

Curriculum Alignment Strategies and Students' Critical Thinking Skills in Mathematics among Secondary Schools in Akwa Ibom State, Nigeria

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Abstract

The study investigated the influence of curriculum alignment strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State, Nigeria. To achieve this purpose, three research objectives and hypotheses were raised and formulated to guide the study. Correlational research design was adopted for the study. The population comprises of all mathematics teachers and students for 2025/2026 academic session. Out of which, 72 teachers and 855 students were selected through multi-stage and simple random sampling technique as sample size. A researcher-developed instruments namely: Curriculum Alignment Strategies Questionnaire (CASQ) and Students' Critical Thinking Skills in Mathematics Questionnaire (SCTSMQ) were used. The instrument was duly validated using face validity and Cronbach Alpha was used in obtaining the reliability coefficient of the instrument which stood at .71 and .76 for CASQ and SCTSMQ respectively. The research questions and hypotheses were answered using Simple Linear Regression to and answer and test the null hypotheses at 0.05 levels of significance. Based on the findings of the study, it was revealed that teachers' instructional strategies, assessment strategies, and technology-enhanced strategies significantly influence students' development of critical thinking in secondary schools in Akwa Ibom State. It was concluded that improving students' critical thinking in mathematics requires the adoption of learner-centred instructional methods, innovative assessment practices, and purposeful use of digital tools. Recommendations were made among others that Mathematics teachers should adopt learner-centred instructional strategies such as

problem-based learning, guided discovery, cooperative learning, and analytical questioning to promote deeper reasoning among students.

Key Words:

Instructional Strategy, Assessment Strategy, and Technology-Enhanced Strategy, and Critical Thinking Skills

Introduction

Critical thinking is an essential skill for students to face the global competition of the 21st century. CT is one of the life skills that students must have, particularly in the field of education, as it involves thinking, communication, and problem-solving in their daily lives. Mathematics education is one of the subjects that can lead students to adopt critical and analytical mindset. Critical thinking (CT) in mathematics refers to the ability of learners to analyze problems, evaluate solution strategies, justify reasoning, and apply mathematical ideas in new and unfamiliar contexts. It goes beyond memorizing formulas or repeating procedural steps; instead, it emphasizes sense-making, logical reasoning, reflective judgment, and the capacity to construct and critique mathematical arguments (NCTM, 2020). Students with strong critical thinking skills are able to interpret mathematical information, identify patterns, question assumptions, and choose methods that best fit a given problem situation.

Mathematics is a critical aspect of secondary school curriculum, as it provides students with essential problem-solving skills and logical reasoning (Okeke and Adinna, 2025). However, mathematics has consistently been identified as a challenging subject for many

students, with a significant proportion struggling to achieve academic success. In Nigeria, the need to improve mathematics education has become increasingly pressing. The country's educational system has faced numerous challenges, including inadequate infrastructure, insufficient teacher training, and poor student performance in mathematics (Federal Ministry of Education, 2020). Akwa bom State, in particular, has struggled to improve its mathematics education outcomes, with students consistently performing below the national average in mathematics (Akwa bom State Ministry of Education, 2022).

Research in mathematics education consistently shows that many secondary school students struggle with critical thinking because classroom instruction often focuses on procedural fluency rather than conceptual understanding (Wang, 2024). When teaching emphasizes only computation and algorithmic steps, students may successfully solve routine problems but find it difficult to explain why a solution works or how a concept connects to real-life contexts. As a result, their reasoning ability remains limited, leading to shallow understanding and reduced problem-solving flexibility. Developing critical thinking in mathematics depends on providing students with opportunities to engage in reasoning-focused tasks such as problem-based learning, inquiry-based discussions, collaborative problem solving, and mathematical investigations (Antonio 2020). These strategies help students articulate their thinking, compare solution strategies, construct proofs, and evaluate the logic of arguments. For instance, engaging students in open-ended tasks encourages exploration and reasoning, while classroom discourse enables students to justify and critique solutions which is essential habits of mathematical thinkers. This is very important when considering curriculum alignment as it enhances students' critical thinking skills in mathematics.

Curriculum alignment could be seen as the deliberate coordination of learning standards, instructional activities, and assessments which is widely recognized as a key driver of meaningful learning in school systems. When the written, taught and tested curriculum are coherent and mutually supportive, instruction becomes more focused on higher-order outcomes such as reasoning, problem solving and critical thinking in mathematics rather

than solely on rote procedures. In mathematics education, curriculum alignment strategies for example: explicit mapping of learning objectives to classroom tasks, use of formative assessment that targets reasoning skills, and adoption of inquiry-based or problem-centred pedagogies have been shown to create classroom conditions that foster critical thinking which is the ability to analyse, evaluate, and construct mathematical arguments rather than mere procedural fluency.

When alignment explicitly targets cognitive demand (e.g., analysis, evaluation, problem modelling) teachers are more likely to plan tasks and assessments that require students to explain, justify, and transfer mathematical ideas rather than merely reproduce procedures (Maskos, 2025). When alignment is weak, teachers can teach topics that are either not assessed or not targeted by standards, producing gaps between what students are expected to learn and what they actually learn. Also, students often engage in rote memorization and repetitive procedures, resulting in limited conceptual understanding and weak reasoning abilities (Wang, 2024).

Curriculum alignment strategies are the systematic methods used to ensure that the learning objectives, instructional content, teaching methods, and assessment practices are all coherently linked and working toward the same educational goals. This alignment ensures that what is taught, how it is taught, and how learning is assessed in classrooms mirrors what students are expected to learn and demonstrates, fostering an engaging and purposeful learning environment with the intended curriculum outcomes. Specifically, the main purposes of curriculum alignment strategies are to ensure learners achieve the expected standards and competencies, improve teaching effectiveness, promote curriculum consistency and policy compliance, ensure learners achieve the expected standards and competencies, and enhance student critical thinking skills and performance.

Effective curriculum alignment ensures that the written curriculum clearly expresses learning objectives that emphasize higher-order reasoning, and that the taught curriculum (instruction) provides opportunities to engage with those objectives through problem-solving tasks, inquiry-based learning, and mathematical discussions. Instructional

strategies such as collaborative problem solving, guided inquiry, and real-world application tasks are more effective when they are deliberately mapped to critical-thinking goals. Studies show that when teachers align their classroom activities with reasoning-oriented standards, students demonstrate stronger capacity to analyze mathematical relationships and to justify solutions (Antonio, 2024).

Instructional strategies are the planned methods teachers use to organise learning activities (e.g., lecture, guided-explanation, inquiry-based learning, problem-based learning, collaborative problem solving). From a constructive-alignment perspective, instructional strategies are the primary vehicle through which intended outcomes (here, mathematical critical thinking) are enacted in classrooms: they create the opportunities for students to construct mathematical meaning and practice reasoning behaviours the curriculum values. Tasks chosen and how they're enacted determine whether students engage in lower-order (recall, algorithmic execution) or higher-order (analysis, justification, modelling) thinking. High-cognitive-demand strategies (open problems, investigations) stimulate conjecturing, proving, and justification — core critical-thinking acts in mathematics (Antonio and Prudente, 2024). Systematic reviews in mathematics education report that problem-based learning (PBL) and inquiry-based learning (IBL) are the most frequently reported strategies associated with improved critical thinking: students taught with these approaches show better reasoning, argumentation, and problem-solving abilities than peers in conventional classes. Meta-analytic evidence from related STEM domains also reports substantial effect sizes for IBL on critical thinking when the approach includes active hands-on tasks and teacher scaffolding (Dinda, et al, 2025).

Meta-analyses and systematic syntheses of inquiry- and problem-based approaches show robust positive effects on higher-order outcomes when implementation preserves cognitive demand and teachers actively scaffold student reasoning. Conversely, when inquiry activities are shallow or poorly orchestrated they may not develop critical thinking (effects vary with fidelity). This underscores that the type and quality of the

instructional strategy not merely its label determine influence on critical thinking. Instructional strategies must be deliberately chosen and sequenced so that classroom tasks mirror the reasoning level in curriculum outcomes and assessments; otherwise students will default to surface strategies despite any stated goals for higher-order thinking (Antonio and Prudente, 2024). Darling-Hammond et al. (2020) and Fredricks, et.al. (2019) argued that interactive pedagogies enhance deeper cognitive processing and active engagement.

Equally important is alignment between curriculum and assessment strategies. If assessments only measure recall and procedure, students are less likely to value or develop critical thinking. However, when assessments require students to explain reasoning, evaluate solution paths, and apply concepts to new situations, students begin to internalize critical-thinking habits. Assessment strategies include formative and summative practices (open response tasks, rubrics, diagnostic quizzes, performance tasks) and the feedback systems that accompany them. In constructive alignment, assessment defines what counts as successful learning; if assessments prioritize reasoning (explanations, proofs, modelling), students and teachers will orient practice toward critical thinking (Maskos, et al. 2025). Lyster & Saito (2016) emphasized that assessments which target higher-order thinking encourage learners to demonstrate understanding beyond surface-level recall. Recent evidence indicates that formative assessments aligned with reasoning outcomes significantly improve students' ability to reflect on their thought processes and correct misconceptions (Maskos, et al. 2025). Thus, assessment alignment influences not only what students learn, but how they learn.

Technology-enhanced instructional environments can further support curriculum alignment. Conceptually, technology acts as both a mediating tool for inquiry (making abstract structures manipulable) and as a data engine for timely assessment and differentiated instruction. Digital learning platforms, dynamic geometry software, and automated formative assessment tools allow teachers to create tasks that visually represent concepts, test conjectures, and provide immediate feedback. In contexts where such tools have been used alongside aligned instructional goals, students exhibited

improved conceptual understanding and greater independence in problem solving (George and Udo, 2024). This suggests that technology has a meaningful role when embedded as part of a coherent instructional and assessment system rather than as an add-on.

Technology-enhanced strategies influence critical thinking by (a) making mathematical structure visible and manipulable, (b) increasing opportunities for experimentation/conjecture testing, (c) providing rapid, diagnostic feedback that supports metacognitive reflection, and (d) enabling differentiated scaffolds that push students progressively toward independent reasoning. When teachers purposefully align these tools with learning goals and assessment tasks, technology becomes a mediator of high-order practices (conjecturing, proving, modelling, evaluating) rather than merely a presentation aid. Alharthi (2022), asserted that technology, when integrated meaningfully, promotes creativity, inquiry, and higher-order reasoning.

Overall, curriculum alignment strategies influence students' critical thinking in mathematics by ensuring coherence and intentionality across teaching, learning, and assessment. When learning objectives emphasize reasoning, instructional practices provide structured opportunities to engage in reasoning, and assessments measure reasoning, students are more likely to develop the confidence, skill, and mindset necessary for critical thinking. Thus, enhancing curriculum alignment is not simply a matter of improving lesson planning, but a systemic approach to shaping how students think, communicate, and solve problems in mathematics.

Despite promising interventions, several studies identify persistent barriers to effective alignment in Nigerian secondary schools that are also visible in Akwa Ibom. These barriers include: exam-driven curricular implementation that privileges algorithmic practice over reasoning; limited access to aligned instructional materials and manipulatives; large class sizes that constrain dialogic teaching; and insufficient, episodic professional development which fails to provide sustained coaching on shifting instructional practice toward higher cognitive demands (John & Aliyu, 2024). Together, these structural and systemic factors explain

why alignment strategies that look promising in pilot settings sometimes fail to scale or to produce durable gains in students' critical thinking.

Theoretical Framework

This study is based on Constructive Alignment Theory was developed by John Biggs in 1996 as a framework for designing teaching and learning environments that support deep and meaningful learning. The theory combines two key ideas: constructivism which is of the view that learners actively construct knowledge through engagement and reflection; and alignment, meaning that all components of the teaching system should work together to support the intended learning outcomes. According to Biggs, effective learning occurs when there is a clear and coherent relationship between the intended learning outcomes (ILOs), the teaching and learning activities (TLAs), and the assessment tasks (ATs). This implies that what students are expected to learn, how they are taught, and how their learning is assessed must be deliberately coordinated. When these elements align, students are more likely to understand what is required of them and therefore adopt deeper learning approaches rather than memorization or surface-level strategies.

Constructive alignment therefore shifts the teacher's role from being a transmitter of knowledge to a designer of learning experiences. Teachers are encouraged to create learning activities that help students construct meaning, while also ensuring that those activities and the assessments reflect the same cognitive level as the learning goals. This shift fosters an environment where students progressively develop confidence in explaining ideas, defending reasoning, critiquing solutions, and applying mathematics to new contexts—tasks central to critical thinking. Furthermore, constructive alignment supports equitable learning by clarifying expectations: students understand not only what to learn but how they are expected to think. This is especially relevant in secondary mathematics classrooms, where students often view mathematics as procedural rather than conceptual. Aligning curriculum goals with teaching strategies and assessments helps reposition mathematics as a reasoning-based discipline rather than a set of computations. Constructive Alignment Theory emphasizes

coherence, intentionality, and the centrality of reasoning as an educational outcome. When properly applied, constructive alignment can transform classroom practice, improve assessment quality, and ultimately enhance students' mathematical thinking.

Empirical Reviews

Considering teachers' instructional strategies and students' critical thinking skills in mathematics, Arifin (2025) investigated the impact of inquiry-based learning (IBL) on students' critical thinking through a meta-analysis of 36 quantitative studies from 2000–2024. Results showed a strong mean effect size of 1.27, confirming IBL's significant positive influence. However, high heterogeneity ($I^2 = 92\%$) revealed contextual differences, prompting subgroup analyses by educational level, strategy type, ICT integration, duration, and evaluation. The study offers evidence-based recommendations to optimize IBL for improving critical thinking skills. Also, Cayud-ong (2024) examined students' critical thinking levels and how they relate to teachers' instructional strategies using a descriptive-correlational design with 320 junior secondary students. Findings showed that students rated teachers' use of questioning, situation analysis, data interpretation, and panel discussions as high, and their own critical thinking levels were also high. Significant positive correlations emerged between each strategy and students' critical thinking. The study encourages teachers to broaden and diversify teaching approaches to further enhance critical thinking. Again, Wang (2024) reviewed 15 empirical studies on instructional interventions aimed at enhancing university students' critical thinking in mathematics. The interventions included problem-based learning, exploratory activities, and peer instruction, showing generally positive outcomes. However, the review emphasized the need for adaptable strategies that instructors can modify to fit diverse contexts. It also noted inconsistencies in assessment tools used across studies and recommended developing validated, multi-method instruments to more accurately measure critical thinking in mathematics.

In the evaluating teachers' assessment strategies and students' critical thinking skills in mathematics, Agtarap et al. (2024) investigated teachers' assessment strategies

and challenges during online learning using a descriptive survey of 50 elementary teachers from seven schools. Findings showed that teachers continued to rely heavily on traditional assessments and used familiar social platforms more than specialized tools. Although they applied varied strategies to meet learners' needs, major difficulties included ensuring participation, conducting authentic assessments, and adopting new technologies. The study recommends balanced assessment designs, timely communication, constructive feedback, multimedia tasks, and alternative digital tools. Also, Putri et al. (2025) explored how 19 pre-service mathematics teachers perceive critical thinking when solving rich, ill-structured mathematical problems. Interviews revealed that limited conceptions of critical thinking hindered their ability to recognize when higher-order reasoning was needed or identify errors in modified tasks. Participants used at least two critical-thinking components, often through questioning and discussion. The study concludes that teacher-education programs must expand pre-service teachers' understanding of critical thinking and provide structured experiences with rich tasks to strengthen instructional and assessment practices. Again, Masong (2025) examined secondary mathematics teachers' experiences assessing higher-order thinking skills through a phenomenological study of ten participants. Emerging themes included difficulties designing appropriate assessment tools, strategies for promoting higher-order thinking, and tensions between standardized tests and deeper assessments. Coping mechanisms involved adaptive instructional approaches, collaborative professional development, and effective feedback. Teachers also highlighted insights on student progress, pedagogical shifts, and continuous improvement. The study underscores the need for targeted teacher training and curriculum adjustments to strengthen HOTS assessment in mathematics. Finally, on teachers' technology-enhanced strategies and students' critical thinking skills in mathematics, Meylani (2025) examined how technology-enhanced learning tools support secondary students' mathematical reasoning and critical thinking. Using a mixed-methods design with 312 students and 18 teachers, findings revealed that interactive software, dynamic geometry systems, and

simulations improved analysis of mathematical relationships and problem-solving justification. Interviews indicated increased engagement, self-paced exploration, and deeper understanding. Challenges included limited teacher digital competence and inconsistent internet access. The study concludes that technology can enhance reasoning and critical thinking when integrated with effective pedagogy and training. Yin (2024) proposed and piloted the Technology-Enhanced Social Learning (TSL) model to foster critical thinking dispositions in junior secondary mathematics students. The model combines collaborative online platforms, guided peer discussions, and structured teacher facilitation. A pilot study with 146 students showed significant gains in questioning assumptions, evaluating arguments, and justifying alternative solutions. TSL also improved student interaction and reflective dialogue. Teachers observed higher motivation and participation. Minor challenges included monitoring online activities, but overall, TSL effectively promotes critical thinking in technology-mediated learning. Zhou and Kim (2024) investigated automated feedback systems' effects on upper-secondary students' quantitative critical thinking in mathematics. In an experimental design, 228 students were assigned to AI-generated instant feedback or traditional teacher feedback. Results indicated that automated feedback significantly enhanced students' abilities to detect errors, evaluate solution strategies, and construct logical arguments. Real-time prompts fostered metacognition and persistence. Teachers reported greater efficiency in assessment. The study concludes that automated feedback can strengthen quantitative critical thinking when aligned with curriculum goals and supported by teacher guidance.

Statement of the Problem

Critical thinking has been recognized globally as an essential skill for success in mathematics learning and real-life problem-solving. The Nigerian senior secondary school mathematics curriculum emphasizes the development of higher-order thinking skills such as reasoning, problem-solving, communication, and analytical judgment. However, despite these curriculum expectations, evidence from classroom practices and students' performance suggests that many learners in Akwa Ibom

State still struggle to apply mathematical concepts critically and logically. External examinations such as WAEC and NECO consistently show persistent weaknesses in students' ability to interpret questions, justify solutions, analyze patterns, and apply knowledge to unfamiliar contexts. This suggests a gap between the intended curriculum and the actual learning outcomes.

One major concern is the extent to which curriculum content, instructional strategies, and assessment practices are aligned to foster critical thinking. Many teachers continue to adopt teacher-centered, procedural, and examination-driven instructional approaches, emphasizing memorization of formulas and routine calculations rather than conceptual understanding and reasoning. Where curriculum guides advocate for inquiry-based, collaborative, and problem-solving strategies, classroom realities often reflect limited implementation due to inadequate training, limited instructional resources, pressure to complete the syllabus, and assessment methods that favour recall over reasoning.

Consequently, there is a growing concern that the lack of effective curriculum alignment strategies may be contributing to students' low critical thinking skills in mathematics. Therefore, it becomes necessary to investigate how curriculum alignment strategies, particularly the alignment of objectives, instruction, and assessment could influence the development of critical thinking skills among secondary school mathematics students in Akwa Ibom State.

Purpose of the Study

This study seeks to explore the influence of curriculum alignment strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State, Nigeria. Specifically, the study seeks to:

- i. determine the influence of teachers' instructional strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.
- ii. determine the influence of teachers' assessment strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.
- iii. determine the influence of teachers' technology-enhanced strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.

Significance of the Study

The study on curriculum alignment strategies and students' critical thinking skills in Mathematics among secondary schools in Akwa Ibom State, Nigeria is significant to several stakeholders such as students, teachers, curriculum experts, school administrators, and researchers in education globally. To students, it helps students develop logical reasoning, creativity, and problem-solving abilities by ensuring that what is taught, learned, and assessed in Mathematics is well-aligned. This promotes deeper understanding and improved performance rather than rote memorization. Considering the teachers, the study provides insights into effective instructional and assessment strategies that foster critical thinking. It guides teachers in aligning their lesson plans, teaching methods, and evaluation techniques with curriculum objectives to enhance student engagement and learning outcomes.

Also, the findings from the study serve as valuable feedback for curriculum designers to review and improve the Mathematics curriculum. It highlights areas where learning objectives, content, and assessment standards need better alignment to promote higher-order thinking skills. Again, the study assists administrators in making informed decisions on teacher training, resource allocation, and supervision to ensure curriculum implementation supports critical thinking development. It also provides a framework for evaluating school performance based on cognitive skill outcomes rather than test scores alone. Additionally, it identifies gaps and contextual factors specific to Akwa Ibom State that future researchers can explore in greater depth, such as the influence of teacher competence, instructional materials, and assessment practices. The findings also contribute to the growing body of knowledge in curriculum studies, educational measurement, and pedagogy, serving as a reference point for comparative studies in other subjects, regions, or educational levels. Overall, the study contributes to improving the quality of Mathematics education and preparing students for real-life problem-solving in an increasingly complex world.

Research Questions

To guide the researcher to achieve the earlier stated research objectives, the following research questions were posed.

- i. What is the influence of teachers' instructional strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State?
- ii. To what extent does teachers' assessment strategies influence students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State?
- iii. What is the influence of teachers' technology-enhanced strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State?

Research Hypotheses

The following hypotheses were formulated to guide the study

- i. There is no significant influence of teachers' instructional strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.
- ii. Teachers' assessment strategies do not significantly influence students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.
- iii. There is no significant influence of teachers' technology-enhanced strategies on students' critical thinking skills in mathematics among secondary schools in Akwa Ibom State.

Research Methods

The study adopted a correlational research design and made use of a questionnaire for data collection. This design entails examining a sample drawn from a larger population in order to collect and analyze data that reflects the characteristics of the group at the time of the study (Nwankwo, 2016). The research was carried out in Akwa Ibom State, Nigeria, which consists of 31 Local Government Areas. The population of the study comprised all students in the 2025/2026 academic session. From this population, a sample of 72 teachers and 855 students was selected using multi-stage and simple random sampling techniques. Two researcher-developed instruments were utilized: The Curriculum Alignment Strategies Questionnaire (CASQ) and the Students'

Critical Thinking Skills in Mathematics Questionnaire (SCTSMQ). The instruments were subjected to face and content validation by three experts in the field. Their internal consistency reliability was established using the Cronbach Alpha method, yielding reliability coefficients of .71 for CASQ and .76 for SCTSMQ based on a trial testing. Data collected were analyzed using Simple Linear Regression to address the research questions and to test the null hypotheses at the 0.05 level of significance.

Data Analysis and Results

Variables	Sum of Squares	Df	Mean Square	F-cal	F-crit	Sig.
Regression	2699.13	1	2699.13	33.76	3.84	.00 0 ^b
Residual	68182.01	853	79.93			
Total	70881.14	854				

*= significant at P<.05 alpha level; N= 855; R= .667^a; R² = .445; adj. R² = .431
Analysis in Table 1 reveals the R value of 0.667 the indicating a strong positive relationship between teachers’ instructional strategies and students’ critical thinking skills in mathematics. Again, the R² of 0.445 means that only 44.5% of the variation in students’ critical thinking skills in mathematics is accounted for by the variation in teachers’ instructional strategies. Also, the calculated F-value of 33.76 is greater than the critical F-value of 3.84 at .05 alpha level of significance with 1 and 853 degrees of freedom. Also, the p-value of .000 is less than the alpha level of 0.05. This confirms that the result is statistically significant and the null hypothesis that there is no significant influence of teachers’ instructional strategies on students’

Research questions are answered alongside testing of hypotheses

Hypothesis 1

There is no significant influence of teachers’ instructional strategies on students’ critical thinking skills in mathematics among secondary schools in Akwa Ibom State.

Table 1: Result of Simple Linear Regression Analysis for the influence of teachers’ instructional strategies on students’ critical thinking skills in mathematics.

critical thinking skills in mathematics among secondary schools in Akwa Ibom State is rejected, confirming that teachers’ instructional strategies play a crucial role in enhancing students’ critical thinking skills in mathematics.

Hypothesis 2

Teachers’ assessment strategies do not significantly influence students’ critical thinking skills in mathematics among secondary schools in Akwa Ibom State.

Table 2: Result of Simple Linear Regression Analysis for the influence of teachers’ assessment strategies on students’ critical thinking skills in mathematics.

Variables	Sum of Squares	Df	Mean Square	F-cal	F-crit	Sig.
Regression	2933.42	1	2933.42	36.83	3.84	.00 0 ^b
Residual	67947.72	853	79.65			
Total	70881.14	854				

*= significant at P<.05 alpha level; N= 855; R= .721^a; R² = .519; adj. R² = .504
Analysis in Table 2 reveals the R value of 0.721 the indicating a strong positive relationship between teachers’ assessment strategies and students’ critical thinking skills in mathematics. Again, the R² of 0.519 means

that only 51.9% of the variation in students’ critical thinking skills in mathematics is accounted for by the variation in teachers’ assessment strategies. Also, the calculated F-value of 36.83 is greater than the critical F-value of 3.84 at .05 alpha level of significance with 1 and 853 degrees of freedom. Also, the p-

value of .000 is less than the alpha level of 0.05. This confirms that the result is statistically significant and the null hypothesis that teachers’ assessment strategies do not significantly influence students’ critical thinking skills in mathematics among secondary schools in Akwa Ibom State is rejected, confirming that teachers’ assessment strategies make a significant contribution to improving students’ critical thinking skills in mathematics.

Hypothesis 3

There is no significant influence of teachers’ technology-enhanced strategies on students’ critical thinking skills in mathematics among secondary schools in Akwa Ibom State.

Table 3: Result of Simple Linear Regression Analysis for the influence of teachers’ technology-enhanced strategies on students’ critical thinking skills in mathematics.

Variables	Sum of Squares	Df	Mean Square	F-cal	F-crit	Sig.
Regression	1914.57	1	1914.57	23.68	3.84	.000 ^b
Residual	68966.57	853	80.85			
Total	70881.14	854				

*= significant at P<.05 alpha level; N= 855; R= .594^a; R² = .353; adj. R² = .548

Analysis in Table 3 reveals the R value of 0.594 the indicating a strong positive relationship between teachers’ technology-enhanced strategies and students’ critical thinking skills in mathematics. Again, the R² of 0.353 means that only 35.3% of the variation in students’ critical thinking skills in mathematics is accounted for by the variation in teachers’ technology-enhanced strategies. Also, the calculated F-value of 23.68 is greater than the critical F-value of 3.84 at .05 alpha level of significance with 1 and 853 degrees of freedom. Also, the p-value of .000 is less than the alpha level of 0.05. This confirms that the result is statistically significant and the null hypothesis that there is no significant influence of teachers’ technology-enhanced strategies on students’ critical thinking skills in mathematics among secondary schools in Akwa Ibom State is rejected, confirming that teachers’ technology-enhanced strategies make a meaningful contribution to improving students’ critical thinking skills in mathematics.

Discussion of Findings

The findings of this study in hypothesis one revealed that teachers’ instructional strategies exert a significant influence on students’ critical thinking skills in mathematics in secondary schools in Akwa Ibom State. This suggests that the manner in which teachers structure lessons, present content, stimulate inquiry, and engage learners determines the extent to which students

develop analytical and reasoning abilities. Learner-centred strategies such as problem-based learning, guided discovery, cooperative learning, and questioning techniques appear to create opportunities for students to think more deeply, evaluate mathematical relationships, and justify solutions. This is consistent with the positions of Cayud-ong (2024) findings showed that students rated teachers’ use of questioning, situation analysis, data interpretation, and panel discussions as high, and their own critical thinking levels were also high. And Fredricks, Wang, & Schallert (2019) also argued that interactive pedagogies enhance deeper cognitive processing and active engagement. Thus, mathematics classrooms that emphasize exploration over rote procedures tend to cultivate stronger critical thinking competencies.

The results in hypothesis two also showed that teachers’ assessment strategies significantly influence students’ critical thinking skills in mathematics. This indicates that when teachers adopt formative assessment practices such as open-ended tasks, feedback-driven evaluation, performance-based assessments, and reflective questioning they provide learners with opportunities to reason, analyze, and apply concepts rather than merely recall procedures. The finding corroborates the view of Lyster & Saito (2016), who emphasized that assessments which target higher-order thinking encourage learners to demonstrate understanding beyond surface-level recall. And Agtarap et al. (2024) findings showed that teachers continued to rely

heavily on traditional assessments and used familiar social platforms more than specialized tools. Although they applied varied strategies to meet learners' needs, major difficulties included ensuring participation, conducting authentic assessments, and adopting new technologies. In the Akwa Ibom context, reliance on traditional testing alone may limit students' reasoning ability, whereas the use of authentic assessment methods appears to foster deeper mathematical thinking.

Furthermore, the study in hypothesis three revealed that teachers' technology-enhanced strategies significantly influence students' critical thinking skills in mathematics. This aligns with contemporary research which demonstrates that digital tools such as dynamic geometry software, simulation apps, virtual manipulatives, and interactive platforms provide environments where students can visualize concepts, test conjectures, model mathematical problems, and explore multiple representations. The findings support the assertions of Alharthi (2022), who argued that technology, when integrated meaningfully, promotes creativity, inquiry, and higher-order reasoning. Meylani (2025) study concluded that technology can enhance reasoning and critical thinking when integrated with effective pedagogy and training.

Also, Zhou and Kim (2024) results indicated that automated feedback significantly enhanced students' abilities to detect errors, evaluate solution strategies, and construct logical arguments. In Akwa Ibom secondary schools, teachers who effectively incorporate digital resources seem better able to engage learners in analytical and exploratory tasks, thereby improving critical thinking.

Conclusion

The study investigated the influence of teachers' instructional strategies, assessment strategies, and technology-enhanced strategies on students' critical thinking skills in mathematics in secondary schools in Akwa Ibom State. The findings established that all three teacher-related variables significantly influence students' development of critical thinking. This implies that students' ability to analyze, evaluate, and solve mathematical problems is shaped not only by what teachers teach but also by how they teach, assess, and integrate technology into the learning process. The results underscore the need for teachers to

adopt more innovative, interactive, and technology-supported approaches to instruction and assessment to enhance students' reasoning abilities and prepare them for 21st-century problem-solving demands. Overall, the study concludes that improving students' critical thinking in mathematics requires the adoption of learner-centred instructional methods, innovative assessment practices, and purposeful use of digital tools.

Educational Implications

- i. Teaching practices must shift from teacher-centred to learner-centred approaches. Since instructional strategies significantly influence critical thinking, mathematics teachers need to adopt methods that promote inquiry, problem-solving, collaboration, and reflective thinking.
- ii. Assessment practices should encourage higher-order reasoning. The significant influence of assessment strategies implies that schools must move beyond routine tests and incorporate formative assessments, open-ended tasks, and feedback-driven activities that promote analytical thinking.
- iii. Technology integration is essential for developing modern mathematical reasoning skills. The findings show that digital tools enhance critical thinking, suggesting the need for adequate ICT facilities, teacher training, and curriculum support for technology-enhanced learning.
- iv. Teacher professional development becomes more crucial. Continuous training in pedagogy, assessment literacy, and ICT use is necessary to strengthen teachers' capacity to foster critical thinking.
- v. School administrators must create enabling learning environments. Supportive supervision, provision of digital resources, and encouragement of innovative teaching practices will enhance students' learning experiences and cognitive development.

Recommendations

- i. Mathematics teachers should adopt learner-centred instructional strategies such as problem-based learning, guided discovery, cooperative learning, and analytical questioning to promote deeper reasoning among students.
- ii. Teachers should employ diverse and authentic assessment strategies including formative assessments, projects, portfolios, reflective journals, and open-ended tasks to encourage

- students to think critically and justify their solutions.
- iii. Government and school authorities should provide adequate digital tools and ICT facilities such as computers, projectors, mathematical software, and internet access to support technology-enhanced mathematics instruction.
 - iv. Regular capacity-building workshops and in-service training should be organized for teachers on modern instructional approaches, alternative assessments, and effective integration of technology in the mathematics classroom.
 - v. Curriculum planners should incorporate more activities that promote critical thinking into the mathematics curriculum, ensuring that classroom activities require analysis, reasoning, and application rather than memorization.
 - vi. School administrators should supervise and encourage innovative teaching practices, provide incentives for effective classroom strategies, and support teachers who demonstrate excellence in promoting critical thinking.
 - vii. Students should be encouraged to engage with digital learning resources and participate actively in problem-solving activities both inside and outside the classroom.

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