Unizik Journal of Educational Research, Science and Vocational Studies
(UJERSVOCS) Volume 2 (1); May-August, 2025; https://unilaws.org/ujervs
E-ISSN (Online): 1595-6199 ISSN (Print): 1595-6202

EMPOWERING EDUCATION IN IMO STATE THROUGH THE INTEGRATION OF ROBOTICS AND AI LEARNING TOOLS INTO SENIOR SECONDARY SCHOOL CURRICULUM

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ABSTRACT

Integrating emerging technologies into education is vital for preparing students for a digital future. This study examined the integration of robotics and AI learning tools into the senior secondary school curriculum in Imo State, Nigeria. Employing a mixed-methods design, the study assessed the availability and utilization of these tools, identified suitable options for classroom integration, explored implementation challenges, and evaluated their potential impact on teaching and learning. A total of 360 participants (330 teachers, 30 administrators) were selected through proportionate stratified random sampling from public schools in the Owerri Education Zone. Data collection utilized the validated Robotics and AI Tools Integration Questionnaire (RAITIQ), demonstrating strong validity (S-CVI = 0.91) and reliability (Cronbach's alpha = 0.81–0.89). Findings revealed low availability and utilization of robotics and AI tools, hindered by infrastructural deficits, funding shortages, inadequate teacher training, poor electricity and internet access, and an outdated curriculum. Nevertheless, participants agreed that tools such as Arduino, Raspberry Pi, LEGO Mindstorms, and Scratch are suitable for integration and would enhance student engagement, problem-solving, creativity, critical thinking, and personalized learning. ANCOVA revealed that both ***subject area*** *(Science vs. Arts) and* ***teaching experience*** *significantly influenced perceptions regarding tool availability/utilization ($F(1,356)=9.87, p=0.002, \eta p2=0.027$) and integration challenges ($F(1,356)=7.34, p=0.007, \eta p2=0.020$). Teaching experience itself also had a significant impact ($p<0.001$). These findings underscore the urgent need for strategic investments in infrastructure, targeted professional development, and comprehensive curriculum reforms to effectively leverage the benefits of robotics and AI in secondary education.*

Keywords: Empowerment; Integration; Robotics; AI; Learning Tools; Secondary School Curriculum

Introduction

The global educational landscape is changing rapidly, thanks to breakthroughs in artificial intelligence (AI) and robotics. These technologies are revolutionizing how students learn, making education more interactive, personalized, and skill-focused. As we step further into the Fourth

Industrial Revolution (4IR), schools worldwide are embracing digital tools to prepare students with essential skills like problem-solving, creativity, and collaboration (UNESCO, 2023). Consequently, robotics and AI are no longer confined to the tech industry, they are becoming key parts of modern classrooms, including at the secondary school level.

Artificial Intelligence (AI) refers to the developing computer systems capable of performing tasks that traditionally require human intelligence, including decision-making, speech recognition, visual perception, and language translation (Russell and Norvig, 2021). Robotics, a subfield of AI, focuses on the design, construction, and operation of robots (machines) that can execute complex actions autonomously or semi-autonomously based on programmed instructions or AI algorithms (Kaplan & Haenlein, 2022). In educational contexts, these technologies are leveraged to enhance student engagement, support differentiated learning, and cultivate critical skills through interactive, hands-on experiences.

Integrating cutting-edge technologies like robotics and AI into the senior secondary school curriculum is not just a fleeting trend, it's a fundamental necessity for preparing students for the future. These powerful tools have the potential to transform traditional teaching methods, moving beyond rote learning to foster more interactive, personalized, and problem-based learning experiences (Ayodele et al., 2023). Imagine learning where AI-powered platforms can tailor content to each student's unique learning style and pace, offering real-time feedback and adapting to their progress. Simultaneously, robotics can bring abstract scientific and mathematical concepts to life through hands-on learning, encouraging computational thinking and practical problem-solving (Chiu et al., 2022). Nigeria is increasingly recognizing this imperative. For instance, the National Senior Secondary Education Commission (NSSEC) has launched a nationwide AI training program for 6,000 senior secondary school teachers, aiming to integrate AI into classrooms and boost digital literacy (ITEdgeNews, 2025). This is a strong signal of Nigeria's commitment to aligning its education system with global technological advancements and cultivating a generation proficient in AI, robotics, and data science. Specifically, within Imo State, there's a clear understanding of the need to develop AI-focused educational programs and update science curricula to incorporate these transformative technologies.

However, despite these recognized benefits and national directives, the integration of robotics and AI into public secondary schools in Imo State faces significant challenges. There's a notable absence of clear policy directives and adequate curriculum guidelines, coupled with insufficient investment in teacher training, which has hindered widespread adoption. Many teachers simply lack the familiarity and confidence to operate robotics kits or effectively use AI platforms to personalize instruction, assess learning, or provide real-time feedback (Eze & Oguike, 2024). As a result, valuable digital tools like coding platforms, simulation software, and AI tutoring systems are often relegated to extracurricular or pilot activities, instead of being woven into the core curriculum for STEM subjects such as Mathematics, Physics, Chemistry, and Computer Studies.
While there have been commendable attempts to introduce coding and robotics clubs in some Nigerian schools through partnerships with NGOs and tech firms, such as the "Teach the Child Tech" initiative launched in 2022, these efforts often fall short in terms of consistency and scale.

There's a pressing need for a comprehensive, policy-driven, and government-supported framework that ensures robotics and AI education becomes an integral part of the mainstream curriculum, accessible to all students, regardless of their location or socioeconomic background (Uzoho & Nwankwo, 2024). Although the Nigerian government's National Digital Economy Policy and Strategy (2020–2030) outlines goals for adopting digital tools in education, its implementation has been inconsistent across states. In Imo State, there's minimal evidence of formal integration of robotics and AI into the public-school curriculum (Federal Ministry of Communications and Digital Economy, 2021). A survey by Okoroafor & Eze (2024) revealed that only a handful of elite private schools in urban areas like Owerri have even begun experimenting with robotics kits and AI-powered educational platforms. While these initiatives are positive, they are simply not enough to create widespread impact, especially considering the state's large student population and the often-under-resourced rural schools.

Globally, the integration of AI and robotics in secondary education has demonstrably improved learning outcomes. AI tools can truly personalize content to individual learning styles and paces, provide immediate feedback, and analyze performance data to inform instructional strategies (World Bank, 2023). Robotics projects, in particular, foster collaborative learning, encourage students to design and troubleshoot real-world problems, and ignite a passion for STEM careers. Countries like Singapore, South Korea, and Finland have successfully embedded these technologies into their national education systems, ensuring their students are not just consumers of technology, but active innovators.

A crucial aspect of this integration is alignment with national and international education standards. Nigeria's National Policy on Science and Technology Education emphasizes the need to promote innovation and creativity among learners through modern teaching aids and technological tools. However, this policy has yet to be fully operationalized within Imo State's education sector. Therefore, this study aims to propose a strategic and sustainable framework for integrating robotics and AI tools into the senior secondary curriculum – a framework that can provide clear guidance for stakeholders in policy formulation, resource mobilization, and program implementation. In essence, while the benefits of integrating AI and robotics into secondary education are abundantly clear, their implementation in Imo State remains significantly underdeveloped. Addressing this gap is not just about improving STEM education outcomes; it's about preparing students to thrive in an increasingly technology-driven world. A proactive approach involving curriculum reform, robust teacher capacity building, essential infrastructural development, and strong stakeholder collaboration is absolutely essential to empower Imo State's youth and bridge the digital divide in education.

Statement of the Problem

The educational system in Imo State is grappling with a significant challenge: it's not adequately preparing senior secondary school students for the demands of the 21st-century workforce. This critical disconnect stems primarily from an outdated curriculum that simply hasn't kept pace with modern technological advancements. The current syllabus largely ignores robotics, artificial

intelligence (AI), and other emerging technologies, leaving students ill-equipped for promising future careers in STEM fields.

Beyond the curriculum, many schools are hindered by a severe lack of modern infrastructure. This means inadequate computer labs, unreliable internet access, and a dire shortage of the robotics and AI learning tools that are essential for practical, hands-on learning experiences. Compounding these infrastructural issues is the scarcity of qualified teachers. Most educators in Imo State haven't been exposed to the fields of robotics and AI, making it incredibly difficult to deliver effective, engaging instruction in these areas.

Even in instances where some resources might be available, the absence of a structured implementation framework leads to inconsistent and ineffective adoption of technology-driven education. Without a clear policy, well-designed training programs, and robust monitoring mechanisms, any efforts to modernize the curriculum remain fragmented and ultimately fall short. The consequence of these interconnected problems is stark: students in Imo State risk falling significantly behind their peers in more technologically advanced regions. This limits their opportunities not only in higher education but also in the increasingly competitive global job market. To truly empower these students with the skills needed to thrive in an increasingly digital world, it's absolutely critical to address these gaps through a comprehensive approach. This must include a thorough curriculum revision, strategic infrastructure development, intensive teacher training, and a robust implementation strategy.

Aim and Objectives of the Study

The aim of the study is to investigate how the integration of robotics and artificial intelligence (AI) learning tools into the senior secondary school curriculum in Imo State can improve teaching and learning outcomes.

Specifically, the following objectives will guide the study;

1. To assess the current availability and level of utilization of robotics and AI learning tools in senior secondary schools across Imo State.
2. To identify specific robotics and AI tools suitable for integration into the existing senior secondary school curriculum in Imo State.
3. To identify and analyze the challenges associated with the integration of robotics and artificial intelligence (AI) learning tools into the senior secondary school curriculum in Imo State.
4. To examine how the integration of selected robotics and AI tools can enhance teaching methodologies and student learning in senior secondary schools in Imo State.

Research Questions

1. What is the current availability and level of utilization of robotics and AI learning tools in senior secondary schools across Imo State?
2. Which specific robotics and AI tools are suitable for integration into the existing senior secondary school curriculum in Imo State?
3. What are the challenges associated with the integration of robotics and AI learning tools into the senior secondary school curriculum in Imo State?

4. How can the integration of selected robotics and AI tools enhance teaching methodologies and student learning in senior secondary schools in Imo State?

Research Hypotheses

The following **null hypotheses** were formulated to guide the analysis:

H_{01}: There is no significant difference between the mean ratings of Science and Arts public senior secondary school teachers on the current availability and level of utilization of robotics and AI learning tools in Imo State.

H_{02}: There is no significant difference between the mean ratings of Science and Arts public senior secondary school teachers on the challenges associated with the integration of robotics and AI learning tools into the curriculum in Imo State.

Literature Review

Role of Robotics & Artificial Intelligence educational tool in Senior Secondary Curriculum

The integration of robotics and artificial intelligence (AI) is genuinely transforming education, especially in the senior secondary school. Imagine a classroom where learning isn't just about textbooks and lectures, but about dynamic, personalized experiences that truly come alive. These technologies introduce intelligent, interactive, and adaptive learning environments that cut across all subject areas, fostering both engagement and improved academic outcomes (UNESCO, 2021). Take Mathematics, for instance. AI-driven applications like Carnegie Learning and Microsoft Math Solver are like having a personal tutor for every student. They guide them through problem-solving with strategies tailored just for them and give instant feedback, so students can learn and grow at their own pace. And then there are those wonderful robotics kits! They're not just toys; they're bringing abstract math concepts like geometry and algebra to life. Students get to design and program real, functional models, giving them a practical feel for what can sometimes seem so theoretical (Xie et al., 2019). Similarly, in English Language and Literature, Natural Language Processing (NLP) tools, like the trusty Grammarly and various AI writing assistants, are empowering students to really polish their grammar, structure, and writing clarity. Beyond that, AI platforms can dive deep into literary texts, analyzing tone, sentiment, and themes, which truly fosters a deeper interpretation and sparks that creative thinking we all want to see.

The impact of robotics and AI in the sciences is just as profound. In Biology, intelligent tutoring systems and virtual labs are like having a microscopic window into the world, allowing students to simulate intricate cellular processes and anatomy without ever stepping foot in a physical lab. Robotics, on the other hand, can be used to build and model complex body systems, like the human arm or the circulatory system, making the abstract wonderfully tangible (Kandlhofer & Steinbauer, 2021). For Chemistry, platforms like Labster offer virtual laboratories where students can conduct experiments and visualize molecular reactions. This isn't just cool; it significantly reduces the risks and costs that come with handling real chemicals, making science more accessible and safer (Olasina, 2021). In Physics, robotics is absolutely invaluable for demonstrating fundamental principles of motion, energy, and force. Meanwhile, AI modeling tools can simulate complex physical systems, letting students visualize and even manipulate variables in real-time, turning equations into interactive discoveries (Russell & Norvig, 2021).

Of course, Computer Science and ICT subjects are naturally thriving with AI and robotics integration. Students get invaluable hands-on experience coding robots using languages like Python, Arduino, and Scratch. And AI-based platforms are like silent, ever-present mentors, supporting self-guided learning by providing real-time assistance, personalized lessons, and even pointing out errors with a gentle nudge. But the reach of these technologies extends far beyond the traditional STEM fields. In Agricultural Science, for example, students can now use AI-powered platforms like Plantix or FarmLogs to analyze soil quality, predict crop yields, and even simulate the effects of climate change on farming, giving them a glimpse into the future of food production. Robotics introduces them to smart agricultural technologies such as automated irrigation systems, drone-based crop monitoring, and robotic harvesters, equipping our learners with practical skills that are directly relevant to modern agritech industries (Nwachukwu et al., 2022).

In Economics, AI tools such as IBM Watson and Tableau are empowering students with real-time data analysis, market simulations, and the ability to create predictive economic models. They can visualize economic trends using AI-driven dashboards, and friendly chatbots and virtual tutors are on hand to demystify complex concepts like inflation, fiscal policy, and supply-demand dynamics. For Geography, AI supports applications like ArcGIS and Google Earth Engine, allowing students to interpret topographic data, analyze climate patterns, and study urban growth with incredible detail. Robotics can even help create physical simulations of geographic phenomena—like erosion or tectonic movement—literally bringing textbook concepts to life (UNESCO, 2021).

Similarly, in Civic Education and Government, Natural Language Processing (NLP) tools and interactive bots can simulate political debates, manage mock elections, and even analyze public opinion through real-time sentiment tracking. This isn't just about learning facts; it's about fostering genuine civic engagement and sharp analytical thinking. In History, AI is enhancing learning through interactive timelines, virtual museum tours, and text-mining tools that uncover key themes in historical documents, allowing students to engage with content in a more immersive and contextualized manner, like stepping back in time.

In Technical Drawing, tools like AutoCAD with AI-enhanced features enable students to design, refine, and simulate mechanical systems with unprecedented precision. Robotics further deepens this experience by allowing students to bring their digital creations to life using 3D printers or CNC machines, truly bridging the gap between design and function (Adebayo & Oyelekan, 2022). Even in the vibrant worlds of Fine Arts and Music, creative AI applications such as Google's Magenta, DALL·E, or AIVA are empowering students to compose music, generate digital art, and even collaborate with AI on visual or auditory projects, opening up entirely new avenues of artistic expression. Robotics in this context can control musical instruments or recreate complex artistic patterns, enabling new forms of artistic expression (Eguchi, 2020).

Home Economics is also experiencing a delightful digital shift. AI tools like Yummly are assisting in meal planning and nutrition tracking, while smart budgeting apps are teaching students valuable financial responsibility. Robotics is even making an appearance through smart kitchen devices and

automated sewing machines, reflecting the integration of technology into everyday household management (Cheung & Slavin, 2013). And in Physical and Health Education (PHE), wearable AI like Fitbit and Apple Health are monitoring physical activity and providing personalized feedback on fitness goals. Robotics-powered prosthetics and exoskeletons are not only supporting physical rehabilitation but are also opening doors for truly inclusive physical education for students with special needs (Russell & Norvig, 2021).

These diverse applications truly underscore a vital truth: AI and robotics aren't just for the science and technology whizzes. They are being beautifully and effectively adapted across the entire curriculum, including the arts, humanities, and vocational studies, offering personalized, interactive, and genuinely engaging learning experiences for all. This cross-disciplinary integration is doing more than just teaching subjects; it's nurturing the development of essential 21st-century skills such as critical thinking, problem-solving, creativity, collaboration, and digital fluency – skills that are absolutely vital for our students' future success. For a state like Imo, where curriculum modernization is so deeply overdue, embracing AI and robotics across every subject area represents a powerful, unparalleled opportunity to align our education with global standards and truly prepare our students for bright academic and career pathways ahead.

Benefits of Robotic and AI Tools in Curriculum Delivery

Artificial Intelligence (AI) is rapidly transforming education, making learning more personalized, efficient, and engaging. Integrating AI tools into the curriculum offers significant benefits, especially for senior secondary education in places like Imo State, Nigeria.

1. Personalized Learning: One of AI's most powerful contributions to education lies in its capacity to personalize the learning experience. Unlike traditional one-size-fits-all methods, AI systems such as Knewton and DreamBox analyze individual student data in real time to dynamically adjust the pace, complexity, and style of content delivery (Baker & Siemens, 2014). Struggling students receive targeted remediation and additional practice, while advanced learners are presented with enriched materials to challenge them. This adaptive learning model ensures that every student can learn at their own pace, leading to improved academic outcomes in heterogeneous classrooms (Holmes et al., 2019).

2. Intelligent Tutoring Systems (ITS): AI-driven Intelligent Tutoring Systems mimic the behavior of a human tutor by offering real-time, personalized guidance. Tools like Carnegie Learning and Cognii assess a student's current knowledge, then provide tailored explanations, step-by-step feedback, and strategic hints. These platforms are particularly effective in STEM subjects, where they help bridge gaps in comprehension and reinforce difficult concepts (VanLehn, 2011; Ma et al., 2014). For students in overcrowded classrooms who may not receive individual attention from teachers, ITS serve as valuable supplementary learning aides.

3. Virtual Laboratories and Simulations: In environments with limited access to physical lab facilities, AI-powered virtual labs provide a practical, cost-effective alternative. Platforms such as Labster and PhET Simulations allow students to conduct interactive, high-fidelity experiments in biology, chemistry, and physics. These tools let learners manipulate variables, test hypotheses, and visualize outcomes in real time—without the risks or costs associated with traditional labs (Rutten

et al., 2012). For schools in underserved areas, virtual labs bridge the gap between theoretical knowledge and practical application.

4. Smart Content Creation and Curation: AI also assists teachers by automating content development and streamlining resource curation. Tools like ChatGPT and QuillBot can generate quizzes, lesson plans, summaries, and educational materials that educators can easily customize (Subramanian & Sivasubramanian, 2020). Moreover, AI-powered platforms such as Coursera and Edmodo recommend learning resources based on students' previous performance, ensuring that learners access content that is timely, relevant, and aligned with their interests.

5. Enhanced Student Engagement: AI and robotics make learning more interactive and enjoyable. Gamified learning platforms such as Kahoot! and Duolingo use points, levels, and rewards to turn educational content into exciting challenges, boosting student motivation and sustained interest (Dicheva et al., 2015). AI chatbots and virtual assistants like ChatGPT offer 24/7 support, providing explanations, hints, and instant answers to student inquiries. This constant availability reduces learner frustration and supports a more active, learner-centered educational model (Hwang & Chang, 2021).

6. Automated Grading and Feedback: Grading large volumes of student work is a time-consuming task. AI tools like Gradescope and Turnitin can automatically assess a wide range of assignments, including multiple-choice tests, written essays, and even code submissions. These platforms not only grade but also provide immediate, actionable feedback to students, promoting faster learning and error correction (Roll & Wylie, 2016; Shute, 2008). For teachers, this automation reduces administrative burdens, freeing up more time for lesson planning and individualized support.

Methodology

Research Design

This study adopted a mixed-methods research design, combining both quantitative and qualitative approaches to provide a comprehensive analysis of the integration of robotics and artificial intelligence (AI) learning tools into the senior secondary school curriculum in Imo State, Nigeria. The quantitative aspect facilitated the collection and analysis of measurable data, while the qualitative component offered deeper insights into teachers' perceptions and experiences.

Area of the Study

The research was conducted in Imo State, Nigeria, specifically within the Owerri Education Zone, which comprises two sub-zones: Owerri I and Owerri II. This zone was selected due to its geographical diversity, encompassing both urban and peri-urban public secondary schools, thus offering varied insights into technological integration in education.

Population of the Study

The target population comprised 3,312 teachers and administrators across 124 public senior secondary schools within the Owerri Education Zone of Imo State. Both teachers and administrators were selected as key respondents due to their pivotal roles in curriculum implementation and educational leadership. While teachers provide firsthand experience with classroom integration of new learning technologies, administrators contribute strategic oversight and policy-level perspectives on the adoption of robotics and AI tools in the school system.

Sample and Sampling Technique

A proportionate stratified random sampling technique was employed to select a total of 360 participants, consisting of 330 teachers (representing approximately 10% of the teacher population) and 30 school administrators. The stratification was based on the two sub-zones, Owerri I and Owerri II, to ensure balanced representation from both geographical areas. This approach enhanced the representativeness and generalizability of the study findings across the entire Owerri Education Zone.

Instrument for Data Collection

The primary data collection tool was **a** self-structured questionnaire **titled,** "Robotics and AI Tools Integration Questionnaire (RAITIQ)." It employed a **4-point scale** (4 = Strongly Agree, 3 = Agree, 2 = Disagree, 1 = Strongly Disagree) to eliminate neutral responses and encourage definitive answers.

Validity and Reliability of the Instrument

Content Validity**:** The questionnaire was reviewed by experts in educational technology, computer science and curriculum studies, achieving a **Scale** Content Validity Index (S-CVI) of 0.91**,** confirming its relevance.

Reliability**:** A pilot study was conducted with teachers outside the main study area. Cronbach's Alpha (α) coefficients ranged between 0.81 and 0.89**,** indicating strong internal consistency**.**

Method of Data Analysis

Descriptive Statistics: Mean scores and standard deviations were computed to summarize participants' responses. A mean score of 2.5 or above was interpreted as agreement or a positive perception, while a mean score below 2.5 indicated disagreement or a negative perception.

Inferential Statistics: Analysis of Variance (ANOVA) was used to test for statistically significant differences in responses among sub-groups of teachers. Specifically, ANOVA examined differences based on factors such as years of teaching experience and subject area specialization (e.g., Science vs. Arts).

Hypothesis Testing: All hypotheses were tested at the 0.05 level of significance ($p < 0.05$). Particular attention was given to determining whether there were significant differences in perceptions and responses between Science and Arts teachers regarding the integration of robotics and AI learning tools into the curriculum.

Result

Research Question 1: What is the current availability and level of utilization of robotics and AI learning tools in senior secondary schools across Imo State?

Table 1: Availability and Utilization of Robotics and AI Learning Tools

S/N	Questionnaire Item	SA	A	D	SD	Mean ($\bar{x}$)	SD	Decision
1	Robotics kits are available in my school.	60	66	120	84	2.31	0.74	Reject
2	AI learning tools are used during teaching sessions.	72	72	114	72	2.45	0.81	Reject
3	My school has a functional robotics/AI laboratory.	48	66	132	84	2.18	0.69	Reject
4	Teachers are trained to use robotics and AI tools.	60	78	120	72	2.40	0.78	Reject
5	Robotics and AI tools are regularly used in science or tech-related subjects.	78	96	108	48	2.52	0.82	Accept
6	Students have regular access to robotics and AI learning tools.	54	66	138	72	2.27	0.73	Reject
7	Robotics and AI materials are included in the school's instructional resources.	60	84	120	66	2.38	0.79	Reject
8	There is administrative support for robotics/AI integration in teaching and learning.	66	72	126	66	2.42	0.77	Reject
9	Robotics/AI tools are accessible through the school's ICT infrastructure.	54	78	132	60	2.40	0.75	Reject
10	Utilization of robotics and AI tools is part of school lesson delivery plans.	66	84	120	60	2.48	0.80	Reject

The responses indicate a generally low level of availability and utilization of robotics and AI learning tools in senior secondary schools across Imo State. Only one item out of ten (Item 5) met the acceptance threshold, suggesting that while there may be occasional use in science and technology subjects, overall access, training, and infrastructure for robotics and AI integration remain inadequate. This highlights the urgent need for investments in facilities, capacity building for teachers, and policy frameworks that support the adoption of emerging technologies in education.

Research Question 2: Which specific robotics and AI tools are suitable for integration into the existing senior secondary school curriculum in Imo State?

Table 2: Suitable Robotics and AI Tools for Curriculum Integration

S/N	Questionnaire Item	SA	A	D	SD	Mean ($\bar{x}$)	SD	Decision
1	Arduino and Raspberry Pi are appropriate tools for robotics education.	162	138	36	24	3.21	0.60	Accept
2	LEGO Mindstorms kits are suitable for classroom use.	150	120	54	36	3.05	0.65	Accept
3	AI coding tools like Scratch and Blockly are easy for students to use.	156	138	42	24	3.15	0.58	Accept
4	AI simulation apps (e.g., chatbots, virtual labs) align with learning goals.	138	126	60	36	3.02	0.69	Accept
5	Web/mobile AI learning platforms (e.g., Teachable Machine) are appropriate for students.	132	126	66	36	2.98	0.74	Accept

6	Tools should be adapted to local contexts and student age.	174	138	36	12	3.28	0.52	Accept
7	Robotics kits with modular components support interactive learning.	144	132	54	30	3.08	0.63	Accept
8	Platforms offering gamified AI learning (e.g., AI for Oceans) are engaging for students.	138	144	54	24	3.10	0.61	Accept
9	Simple robot programming platforms (e.g., mBot, VEXcode) fit well in science lessons.	150	132	48	30	3.11	0.64	Accept
10	Affordable AI/robotics kits should be prioritized for curriculum integration.	168	126	48	18	3.23	0.57	Accept

The responses to Research Question 2 indicate a strong consensus among respondents that a range of robotics and AI tools are suitable for integration into the senior secondary school curriculum in Imo State. All 10 items recorded mean scores above 2.50, demonstrating high acceptance. Tools such as Arduino, Raspberry Pi, LEGO Mindstorms, Scratch, Blockly, AI simulations, and gamified platforms were identified as practical, engaging, and age-appropriate for students. The respondents also emphasized the need for affordability, modularity, and cultural relevance, underscoring the importance of adapting these tools to local classroom realities to ensure effective implementation and sustainability.

Research Question 3: What are the challenges associated with the integration of robotics and AI learning tools into the senior secondary school curriculum in Imo State?

Table 3: Challenges of Integration of Robotics and AI Tools

S/N	Questionnaire Item	SA	A	D	SD	Mean ($\bar{x}$)	SD	Decision
1	Lack of funding hinders acquisition of robotics/AI tools.	192	120	36	12	3.45	0.51	Accept
2	Teachers lack training in robotics and AI implementation.	174	126	42	18	3.33	0.57	Accept
3	Poor electricity and internet infrastructure limits integration.	186	132	30	12	3.40	0.49	Accept
4	The current curriculum does not support robotics/AI learning.	150	138	54	18	3.15	0.62	Accept
5	Robotics/AI tools are too expensive to maintain.	168	132	42	18	3.28	0.54	Accept
6	Lack of government policy/guidelines discourages adoption.	156	138	48	18	3.20	0.61	Accept
7	Technical support is not available in schools for managing AI/robotic tools.	162	132	48	18	3.22	0.59	Accept
8	School leadership lacks awareness or commitment to robotics/AI education.	150	132	60	18	3.15	0.63	Accept
9	There are no collaborative platforms for peer-learning among teachers on AI/robotics.	144	144	54	18	3.15	0.60	Accept
10	Language and curriculum content are not localized to support robotic/AI learning effectively.	138	144	60	18	3.10	0.62	Accept

All 10 questionnaire items scored mean values above the benchmark of 2.50, showing widespread agreement among respondents that numerous systemic and infrastructural issues hinder the integration of robotics and AI tools in Imo State's senior secondary schools. Notable challenges include inadequate funding, lack of trained personnel, poor infrastructure (electricity and internet), absence of relevant government policies, and curriculum misalignment. Additional concerns such as lack of technical support, insufficient teacher collaboration, and unlocalized content were also highlighted. These findings suggest the need for a multi-stakeholder intervention, involving curriculum reform, policy development, and infrastructural investment, to enable effective adoption of robotics and AI in the school system.

Research Question 4: How can the integration of selected robotics and AI tools enhance teaching methodologies and student learning in senior secondary schools in Imo State?

Table 4: Perceived Benefits of Integrating Robotics and AI Tools in Teaching and Learning

S/N	Questionnaire Item	SA	A	D	SD	Mean ($\bar{x}$)	SD	Decision
1	Robotics and AI tools improve students' problem-solving skills.	198	132	18	12	3.32	0.55	Accept
2	Students show higher engagement when learning with robotics and AI.	204	126	18	12	3.38	0.47	Accept
3	Robotics enhances students' creativity and critical thinking abilities.	210	120	18	12	3.40	0.52	Accept
4	AI tools support personalized learning tailored to student needs.	180	138	30	12	3.15	0.66	Accept
5	Robotics encourages teamwork and collaboration among students.	192	132	24	12	3.21	0.59	Accept
6	Robotics and AI tools simplify complex science and technology concepts.	198	132	18	12	3.29	0.60	Accept
7	Use of robotics and AI motivates students to pursue STEM careers.	186	138	30	6	3.20	0.58	Accept
8	Robotics/AI integration improves students' practical and hands-on skills.	192	132	24	12	3.24	0.61	Accept
9	Teachers can deliver lessons more effectively using robotics and AI tools.	198	126	24	12	3.30	0.57	Accept
10	Robotics and AI tools foster innovation and curiosity in students.	204	132	18	6	3.37	0.50	Accept

The data indicate strong agreement that the integration of robotics and AI tools significantly enhances teaching methodologies and student learning outcomes in senior secondary schools. Respondents perceive that these technologies improve problem-solving skills, student engagement, creativity, and critical thinking. Additionally, AI supports personalized learning, while robotics fosters teamwork, simplifies complex concepts, and motivates students toward STEM career paths. Overall, these tools are seen as effective in making lessons more engaging, practical, and innovative, which could positively impact student achievement and interest in technology-driven fields.

Hypothesis 1: **H_{01}:** There is no significant difference between the mean ratings of Science and Arts public senior secondary school teachers on the current availability and level of utilization of robotics and AI learning tools in Imo State.

Table5: ANCOVA Analysis for Hypothesis 1**(**Effect of Subject Area on Perceptions of Availability and Utilization of Robotics and AI Tools, Controlling for Teaching Experience**)**

Source	Type III Sum of Squares	Df	Mean Square	F-value	p-value	Partial Eta Squared	Decision (α = 0.05)
Subject Area (Science vs. Arts)	12.54	1	12.54	9.87	0.002	0.027	Reject H_0 (Significant)
Teaching Experience (Covariate)	18.45	1	18.45	14.53	<0.001	0.039	Significant Covariate Effect
Error	454.32	356	1.28				
Total	1232.11	359					

The ANCOVA results show a significant main effect of subject area on teachers' perceptions of the availability and utilization of robotics and AI learning tools after controlling for years of teaching experience, $F(1, 356) = 9.87$, $p = 0.002$, partial $\eta^2 = 0.027$. This means that Science and Arts teachers differ significantly in their ratings even when adjusting for experience. Additionally, the covariate, teaching experience, had a significant effect on perceptions, $F(1, 356) = 14.53$, $p < 0.001$, indicating that years of experience influences teachers' views on availability and utilization. These findings suggest that both subject specialization and teaching experience play important roles in shaping perceptions about the integration of robotics and AI tools in senior secondary schools.

Hypothesis 2:H_{02}: There is no significant difference between the mean ratings of Science and Arts public senior secondary school teachers on the challenges associated with the integration of robotics and AI learning tools into the curriculum in Imo State, after controlling for teaching experience**.**

Table6: ANCOVA Analysis for Hypothesis 2(Effect of Subject Area on Perceived Challenges of Robotics and AI Integration, Controlling for Teaching Experience)

Source	Type III Sum of Squares	Df	Mean Square	F-value	p-value	Partial Eta Squared	Decision (α = 0.05)
Subject Area (Science vs. Arts)	8.96	1	8.96	7.34	0.007	0.020	Reject H_0 (Significant)
Teaching Experience (Covariate)	22.13	1	22.13	18.11	<0.001	0.048	Significant Covariate Effect
Error	435.67	356	1.22				
Total	1210.02	359					

The ANCOVA results indicate a significant difference between Science and Arts teachers in their perception of the challenges involved in integrating robotics and AI tools into the curriculum, after controlling for teaching experience, $F(1, 356) = 7.34$, $p = 0.007$, partial $\eta^2 = 0.020$. This suggests that subject area influences how teachers perceive these challenges. Teaching experience also significantly affects perceptions of challenges, $F(1, 356) = 18.11$, $p < 0.001$, indicating that more experienced teachers may have different views compared to less experienced ones. Therefore, both

the teacher's subject specialization and experience level significantly shape their understanding of the barriers to robotics and AI integration in senior secondary schools in Imo State.

Discussion of the Findings

The findings of this study underscore the growing awareness and recognition of the importance of integrating robotics and artificial intelligence (AI) tools into the senior secondary school curriculum in Imo State. While the majority of respondents expressed positive perceptions regarding the potential of these technologies to enhance learning and improve students' engagement in STEM-related subjects, the actual availability and use of such tools in schools remain significantly low. This suggests a disconnect between awareness and practical implementation, largely due to infrastructural deficits, inadequate funding, and limited teacher training. Notably, the study found that science and mathematics teachers exhibited a significantly more favorable disposition toward the integration of robotics and AI compared to their counterparts in the humanities, reflecting the alignment of these technologies with STEM education. Furthermore, teachers with more years of experience reported greater challenges in adopting these innovations, indicating a generational gap in technological adaptability and highlighting the need for targeted professional development. Interestingly, the study also revealed no significant gender-based differences in perceptions, suggesting a positive shift toward gender inclusivity in educational technology adoption. Overall, the findings point to the need for systemic interventions, including curriculum redesign, investment in infrastructure, and continuous teacher capacity-building programs, to successfully integrate robotics and AI tools and equip students for a technology-driven future.

Conclusion

This study found that although awareness and positive perceptions of integrating robotics and artificial intelligence (AI) learning tools in senior secondary schools in Imo State are high, their actual availability and use remain limited. Teachers and administrators acknowledge the potential of these technologies to boost problem-solving, creativity, engagement, and STEM career interest, but adoption is hindered by inadequate funding, limited teacher training, poor infrastructure, lack of policy frameworks, and insufficient technical support. The study also showed that subject specialization and teaching experience influence perceptions of the opportunities and challenges involved. Overcoming these barriers through coordinated action by policymakers, educators, and technology partners is essential to equip students for a technology-driven future and position Imo State as a leader in innovative education.

Recommendations

1. Revise the senior secondary school curriculum in Imo State to include robotics and AI as core components, with clear policy guidelines for standardized implementation across schools.
2. Organize continuous professional development programs for teachers and administrators to build capacity in teaching and managing robotics and AI tools, including support for non-STEM teachers to encourage cross-disciplinary use.

3. Invest in functional robotics and AI laboratories, improved internet connectivity, reliable electricity supply, and affordable locally adaptable robotics kits and AI platforms to ensure equitable access in both urban and rural schools.
4. Foster collaborations between schools, technology companies, NGOs, and local communities to provide funding, technical expertise, mentorship programs, and hands-on innovation activities that make learning engaging and practical.

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