend beyond technical training to include pedagogical AI literacy and strategies for maintaining students' independent reasoning. Curriculum developers should incorporate responsible AI use, information verification, reasoning, and reflective judgement into existing learning outcomes. At the policy level, AI integration should be accompanied by guidance on equitable access, teacher preparation, responsible use, and the evaluation of AI-generated information.

Limitations of the Study

Several limitations should be considered when interpreting the findings. First, the cross-sectional design prevents conclusions about temporal ordering or causality. The observed association cannot establish whether AI use influences critical thinking or whether students with stronger critical-thinking abilities are more likely to use AI productively. Second, critical thinking was measured through self-report rather than an objective performance-based assessment. Students may therefore have overestimated or underestimated their actual critical-thinking abilities. Future research should combine self-

report measures with validated critical-thinking or reasoning tasks. Third, AI use and critical-thinking practices were measured through the same questionnaire, creating the possibility of common-method variance and potentially inflating the observed association. Fourth, the study covered only five schools in Ekiti State, limiting the generalisability of the findings to other Nigerian secondary-school contexts. The relatively small number of schools also means that students were nested within schools; the Pearson correlation did not explicitly account for this clustering, and the result should therefore be interpreted cautiously. Fifth, the qualitative sample was relatively small, comprising 10 students and five teachers, and was intended to provide explanatory perspectives rather than broad qualitative generalisation. Sixth, the qualitative evidence reflects participants' perceptions rather than direct observations of classroom practice. Consequently, reported verification, responsible AI use, or independent thinking may not necessarily correspond to actual behaviour. Finally, the use of self-reported data introduces the possibility of social-desirability bias, particularly given the sensitivity surrounding responsible and ethical AI use.

Suggestions for Future Research

Future studies should employ longitudinal or experimental designs to examine whether changes follow different forms of AI use in objectively assessed critical-thinking performance. Research should distinguish between productive AI use, such as questioning, comparison, and verification, and substitutive use, in which students outsource reasoning to AI. Future studies should also examine AI literacy, prior achievement, digital access, self-regulated learning, and teacher guidance as possible mediating or moderating factors. Given the school-level clustering in the present study, studies involving larger numbers of schools should employ multilevel analytical approaches. Classroom observations could complement student and teacher perceptions and provide evidence of how AI is actually used during instruction. Finally, because the present study did not employ a mathematics-specific critical-thinking performance measure, future research should examine AI use in relation to objectively assessed mathematical reasoning and problem-solving. Such research would provide stronger evidence regarding whether the observed relationship extends specifically to mathematics learning.

4. CONCLUSION

This study concludes that artificial intelligence use is positively associated with students' self-reported critical-thinking practices in Nigerian secondary schools. However, the qualitative findings demonstrate that this relationship is multifaceted. Students identified AI as a useful resource for accessing alternative perspectives, obtaining detailed explanations, and deepening their understanding, while also recognizing that excessive reliance on AI-generated answers may discourage independent thinking. Teachers similarly acknowledged the educational value of AI but emphasized that it should function as a learning aid rather than a substitute for students' cognitive effort. Overall, the findings suggest that the value of AI for critical thinking depends less on its mere use than on the manner in which students engage with it. Purposeful, evaluative, ethical, and guided use of

AI may support critical thinking, whereas uncritical dependence may undermine independent reasoning. AI integration in Nigerian secondary education should therefore prioritize students' continued cognitive engagement, critical evaluation of AI outputs, and ownership of the learning process.

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APPENDIX

Section A: Demographic Information

Gender: Male [ ] Female [ ]

Age: 10–12 years [ ] 13–15 years [ ] 16–18 years [ ] Above 18 years [ ]

Class: SS 1 [ ] SS 2 [ ] SS 3 [ ]

School Type: Public School [ ] Private School [ ]

Section B: Students' Use of Artificial Intelligence for Learning

Instruction: *The following statements ask about how you use AI tools such as ChatGPT, Microsoft Copilot, Gemini, Meta AI, or other AI-enabled learning tools for your schoolwork. Please indicate how often you engage in each activity.*

S/N	Item	Never	Rarely	Sometimes	Often	Very Often
AIU1	I use AI tools to help me understand difficult topics in my school subjects.					
AIU2	I use AI tools to obtain explanations when I do not understand a lesson.					
AIU3	I use AI tools to find information related to my school assignments.					
AIU4	I use AI tools to generate ideas when completing school assignments or projects.					
AIU5	I use AI tools to obtain examples that help me understand what I am learning.					
AIU6	I use AI tools to check or improve my answers to schoolwork.					
AIU7	I use AI tools to explore different ways of solving a problem.					
AIU8	I use AI tools to summarise or explain information from my school materials.					
AIU9	I use AI tools to support my preparation for tests or examinations.					
AIU10	I use AI tools when I need additional help with my schoolwork outside the classroom.					

Section C: Self-Reported Critical-Thinking Practices in AI-Supported Learning

Instruction: *The following statements describe how you think and act when using AI tools for schoolwork. Please indicate the extent to which you agree or disagree with each statement.*

SA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly Disagree

S/N	***Item***	***SA***	***A***	***N***	***D***	***SD***
CT1	I check whether information provided by AI is accurate before using it in my schoolwork.					
CT2	I consider different explanations before deciding whether an AI-generated answer is correct.					
CT3	I examine the reasons given by AI instead of simply accepting its answers.					
CT4	I compare AI-generated information with information from other sources.					
CT5	I question AI responses when they do not seem logical or convincing.					
CT6	I think about whether the evidence supports an answer provided by AI.					
CT7	I try to solve a problem myself before relying completely on an AI-generated answer.					
CT8	I consider possible bias or errors in information generated by AI.					
CT9	I evaluate the strengths and weaknesses of different answers provided by AI.					
CT10	I reflect on what I have learned from AI before making an academic decision.					