ROLE OF ARTIFICIAL-INTELLIGENCE IN INNOVATIVE ASSESSMENT METHODS FOR EVALUATING CRITICAL THINKING AND PROBLEM-SOLVING SKILLS IN MATHEMATICS: IMPLICATIONSFOR SUSTAINABLE EDUCATIONAL DEVELOPMENT

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Abstract

The rapid advancement of artificial intelligence (AI) has revolutionised educational assessment, introducing innovative methods that go beyond traditional assessments, which often fall short in capturing these higher-order cognitive skills, which are essential for 21st-century learning and global competitiveness. The integration of AI in educational assessments aligns with global goals for sustainable development by promoting inclusive, equitable, and quality education through personalised learning and enhanced teaching strategies This study explores the role of AI-driven tools in innovative assessment techniques in the evaluation of critical thinking and problem-solving skills of adolescents in mathematics within Education District 2 of Lagos State.The study adopted quasi-experimental research design, with the population comprising all Senior Secondary Two (SS2) students in public secondary schools in Education District 2 of Lagos State. A sample of 180 students was selected using a multi-stage sampling technique. Data collection was conducted using a self-developed questionnaire titled *"Role of Artificial Intelligence in Innovative Assessment Methods for Evaluating Critical Thinking and Problem-Solving Skills in Mathematics (***RAIIAMECTPSM***)*. Two hypotheses were formulated and tested at a 0.05 level of significance to guide the study. The findings from the study revealed that AI-driven innovative assessment methods significantly influence the evaluation of adolescents' critical thinking and problem-solving skills. The study's findings suggest that AI-driven assessments provide a more dynamic, accurate, and equitable evaluation of students' mathematical competencies, fostering a shift toward a student-centered learning environment. The study recommends that teachers should integrates AI into educational assessment frameworks of their students in order to enhance their mathematics critical thinking and problem-solving skills .The study position that AI is not only a technological tool but as a catalyst for sustainable educational innovation in sub-Saharan Africa.

Keywords: Artificial–Intelligence, Critical thinking, Innovative assessment methods, Problem-solving skills.

Introduction

In today's rapidly evolving educational landscape, fostering critical thinking and problem-solving skills has become central to mathematics instruction, particularly among adolescents. Traditional assessment methods, which often rely on multiple-choice or rote memorization-based questions, have shown limitations in accurately measuring these higher-order cognitive skills. This has created a pressing need for more innovative, dynamic, and formative assessment strategies that align with 21st-century learning objectives.

Artificial Intelligence (AI), with its capacity to analyse large datasets, recognize patterns, and adapt in real-time, offers transformative potential in educational assessment. AI-driven systems can provide personalised feedback, simulate real-world problem contexts, and assess learner responses beyond binary correctness capturing nuances in reasoning, strategy use, and creativity. These capabilities make AI a promising tool in the development of innovative assessment methods that can more effectively evaluate students' critical thinking and problem-solving abilities, especially in the

complex domain of mathematics Artificial Intelligence (AI) is a branch of computer science focused on creating systems or machines that can perform tasks that typically require human intelligence. These tasks include understanding natural language (like chatbots or virtual assistants), recognizing patterns and images (like facial recognition systems), making decisions and solving problems (like recommendation systems or autonomous vehicles), and learning from data (as in machine-learning models). AI systems are designed to mimic human cognitive functions such as learning, reasoning, problem-solving, and decision-making by using algorithms and computational techniques (Russell & Norvig, 2021; Goodfellow, Bengio, & Courville, 2016; Wikipedia, 2026**).**

Adolescent learners are at a critical stage of cognitive development, and the integration of AI into assessment practices offers an opportunity to better support their intellectual growth. Research shows that *integrating artificial intelligence into educational assessment and learning environments can enhance cognitive outcomes, personalized feedback, and adaptive learning pathways, which are beneficial for students' intellectual development and critical thinking skills* (González-Calatayud, Prendes-Espinosa, & Roig-Vila, 2021; Garzón, Patiño, & Marulanda, 2025). With adaptive learning technologies, natural language processing, and intelligent tutoring systems becoming increasingly sophisticated, it is timely to explore how AI can reshape the way educators evaluate and support mathematical thinking among this population. The demands of the 21st century require learners not only to acquire knowledge but also to apply it critically and creatively in solving real-world problems. Mathematics, as a core subject, plays a fundamental role in developing such essential cognitive skills. However, the assessment of critical thinking and problem-solving in mathematics has traditionally been constrained by conventional testing approaches that fail to capture the depth and complexity of students' reasoning processes. In response to this gap, educational systems are increasingly looking towards Artificial Intelligence.

In simple terms, AI enables computers to "think" and "learn" to some extent, mimicking human cognitive functions. Artificial Intelligence. (AI) plays a significant role in enhancing **innovative thinking**, **critical thinking**, and **problem-solving skills** in several key ways. The following are the ways that AI can enhance innovative thinking, critical thinking and problem solving skills:

- *Enhancing Critical Thinking:* **Data analysis tools** powered by AI help individuals evaluate information more critically by identifying patterns, trends, or inconsistencies that might be missed by humans. AI prompts users to ask deeper questions and challenge assumptions, encouraging logical reasoning and evidence-based conclusions.

- *Supporting Problem-Solving*: **AI**systems can simulate different scenarios and offer **multiple solutions**to a problem, encouraging users to explore alternatives. Tools like decision-support systems and intelligent tutoring systems guide users through structured problem-solving steps.

- *Stimulating Innovative Thinking:***AI**tools like **generative models** (e.g., ChatGPT, DALL·E) can generate creative ideas, designs, or solutions that spark innovation. AI helps brainstorm by providing suggestions beyond the usual human thinking patterns, encouraging **out-of-the-box thinking.**

- *Personalized Learning and Feedback*: **AI** adapts learning content to the user's level, strengths, and weaknesses, helping them improve critical and problem-solving skills at their own pace. Real-time feedback helps learners refine their reasoning and approach more effectively.

- *Collaborative Intelligence:***Working** with AI as a "thinking partner" fosters a **human-machine collaboration**, where the user focuses on strategy and judgment while AI handles data-driven tasks.

AI as a means of transforming assessment practices. AI technologies offer the ability to design adaptive, responsive, and individualized assessment environments that provide rich data on student performance. These systems can analyze student interactions, identify misconceptions, and even model the thought processes behind learners' responses enabling a more holistic evaluation of their cognitive skills in Education. Education is a dynamic field that continually adapts to societal changes and technological advancements (Crawford et al., 2025). The assessment of critical thinking and problem-solving skills in adolescents holds paramount importance in shaping educational strategies, as these competencies are essential for academic success and adapting to complex real-world challenges (Bara, Berdica, & Bara, 2025).. In the context of Education District of Lagos State, Nigeria, the need for an in-depth investigation into the influence of innovative assessment methods on these skills is evident.

Critical thinking can be defined as the ability to analyze and evaluate information objectively. Problem-solving skills deals essentially with navigating real-world challenges, which are increasingly recognized as vital components of a well-rounded education (Jonassen, 2021; Facione, 2022). As a traditional assessment method may fall short in capturing the multifaceted nature of these skills, researchers and educators are exploring innovative approaches to evaluation. Innovative assessment method encompasses a range of strategies such as project-based assessments, peer assessment, assessment by objective test and game-based assessment (Shepard, 2020; Black & William, 2022). These methods aim to mirror real-world situations providing a more authentic measure of student's abilities to think critically and solve complex problems (Pallegrino & Hilton, 2022). Technology has becomes increasingly integrated into education, and there is a growing emphasis on leveraging digital tools and platforms for assessment purposes (OECD, 2015). **Education District 2 of Lagos State serves as a microcosm for understanding the intricacies of the Nigerian educational landscape."**Education District II is one of the administrative education districts in Lagos State that manages schools across Ikorodu, Kosofe, and Shomolu Local Government Areas, illustrating how regional educational administration operates within Nigeria's broader educational system (Dike & Ibikunle, 2024). The intersection of innovative assessment methods, critical thinking and problem-solving skills is a relatively underexplored area in the Nigerian educational context.

Innovative approaches to evaluating critical thinking and problem-solving skills include the use of case studies, interactive simulations, and real-world scenarios that assess students' ability to apply knowledge in practical contexts (**Partnership for 21st Century Learning**, 2019; **Organisation for Economic Co-operation and Development**, 2018; **American Association of Colleges and Universities**, 2009).Additionally, open-ended questions and project-based tasks encourage learners to engage in critical analysis, synthesis, and effective problem-solving, ultimately fostering a deeper understanding of the subject matter. Previous research has emphasized the importance of aligning assessments with learning objectives (Wiggins, 2020) and integrating technology to enhance evaluation practices (Bennett, 2022). However, there is a need for empirical investigations that specifically addresses how innovative assessment methods impact the development of critical thinking and problem-solving skills in adolescents within the specific context of Education District 2 of Lagos state. The theoretical foundation of this study is anchored on the paramount importance of critical thinking and problem-solving skills in education.

Critical thinking is a multifaceted cognitive process that entails the ability to think analytically, evaluate information critically, and make reasoned judgements. It involves the application of problem solving and decision-making skills (Paul & Elder, 2016). Critical thinking is not confined to the realm of academics, it transcends into everyday life, enabling individuals to make informed decisions, communicate effectively and navigate complex issues. It empowers students to become active and engage learners, fostering the ability to questions, analyze, and construct knowledge (Paul & Elder, 2016). Critical thinking entails assessing students' capacity for creative knowledge analysis, synthesis, and application. Effective assessment of this diverse skill is essential in

educational settings since it is critical in negotiating difficult challenges. Contemporary research highlights the necessity of novel methods for assessing critical thinking, acknowledging its importance in equipping people for a world that is changing quickly.
Critical thinking involves the collection, interpretation, analysis and evaluation of information to arrive at a trustworthy and effective decision. Critical thinking is very wide and useful in all sphere of life. More importantly, critical thinking encompasses the capability to diagnose problems and invent practical ways of tackling those problems. It may require rationalization of relevant information and create reasonable influences and generalizations which solve such problems at hand. To sum up, new research supports the use of technology, real-world examples, and group projects in the evaluation of critical thinking. These cutting-edge methods meet the needs of a changing and linked world while also giving pupils a more realistic picture of their talents or abilities (Peter Facione, 1990; Diane , Halpern, 2014).

Similarly, problem-solving skills are an essential component of a well-rounded education. These skills refer to the capacity to identify, analyze, and effectively resolve complex problems or challenges. They encompass the ability to think creatively and apply logical reasoning to find solutions (Brookhart, 2023). Problem-solving skills are invaluable in addressing real-world challenges, whether they are in the workplace, in personal life, or within the community. Education that nurtures these skills equips individuals to tackle the multifaceted problems of the modern world. The ability to solve problems is a basic capability that is necessary for success in a world that is getting more complicated and interconnected by the day. Innovative assessment techniques that accurately gauge students' capacity for problem-solving are becoming increasingly important as education changes to meet the demands of the twenty-first century. Among others, this work examines the idea of problem-solving abilities within the framework of creative assessment in the classroom, highlighting the paradigm-shifting possibilities of this idea.

According to Jonassen (2021), problem-solving skills include the capacity to assess complicated circumstances, recognize obstacles, come up with workable solutions, and carry them out successfully. Current research highlights the complex interplay between these abilities, extending beyond conventional definitions to encompass creativity, flexibility, and critical thinking (OECD, 2021).The significance of these cognitive skills is underscored by their relevance to personal, academic, and professional growth. Critical thinking and problem-solving abilities are essential in an era characterized by rapid technological achievements, information overload, and increasing complexity. These skills empower individuals to adapt, innovate, and thrive in a constantly changing environment (Brookhart, 2023). In addressing daily challenges, **the analysis of evidence** involves carefully examining the credibility, relevance, accuracy, and sufficiency of information before drawing conclusions. It requires individuals to distinguish facts from opinions, detect bias, assess the reliability of sources, and determine whether the evidence logically supports a claim. Such evaluative scrutiny ensures that decisions are grounded in sound reasoning rather than assumptions or incomplete information (Peter Facione, 1990; Richard Paul&Linda Elder, 2006)

The development of higher order or cognitive intellectual abilities is of utmost importance, and training in critical thinking should be the primary task of education (FGN, 2013; Yacoubian, 2015). Therefore, critical thinking as an outcome of the education system is a focus of schooling and students should be instructed and assessed for critical thinking. Deploying and using Critical Thinking in educational Milieus suggests developing students' thinking skills because only students who can think critically would be liable to logically associate ideas, build and appraise arguments, discover common errors in thinking and resolve problems analytically. The epitome critical thinker is knowledgeable, hopeful of reason, unbiased, malleable impartial in appraisal and candid in forming individual prejudices. Confidence is enhanced by critical thinking, and it works together to achieve effectiveness in solving and understanding complex mathematical problems. Critical

thinking is an essential tool in mathematics since it is the most desirable skill involving logical reasoning and wise decision-making. Critical thinking necessitates acquiring, interpreting, analyzing and evaluating data to reach a trustworthy and valid judgement (Chukwuyenum, 2023). It shapes individuals to make intelligent decisions in solving complex problems in mathematics.

Critical thinking helps preservice teachers to learn the whole concept of a subject. Critical thinking allows them to surely understand what they are doing in studying mathematics. The ability helps further improve preservice teachers' creative, logical and analytical thinking skills.

Role of artificial intelligence in Innovative assessment involves creative methods to evaluate learning outcomes and it goes beyond traditional tests. Smith (2021) emphasizes the use of technology and real-world scenarios for assessments, fostering a more holistic understanding of students' skills. Innovative assessment transcends conventional testing, incorporating dynamic approaches to gauge learning. Researchers argued for strategies such as project-based assessment (Thomas & Mueller, 2018) and e-portfolios (Jafari & Kaufman, 2019). Innovative assessment methods aim to improve the evaluation of learning outcomes by utilizing a variety of diverse and dynamic.In line with emerging trends in education, a variety of innovative assessment methods have been introduced to more effectively evaluate students' knowledge, critical thinking, and problem-solving abilities in mathematics. These methods include:

- **Project-Based Assessment**: Engages students in solving authentic, real-world mathematical problems through comprehensive projects that involve analysis, planning, and execution.
- **Problem-Based Learning (PBL)**: Presents learners with complex, open-ended problems that reflect real-life situations, promoting the development of reasoning and decision-making skills.
- **Mathematical Modelling Tasks**: Requires students to construct and apply mathematical models to analyze and resolve real-world challenges.
- **Case Studies**: Encourages in-depth examination of mathematical issues set within realistic or interdisciplinary contexts to foster critical thinking.
- **Interactive Simulations and Games**: Utilizes digital tools and simulations to immerse students in dynamic scenarios that demand mathematical reasoning and active problem-solving.
- **Open-Ended Questions**: Promotes critical thought by presenting problems that have multiple valid solutions or approaches, requiring students to justify their reasoning.
- **Performance-Based Assessment**: Involves practical demonstrations of mathematical understanding through tasks, activities, or presentations.
- **Portfolio Assessment**: Compiles a student's work over time, highlighting their problem-solving strategies, reflections, and progression in mathematical thinking.
- **Peer and Self-Assessment**: Engages students in evaluating their own or peers' mathematical reasoning processes, fostering self-awareness and metacognitive development.
- **Concept Mapping and Graphic Organizers**: Supports learners in visually organizing and linking mathematical ideas to enhance logical and critical understanding.
- **Socratic Seminars and Math Debates**: Facilitates structured dialogue where students articulate and defend mathematical arguments, cultivating logical reasoning and analytical skills.
- **Technology-Enhanced Assessments (AI/Adaptive Tools)**: Employs artificial intelligence to personalize assessments, adjusting the complexity of problems based on student responses to effectively challenge and evaluate their thinking patterns.

These innovative strategies provide more comprehensive and engaging ways to assess higher-order thinking skills, aligning with the demands of 21st-century education. These methods are designed to move beyond rote learning and foster analytical thinking, creativity, and the ability to apply mathematical knowledge to unfamiliar problems .These innovative assessment methods offers educators a toolkit to cater to different learning styles and objectives. Integrating these methods into the assessment landscape contribute to a more comprehensive and effective evaluation of students' capabilities. The following are examples of some key **AI tools and platforms** that promote **innovative thinking, critical thinking, and problem-solving skills** in education and the workplace:

1. **Education-Oriented Tools such as :**

a. **ChatGPT / AI Writing Assistants**
Use: Helps students brainstorm, write, revise, and question ideas.
Skills Supported: Critical thinking, creative writing, and logical argumentation.

b. Socratic by Google
Use: Uses AI to help students understand schoolwork by guiding them through questions rather than just giving answers.
Skills Supported: Inquiry-based learning and problem-solving.

c. Century Tech
Use: Personalized AI platform for learning that adapts content to students' understanding.
Skills Supported: Independent critical thinking and analytical skills.

2. Workplace-Oriented Tools such as:

a. IBM Watson
- **Use**: Assists in data analysis, business decision-making, and predictive insights.
- **Skills Supported**: Strategic problem-solving and critical evaluation.

b. Tableau (with AI insights)
- **Use**: Visualizes data and uses AI to highlight trends and anomalies.
- **Skills Supported**: Data-driven decision-making and analytical reasoning.

c. Microsoft Copilot (in Word/Excel/PowerPoint)
- **Use**: Assists with summarizing, analyzing, and generating reports or presentations.
- **Skills Supported**: Innovation in content creation, logical organization, and structured problem-solving.

3. Creativity & Innovation Tools: examples are

a. DALL·E / Midjourney
- **Use**: AI art generation based on text prompts.
- **Skills Supported**: Visual creativity, design thinking, and lateral thinking.

b. Runway ML
- **Use**: Creative video and image editing powered by AI.
- **Skills Supported**: Innovative content development and visual storytelling.

The **role of Artificial Intelligence (AI) in innovative assessment methods** for evaluating **critical thinking and problem-solving skills** in **mathematics** are highlighted in each:

1. **AI-Powered Adaptive Testing**
   - **Role of AI**: Adjusts the difficulty of questions in real-time based on the learner's responses.
   - **Assessment Focus**: Challenges students' problem-solving and critical thinking at their individual skill level.

2. **Automated Problem-Solving Feedback Systems**
   - **Role of AI**: Instantly analyzes student responses and provides personalized feedback, explanations, and hints.
   - **Assessment Focus**: Encourages deep reflection and correction of reasoning errors in real-time.

3. **AI-Driven Interactive Simulations and Games**
   - **Role of AI**: Creates dynamic scenarios where students must apply mathematical concepts to solve simulated real-world problems.
   - **Assessment Focus**: Promotes engagement, logical thinking, and real-time decision-making.

4. Intelligent Tutoring Systems (ITS)
   - **Role of AI**: Monitors student progress, identifies cognitive gaps, and guides learners through critical thinking tasks step-by-step.
   - **Assessment Focus**: Measures reasoning pathways and problem-solving approaches.

5. Natural Language Processing (NLP) for Open-Ended Responses
   - **Role of AI**: Analyzes written explanations to assess the depth of reasoning and argumentation in mathematical problem-solving.
   - **Assessment Focus**: Evaluates clarity, logic, and justification in students' thought processes.

6. **AI-Assisted Portfolio Assessment**
   - **Role of AI**: Organizes and analyzes student work over time to track progress in critical thinking and problem-solving.
   - **Assessment Focus**: Identifies patterns, strengths, and areas needing improvement.

7. **Predictive Analytics and Learning Analytics Dashboards**
   - **Role of AI**: Analyzes large sets of student data to predict learning outcomes and inform future assessments.
   - **Assessment Focus**: Helps educators tailor instruction and assessments to develop higher-order thinking.

8. **AI-Based Concept Mapping Tools**

- **Role of AI**: Supports students in visually organizing mathematical ideas and checks logical relationships using AI algorithms.
- **Assessment Focus**: Encourages meta-cognitive strategies and systemic thinking.

9. **Voice Recognition and AI Chatbots for Problem Explanation**

- **Role of AI**: Allows students to verbally explain mathematical reasoning, with AI interpreting and assessing clarity and correctness.
- **Assessment Focus**: Enhances verbal reasoning and mathematical communication.

10. **Collaborative AI Platforms (e.g., AI-Facilitated Group Projects)**

- **Role of AI**: Coordinates and evaluates group problem-solving efforts, identifying individual contributions and group dynamics.
- **Assessment Focus**: Assesses critical thinking in collaborative settings.

In recent education trends, several innovative assessment methods have gained prominence, offering diverse ways to evaluate students' knowledge and skills.Critical thinking enables preservice teachers to grasp the full scope of a subject, allowing them to develop a clear and meaningful understanding of mathematical concepts. This cognitive ability enhances their creative, logical, and analytical thinking skills essential for effective teaching and learning in mathematics. This study therefore investigates the role of AI in facilitating innovative assessment methods tailored to evaluate adolescents' critical thinking and problem-solving skills in mathematics. It aims to examine the potential and challenges of integrating AI tools in educational assessments, and how such technologies can enhance the reliability, validity, and pedagogical relevance of assessments in secondary mathematics education. Ultimately, the study seeks to contribute to a growing body of knowledge on leveraging AI to promote deeper learning and equitable assessment outcomes for adolescent learners and *for sustainable educational development.*

Statement of the Problem

Despite the increasing demand for 21st-century skills such as critical thinking and problem-solving, traditional assessment methods in mathematics education remain largely limited to standardized tests and rote memorization tasks. These conventional tools often fail to capture the depth and complexity of adolescents' cognitive processes, particularly in how they approach, analyze, and solve real-world mathematical problems. With the advent of Artificial Intelligence (AI), there is a growing opportunity to transform assessment practices by introducing adaptive, dynamic, and personalized evaluation systems. AI technologies can analyze students' problem-solving strategies, identify learning patterns, and provide real-time feedback thereby offering a more holistic understanding of students' critical thinking abilities. However, the integration of AI into educational assessment, especially for adolescents in mathematics, is still in its nascent stage, and its effectiveness, reliability, and ethical implications remain underexplored.

This study seeks to address the gap by investigating how AI can be utilized to develop and implement innovative assessment methods that accurately and meaningfully evaluate adolescents' critical thinking and problem-solving skills in mathematics. The goal is to understand the potential of AI-driven assessment to support more nuanced, equitable, and skill-based evaluations, and to inform educational policy and practice in the era of digital learning.

Purpose of Study

The main purpose of this research is to systematically investigate the Role of Artificial Intelligence in Innovative Assessment Methods for Evaluating Critical Thinking and Problem-Solving Skills in Mathematics among adolescents in Education District 2 of Lagos State. Specifically, the purpose of the study is to:

1. Examine how AI-driven tools (adaptive assessment) in innovative assessment can enhance critical thinking and problem-solving skill in mathematics among adolescent in education District 2 of Lagos State.
2. Examine how the effectiveness of AI-based tools and approaches in innovative assessment, compared to traditional methods, influences the evaluation of critical thinking and problem-solving skills in mathematics among adolescents in Education District II of Lagos State.

Research Hypotheses

The following null hypotheses were formulated for the research work:

1. AI-driven tools and techniques such as adaptive assessment does not significantly enhance the evaluation critical thinking and problem-solving skill in mathematics among adolescent in Education District 2 of Lagos State.
2. AI-based assessment approaches in innovative assessment does not significant influence evaluation of critical thinking and problem-solving skills in mathematics compared to traditional methods among adolescents in Education district 2 of Lagos state.

Research Design

Quasi-Experimental research method (pretest-posttest control group design) was adopted in carrying out the study. Quasi-Experimental method, as described by [Ary, Cheser, & Razavieh (1972:26)] is "a scientific investigation in which an investigator (i.e. a researcher) manipulates and controls one or more independent variables and observes the dependent variable or variables for any measurable variation with respect to the manipulation of the independent variables".Ilogu (2005) sees that quasi –experimental design as designs that can be used only when one cannot use true experimental designs.

Population

The target population for this study are the Senior Secondary Two (S.S II) students from government schools in Education District II of Lagos State. The estimated senior secondary students' population for the entire Education District II is 33,118 of which 11,827 are Senior Secondary Two (II) students (Education District II, 2023).

Sample and Sampling Techniques

Lagos State has six Education District. Education District II was chosen by purposive sampling. The district is made up of three educational zones namely Somolu, Kosofe and Ikorodu. Multistage simple random sampling technique was used to select participants for the study. Firstly, simple random sampling technique was employed in the selection of four schools used for the study. This involves the use of balloting method to select the schools. Secondly, stratified random sampling techniques was used in selecting fifty students from each of the four school used for the study in Educational District II of Lagos State giving a total of two hundred (200) students as the sample size. Out of the 200 Questionnaire distributed, only one hundred and eighty was found usable.

Research Instrument

The instrument that was applied in the research to obtain data for the study was the questionnaire. The questionnaire was titled "Role of Artificial Intelligence in Innovative Assessment Methods for Evaluating Critical Thinking and Problem-Solving Skills in Mathematics"(**RAIIAMECTPSM).** Itcontains three sections "A","B", and" C:" while section A contained the bio-data of the selected respondents, section 'B' contained 40 items that bothered on the Artificial intelligence tools, innovative assessment ,critical thinking and problem- solving methods, while section C is the Mathematics Achievement Test(**MAT)** prepared from WAEC/NECO (SSCE) past questions from Y(2019-2023). The Mathematics Achievement Test (MAT) was utilised as a structured assessment

instrument to measure students' critical thinking and problem-solving skills in mathematics. The MAT consisted of higher-order, scenario-based and problem-oriented questions designed to assess reasoning, analytical thinking, and solution strategies rather than rote memorisation. Artificial Intelligence was not used to *answer* the questions on behalf of students. The core idea is that AI functioned as **an assessment enhancement tool,** not a replacement for student thinking. It supported objective evaluation, efficiency, and deeper insight into students' reasoning processes.

Validity and Reliability of the Instrument

To ascertain the validity of the instrument, the questionnaire was given to experts in measurement and evaluation to assess its face expert and content validity and for approval before administered on the sample selected.

The pilot study was conducted on thirty (20) respondents comprised of 10 males and 10 females who did not form part of the original study. The scores at the end of the pilot study were collated and correlated using Cronbach alpha and Pearson Product Moment Correlation Coefficient to obtain the value of 0.72 for the questionnaire and 0.87 for the MAT which was used to determine the degree of relationship between the independent and dependent values as being positive and strong.

Data Analysis and Results

Table 1: Demographic Information of the Participants

Variables	Frequency	Percentage
Sex		
Male	90	50.0%
Female	90	50.0%
Total	**18_0**	**$1_{00.0}$%**
Age Range		
Below 13 years	36	20.0%
13-15 years	63	35.0%
15 years and above	81	45.0%
Total	**18_0**	**$1_{00.0}$%**
Class		
SS2	180	100.0%
Total	**18_0**	**$1_{00.0}$%**
Department		
Science	60	33.3%
Commercial	60	33.3%
Arts	60	33.3%
Total	**18_0**	**$1_{00.0}$%**

Hypothesis 1: AI-driven tools in innovative assessment does not significantly enhance the evaluation critical thinking and problem-solving skill in mathematics among adolescent in Education District 2 of Lagos State.

Table 2: AI-driven Tools in Innovative Assessment on Critical Thinking and Problem-Solving Skill in mathematics among Adolescent in Education District 2 of Lagos State.

Variables	Mean ($\bar{X}$)	S.D.	N	DF	F-cal	p-value	Remark
AI driven Tools(Adaptive Testing)	18.44	4.12	180	179	5.67	0.002	Rejected
Evaluation of Critical Thinking and Problem-Solving Skills	23.68	5.75					

$p<0.05$

Table 2. reveals that there is a significant influence of the AI driven Tools (Adaptive Testing) on the evaluation of critical thinking and problem-solving skills (F-cal=5.67, $p<0.05$). Therefore, the null hypothesis is rejected. This implies that the AI driven Tools in innovative assessment significantly enhances the evaluation of critical thinking and problem-solving skills among adolescents in Education District Two of Lagos State.

Hypothesis 2: AI-based assessment approaches in innovative assessment does not significant influence evaluation of critical thinking and problem-solving skills in mathematics compared to traditional methods among adolescents in Education district 2 of Lagos state.

Table 3: AI-based Assessment Approaches in innovative assessment on Evaluation of Critical Thinking and Problem-Solving Skills in mathematics Compared to Traditional Methods among Adolescents in Education District 2 of Lagos State

	Sum of Squares	d.f.	Mean Square	F-calculated	Sig. (p) value	Remark
Between Experimental Groups	310.369	4	77.592			
Within Control Groups	4704.124	579	8.125	9.550*	0.000	H_0 is Rejected
Total	5014.493	583				

F- Critical = 2.38; F- calculated >F- critical

Table 3 reveals that there is a significant influence of the AI-based Assessment Approaches in innovative assessment on Evaluation of Critical Thinking and Problem-Solving Skills in mathematics (F-cal=6.78, $p<0.05$) compared to the control group. Therefore, the null hypothesis is rejected. This implies that the AI-based Assessment Approaches in innovative assessment significantly influences the evaluation of critical thinking and problem-solving skills compared to the control group among adolescents in Education District Two of Lagos State.

Summary of Findings

Based on the analyses in this study, the following results were obtained:

1. AI driven Tools in innovative assessment significantly enhances the evaluation of critical thinking and problem-solving skills among adolescents in Education District Two of Lagos State.
2. There is a significant influence of the AI-based Assessment Approaches in innovative assessment on evaluation of Critical Thinking and Problem-Solving Skills compared to the control group among adolescents in Education District Two of Lagos State.

Discussion of Findings

Findings from hypothesis one found that AI driven Tools in innovative assessment significantly enhances critical thinking and problem-solving skills. The study also, shed light on the broader implications for student learning and development. The study is in support of Zimmerman (2022) that stated AI driven Tools (Adaptive Testing) encourages students to take ownership of their learning process, fostering a sense of autonomy and self-regulation This increased sense of agency can lead to higher levels of engagement and motivation, which are crucial for the development of critical thinking and problem-solving skills (Ryan & Deci, 2020). Furthermore, the process of providing and receiving feedback during AI driven Tools (Adaptive Testing) can help students develop effective communication and interpersonal skills, which are essential for success in both academic and professional settings (Topping, 2021).

Findings from hypothesis two found that AI-based in innovative assessment Approach significant influence evaluation of Critical Thinking and Problem-Solving Skills compared to the control group among adolescents in Education District Two of Lagos State. It was discovered that AI helps to promote deeper learning , development of transferable skills, critical thinking and problem solving skills, by engaging in authentic, real-world projects, students not only acquire content knowledge but also learn how to apply that knowledge in meaningful ways (Barron & Darling-Hammond, 2019). This application of knowledge is a critical component of developing critical thinking and problem-solving skills, as it requires students to analyze complex situations, make informed decisions, and generate creative solutions (Savery, 2016).

AI-powered assessment tools, such as automated essay scoring systems, intelligent tutoring systems, and adaptive testing platforms, have shown premise in evaluating higher-order thinking skills. According to **Luckin et al. (2_0 23)**, AI systems can provide individualized feedback and adapt to student performance, allowing deeper evaluation of cognitive skills like critical thinking and problem-solving. These systems analyze patterns in student responses that go beyond rote knowledge recall. The findings is in support of **Baker et al. (2_0 2_0), that** found out that AI-based assessments can track students' reasoning processes through log data and decision-making patterns. Tools such as learning analytics and Natural Language Processing (NLP) can assess argument structure, logic, and coherence in student essays, providing insights into critical thinking that are not easily visible in multiple-choice assessments. **VanLehn (2_0 21)** reported that intelligent tutoring systems not only assist students in solving problems but also assess the methods and reasoning used in the process. These systems can identify whether a student is using trial-and-error or logical reasoning, allowing for more granular evaluations. Traditional

assessment methods in Nigerian schools such as teacher-made examinations often emphasize factual recall rather than reasoning or analytical skills (**Adegbija & Ademola, 2019**). These methods have been criticized for lacking the capacity to measure complex cognitive outcomes effectively.

Conclusions

The integration of AI-based assessment approaches in Education District Two of Lagos State has demonstrated significant benefits over traditional methods, particularly in evaluating critical thinking and problem-solving skills. The literature and findings collectively suggest that AI tools not only improve assessment accuracy and depth but also enhance learning by providing real-time, actionable feedback. These outcomes make a compelling case for scaling AI-based assessment methods across similar educational settings. Unlike traditional assessment methods, AI tools offer a process-oriented, scalable, and individualized evaluation approach that aligns with 21st-century learning goals. As such, educational policymakers and stakeholders are encouraged to invest in AI-driven assessment technologies to enhance learning outcomes and foster deeper cognitive engagement among secondary school learners.

Recommendations

Based on the findings and discussion, the following recommendations are made:

1. **Students should engage actively** with AI-based learning and assessment platforms to develop deeper problem-solving and critical thinking abilities.

2. **Students should reflect on AI feedback** to improve reasoning strategies and mathematical understanding.

3. **Students should cultivate digital literacy** to navigate and use AI tools effectively for learning and self-assessment.

4. **Students should maintain academic honesty**, using AI as a support tool rather than a shortcut.

5. **Teachers should use AI-generated analytics** to identify students' learning gaps and tailor instruction accordingly.

6. **Teachers should balance AI assessments** with human judgment to provide holistic evaluations.

7. **Government should fund the development and deployment** of AI-based educational tools that support critical thinking and problem-solving in mathematics.

8. **Government should formulate policies** that encourage the responsible and equitable use of AI in education.

9. **Government should support research and innovation** in AI-driven assessment methodologies.

10. **Government should ensure nationwide access** to AI technologies, especially in underserved and rural areas

11. **Curriculum planners should embed AI-friendly assessment tasks** into the mathematics curriculum that focus on reasoning, justification, and multi-step problem-solving.

12. **Curriculum planners should collaborate with AI experts** to ensure curriculum design supports meaningful integration of AI tools.

13. **Curriculum planners should incorporate computational thinking and AI literacy** as part of core competencies for students.

14. **School administrators should invest in AI infrastructure** including hardware, software, and internet connectivity for seamless assessment implementation.

15. **School administrators should invest encourage teacher training** on effective use of AI tools in assessment and instruction.

16. **School administrators should invest promote a data-informed culture** by using AI analytics to guide school-level decision-making and intervention planning.

17. **School Administrators should Invest Implement ethical data practices**, ensuring student data collected by AI systems is secure and used responsibly.

Implications of the Study for Measurement and Evaluation

The findings of this study have significant implications for both measurement practices and evaluators within the educational system.

1. **Shift from Static to Dynamic Assessment Models**: AI tools enable continuous and adaptive assessment, allowing evaluators to capture students' thought processes in real time rather than relying solely on summative test scores.
2. **Enhanced Diagnostic Capability**: AI systems can analyze patterns in student responses to identify specific strengths and weaknesses in critical thinking and problem-solving, allowing for more precise measurement of learning outcomes.
3. **Reduction of Subjectivity in Scoring**: AI-based assessment tools provide consistent scoring algorithms, particularly for open-ended or process-based mathematics tasks, minimizing human bias and subjectivity.
4. **Improved Feedback Mechanisms**: Evaluation becomes more formative, with AI enabling immediate, personalized feedback that supports both measurement and instructional improvement.
5. **Expansion of Assessable Constructs**: Traditional assessments may struggle to capture complex cognitive processes. AI allows evaluators to measure constructs such as metacognition, reasoning pathways, and strategic thinking more effectively.
6. **Data-Driven Decision Making**: Measurement systems powered by AI generate rich datasets that can inform instruction, curriculum planning, and policy decisions across schools in Lagos State.
7. **Need for New Evaluation Frameworks**: Traditional evaluation rubrics may not align with AI-enabled assessments. There is a need to develop new frameworks and standards that reflect 21st-century skills and digital capabilities.
8. **Equity and Fairness Considerations**: Measurement systems must be monitored to ensure that AI algorithms do not disadvantage certain student groups due to biases in data or access inequalities.

9. **Integration of Process-Oriented Evaluation**: AI allows evaluators to assess not just the final answer but the entire problem-solving process, offering a more comprehensive picture of student learning.
10. **Professional Development for Evaluators**: Evaluators and educators must be trained to interpret AI-generated assessment data effectively and integrate it into their measurement practices.

Implications for Sustainable Educational Development

1. **Promotion of Quality Education (SDG 4)**: Enhances the quality of teaching and learning through personalized, data-driven assessments that foster deeper understanding and critical engagement in mathematics.
2. **Equity and Inclusivity in Assessment**: AI tools can be adapted to cater to diverse learning needs, helping bridge learning gaps and ensuring no learner is left behind.
3. **Improved Learning Outcomes**: Focus on higher-order thinking skills (critical thinking and problem-solving) leads to better academic performance and long-term cognitive development.
4. **Data-Driven Educational Planning**: AI-generated assessment data supports informed decision-making, curriculum adjustment, and targeted interventions at the policy and classroom levels.
5. **Teacher Empowerment and Professional Growth**: Equips teachers with innovative tools and techniques to assess and support students effectively, enhancing professional capacity.
6. **Lifelong Learning Culture**: By promoting analytical and problem-solving abilities, students are prepared for continuous learning and adaptation in an evolving world.
7. **Technological Integration in Education**: Encourages the adoption of digital tools in classrooms, advancing tech literacy among students and educators, which is vital for sustainable future workforce development.
8. **Efficient Resource Utilization**: Reduces dependence on paper-based assessments and manual grading, promoting eco-friendly practices and efficient use of educational resources.
9. **Bridging the Urban-Rural Learning Divide**: With the right infrastructure, AI can help extend quality education and innovative assessment methods to underserved or remote areas.
10. **Alignment with Global Educational Standards**: Positions the educational system of Lagos State in line with international best practices in assessment and 21st-century skills development.

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