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Educational Robots in Teaching and Learning Robotics: Availability, Utilization and Perceived Factors Constraining Implementation and Utilization

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Abstract

This study investigated the availability, utilization, and factors inhibiting the integration of educational robots in teaching and learning robotics in secondary schools in Akwa Ibom State, Nigeria. The descriptive survey research design was adopted, involving a sample size of 200 respondents comprising 50 teachers and 150 students. Data were collected using a structured questionnaire validated by experts in computer education and educational technology, with a reliability coefficient of 0.78 for teachers and 0.81 for students. The questionnaire assessed the availability and extent of utilization of robotics tools, as well as lecturer-based and student-based challenges impeding their integration. Findings revealed that robotics tools were generally limited in availability, with only the Python Tutorial Package (60%) and Temperature Sensors (53.3%) being moderately accessible. Utilization of the tools was also low, with a cluster mean of 1.81, indicating limited incorporation of robotics tools into teaching and learning. Critical lecturer-based barriers included inadequate robotics skills (Mean = 3.78), limited access to robotics tools (Mean = 3.76), and poor funding for capacity building (Mean = 3.52). Student-based factors included poor access to robotics laboratories (Mean = 3.67), difficulty in programming robots (Mean = 3.75), and lack of robotics kits (Mean = 3.59). The study concludes that insufficient access to tools, lack of technical expertise, inadequate training, and motivational challenges significantly hinder the integration of robotics education. It recommends increasing funding for robotics education, establishing well-equipped laboratories, organizing capacity-building programs for teachers, and promoting hands-on robotics activities to engage students. Addressing these barriers will enable secondary schools in Akwa Ibom State to leverage robotics education effectively, equipping students with the critical STEM skills needed for the modern workforce.

Keywords: Educational Robots, Robotics Education, STEM, Secondary Schools, Akwa Ibom State

Introduction

Technologies in every aspect of human existence are propelling world evolution. By keeping up with technology, 21st-century education meets student requirements. From manufacturing to farming, space exploration, and education, technology has affected every aspect of human life. Technology like IoT, Big Data, and Robotics has transformed teaching. Robots can make abstract concepts fun to learn. Computers, smart gadgets, and robots are introduced to students early on. Robots imitate humans to perform tough tasks.

Robots are multi-function manipulators that may be programmed to move materials, equipment, or specialist devices, according to the Robotics Institute of America (2010). The engineering field of robotics studies robots that design, build, operate, and organise themselves in space and time. According to the British Robots Association (2020), software, mechanical, and electronics skills are needed. Singh and Mansotra (2019) say robotics inspires pupils to study engineering and computer science. Robots can do complex tasks autonomously, according to Eguchi (2012). Due to electronics, sensors, actuators, and software, robots may perform tasks independently (Haidegger, 2021). Digital computer technology with articulated chain servo-control make robots computer-controlled (Kumar, 2014). Robots are versatile, multi-purpose manipulators that may be programmed to manipulate materials, components, tools, or specialist equipment using specified movements, according to Iroju, Olaleke, Afolabi, and Idowu (2021). Robots must have sensors to monitor and respond to environmental changes. Even while some robots seem human, most are devices that do jobs and were designed for utility rather than beauty (Benitti, 2012). Robots can be industrial, medical, household, or military, among others. Although robots are already omnipresent, there is still potential for creativity in the classroom. As teachers, tools, or peers, robots help students learn (Carne, 2019). The phrase "educational robot" refers to classroom machines that stimulate learning.

Educational robots handle classroom challenges (Gan, 2004). Khanlari (2015) defines educational robots as digital technology that engages and motivates students and teachers. Educational robots are becoming more popular as innovative learning tools (Eguchi, 2010). Educational robots are developed to aid humans in the classroom (Feil-Seifer & Matarić, 2011).

Through social interaction, assistive robots may learn alongside their human teachers and pupils. Children can program tiny robots, while larger ones are socially developed to interact with students. Educational robots can be virtual or non-virtual, according to Pei and Nie (2018) and Berland and Wilensky (2015). Software robots are virtual robots coded and programmed from robotic source files in a computer simulation environment. Physically present robots are autonomous, intelligent, and can be sensed and touched, enabling more nuanced interaction. Pedagogical tools, intelligent teachers, and collaborative study companions are often physical robots. Educational robots can adapt, digitise, reproduce, humanise, and interact (Chang et al., 2010). Educational robots include Ozobot, Sphero, NAO, OWI 535, Makeblockm Bot, Robo Wunderkind, and VEX Robotics. These robots will provide teachers additional resources and make learning more engaging. Educational robots make classrooms more interactive. It is crucial to learning and remembering. Educational robots create and execute activities that improve student learning, according to Atmatzidou and Demetriadis (2016).

Educational robots promote student engagement and learning through interactive activities, according to Wei, Hung, Lee & Chen (2011), Highfield (2010), and Chen, Quadir & Teng (2011). Educational robots often assist teachers or act as avatars for remote learners. Educational robots may improve student engagement, learning, and academic achievement for teachers. Several educational robots incorporate AI, so they can adapt to student needs in real time. Educational robots make courses more entertaining, promote practical learning, and help students gain marketable skills like problem-solving, coding, and programming. Educational robots help kids learn computational and mathematical thinking via play. Simply said, instructional robots teach problem-solving through a methodical methodology.

Recently, smaller, cheaper robots have made robotics kits affordable for lower-tier educational institutions worldwide. This comprises elementary, pre-primary, and secondary schools. In Nigerian secondary and university computer science curriculum, robotics has become essential (Armstrong, 2020). Many public and private secondary schools in Nigeria offer robotics despite the lack of a defined curriculum. Secondary schools provide varying amounts and types of robotics training (Benyeogor et al., 2021). Schools that emphasise technology and innovation provide robotics courses or extracurriculars. Nigeria is realising the relevance of robotics education as a STEM subject (Nnadi, 2019). Enugu state, Nigeria, has little information on these robotic kits' availability and use.

Demand for education is driving technology users to develop creative ways to help academic institutions achieve their aims. Robotic technology is a major educational answer in the contemporary economy (Ajith & Hemalatha, 2020). Fagbola (2019) stated that robotic technology in secondary schools will improve learning and spark students' interest in computer science. Mehmet and Serhat (2015) noted that robots technology may educate computer programming, electrical, and engineering. Medical schools use digital archives, marketing materials, and robot-assisted learning to teach future doctors how to do difficult procedures precisely. Nigeria University is one. Roido et al. (2012) suggest that educational robots may teach humans life skills like teamwork, creativity, and critical thinking, helping them attain their full potential. In the last decade, researchers and educators have become interested in robotics because it can help kids' cognitive and social development across academic subjects, from elementary to high school (Ayuba & Timayi, 2018). According to Ayuba and Timayi (2018), robots do dull, repetitive work that humans find dangerous or challenging. Also used in car and electrical gadget manufacture. Other robot missions include submarine and interplanetary exploration. We utilise robots because they are cheaper, easier, and often our only alternative. People dread petrol tanks, volcanoes, and Mars, yet robots can explore. Robots are also adept at repeating tasks without fatigue.

One further reason to like robots is that they never get sick, require a break, or whine. Robots can improve education, but little is known about whether Nigerian schools use robotics kits. Benitti (2011) noted that most classroom robot research is descriptive, relying on teachers' efforts. Recent debate has focused on whether robots might boost students' academic performance (Bredenfeld et al., 2010). Few quantitative research have addressed this possibility. Due to the lack of a consistent assessment methodology and indicators, the expected benefits have not been explicitly defined or analysed (Ortiz et al., 2011). Despite positive benefits on education and motivation, studies demonstrate a paucity of rigorous quantitative research. The new robotic paradigm compares the merits and downsides of old schooling. Virtualisation ideas like LEGO Mindstorms, Arduino, and Raspberry Pi have made robotic technology one of the fastest-growing fields of education. Low cost and ease of use make these robots popular (Armstrong, 2020).

Robots must be tested to improve student learning and skill development. Few studies have examined the instructional use of these robotics kits in Nigerian classrooms. Raptopoulou et al. (2021) discovered that robotics technology helped children with developmental problems and attention impairments focus and communicate, while autistic youngsters learnt social skills. STEM and robotics are linked (Eguchi & Uribe, 2017). Researchers predict kids' behavioural, social, cognitive, and intellectual skills to improve (Rahman, 2021). This extends beyond topic knowledge, as in traditional learning. Yu et al. (2024) found that instructional robots work in STEM, linguistic, transdisciplinary, and special education. Yusuf (2012) suggests standardising Nigeria's educational system internationally utilising robots to equip students for today's and tomorrow's information technology occupations. Despite these encouraging results, robots in the classroom, especially in senior levels, nonetheless raise worries. Even though technology is everywhere, the Nigerian education system has yet to properly integrate instructional robots into teaching and learning. The current study surveyed secondary school robotics teachers in Nigeria about their students' access to and use of robotics tools for instruction and the perceived barriers to their widespread adoption to fill gaps in previous research.

Statement of the Problem

The western world has been using the services of physical educational robots as an assistance teaching tool or as co-instructors for the purpose of teaching and learning in their schools. But, there are limited evidence of adopting educational robots in teaching and learning in the Nigerian universities probably because of insufficient funds to purchase the educational robot kits, inadequate skill to manipulate the robotic kits or because of fear of robots taking over the entire teaching position in classroom setting. As a consequence of this, the passive teaching style continued to be the predominant approach utilised in the educational system of Nigeria. It may be deduced from this that the implementation of robots to support or, more accurately, help in the process of teaching and learning has not yet begun. Hence, this study seeks to address this vacuum by performing a complete inquiry on the degree of availability, utilisation of robotics tools in Nigerian schools for teaching and learning and perceived constraints preventing the integration of educational robots in teaching and learning robotics in secondary schools that limit the installation and utilisation of these educational robots in the classroom and for learning purposes.

Research Questions

The following research questions were formulated to guide the research study:

What are the available robotics tools for teaching robotics in secondary schools in Akwa Ibom State?

To what extent is the available robotics tools utilized in teaching robotics in secondary schools in Akwa Ibom State?

What are the teachers-based factors inhibiting the integration of educational robots in teaching Robotics in secondary schools in Akwa Ibom State?

What are the students-based factors inhibiting the integration of educational robots in learning Robotics in secondary schools in Akwa Ibom State?

Methodology

The study adopted a descriptive survey research design to investigate the integration of educational robots in teaching and learning robotics in secondary schools in Akwa Ibom State. This design was chosen because it allows the collection of data from a population to describe the current state of affairs regarding the availability, utilization, and factors inhibiting the use of educational robots. The study's population comprised secondary school teachers and students in Akwa Ibom State. The sample size was 200 respondents, consisting of 50 teachers and 150 students selected from secondary schools in the state.

Data were collected using a structured questionnaire developed by the researchers. The questionnaire was divided into four sections:

1. Demographics: This section captured the respondents' background information.
2. Availability of Robotics Tools: This section included items to evaluate the availability of specific robotics tools in secondary schools.
3. Utilization of Robotics Tools: This section assessed the extent to which robotics tools were utilized for teaching and learning.
4. Factors Inhibiting Robotics Integration: This section addressed both teacher-based and student-based factors hindering the integration of robotics in education.

The instrument utilized a 4-point Likert scale for responses, ranging from Strongly Agree (4) to Strongly Disagree (1). The questionnaire was subjected to face and content validation by three experts in the field of computer education and educational technology. Suggestions and modifications were incorporated to ensure clarity, relevance, and comprehensiveness. The reliability of the instrument was established through a pilot test conducted with 30 respondents outside the study area but with similar characteristics. The Cronbach Alpha reliability coefficient was calculated, yielding values of 0.78 for teachers and 0.81 for students, indicating a high level of reliability. The questionnaires were administered by the researchers and research assistants through personal visits to the selected schools. Respondents were given adequate time to complete the questionnaire, and all questionnaires were retrieved, achieving a 100% response rate. Mean and standard deviation were used to answer the research questions, with a mean score of 2.50 as the decision benchmark for agreement.

Results

What are the available robotics tools for teaching robotics in secondary schools in Akwa Ibom State?

Table 1: Availability of Robotics Technology in Secondary Schools

Robotics Technology	Availability (%)
Python Tutorial Package	60%
Temperature Sensor	53.3%
Lego Mindstorm Education EV3	33.3%
Lego Mindstorm Robotics Tool Kits	26.7%
Arduino Kits	40%
Raspberry Pi	30%
Scratch (Block Programming) Package	46.7%
PIR Motion Sensor	36.7%
Ultrasonic Sensor	43.3%

The analysis of the data reveals limited availability of robotics tools for teaching in secondary schools in Akwa Ibom State. Among the tools assessed, only the Python Tutorial Package (60%) and the Temperature Sensor (53.3%) were identified as available by more than half of the respondents. This suggests that these tools are the most accessible to teachers and students, possibly due to their affordability and ease of integration into existing teaching practices. However, the availability of these tools alone may not sufficiently support comprehensive robotics education, which typically requires a diverse range of equipment.

Other robotics tools, such as Lego Mindstorm Education EV3 (33.3%), Lego Mindstorm Robotics Tool Kits (26.7%), Arduino Kits (40%), Raspberry Pi (30%), Scratch (Block Programming) Package (46.7%), PIR Motion Sensor (36.7%), and Ultrasonic Sensor (43.3%), were reported to have availability rates below 50%. This indicates that the majority of schools in the region lack access to these essential tools, which are critical for providing hands-on experience in robotics education. Overall, the findings highlight significant gaps in the availability of robotics tools in secondary schools in Akwa Ibom State.

To what extent is the available robotics tools utilized in teaching robotics in secondary schools in Akwa Ibom State?

Table 2: Extent of Utilization of Robotics Technology

Robotics Technology	Mean (x)	SD	Extent of Use
Lego Mindstorm Education EV3	1.27	0.69	Low Extent
Arduino Kits	1.83	1.09	Low Extent
Raspberry Pi	1.43	0.94	Low Extent
Scratch (Block Programming) Package	1.63	1.00	Low Extent
Python Tutorial Package	2.27	1.11	Moderate Extent
PIR Motion Sensor	1.97	1.22	Low Extent
Temperature Sensor	2.20	1.19	Moderate Extent
Ultrasonic Sensor	1.87	1.25	Low Extent

Cluster Average: 1.81 ± 0.59 (Low Extent)

The analysis of Table 2 reveals that the utilization of available robotics tools in teaching robotics in secondary schools in Akwa Ibom State is generally low. Among the tools evaluated, only two items—Python Tutorial Package (Mean = 2.27, SD = 1.11) and Temperature Sensor (Mean = 2.20, SD = 1.19)—were utilized to a moderate extent. These tools, being more accessible and familiar, are more likely to be incorporated into teaching practices compared to other tools. The remaining tools, including Lego Mindstorm Education EV3 (Mean = 1.27, SD = 0.69), Arduino Kits (Mean = 1.83, SD = 1.09), Raspberry Pi (Mean = 1.43, SD = 0.94), Scratch (Block Programming) Package (Mean = 1.63, SD = 1.00), PIR Motion Sensor (Mean = 1.97, SD = 1.22), and Ultrasonic Sensor (Mean = 1.87, SD = 1.25), were reported to be utilized to a low extent. This suggests that despite the potential of these tools to enhance hands-on learning and foster practical skills in robotics, they are largely underutilized in secondary schools. The cluster average of 1.81 ± 0.59 further reinforces the finding that the overall extent of utilization of robotics tools is low. These findings indicate that while a few robotics tools are being moderately utilized, most available tools are underused, thereby limiting the effectiveness of robotics education in secondary schools.

What are the teachers-based factors inhibiting the integration of educational robots in teaching Robotics in secondary schools in Akwa Ibom State?

Table 3: Lecturer-Based Factors Inhibiting the Integration of Educational Robots in Teaching Computer Education Courses in Universities

S/N	Item	N	Mean ($\bar{X}$)	SD	Decision
1	Poor attitude (inability to embrace innovation)	50	3.80	0.50	Agree
2	Poor funding for capacity building of lecturers in robotics field	50	3.52	0.82	Agree
3	Limited accessibility of robotics tools by lecturers	50	3.76	0.52	Agree
4	Incompetent robotics skills by lecturers	50	3.78	0.42	Agree
5	Poor attitude to innovation	50	3.76	0.60	Agree

6	Non-possession of robotic kits	50	3.72	0.54	Agree
7	Ill-equipped robotics lab for teaching robotics education	50	3.74	0.54	Agree
8	Lecturers' resistance to change	50	3.60	0.76	Agree
9	Inadequate training on robotics discipline	50	3.48	0.87	Agree
10	Poor funding for procurement and maintenance of innovative robotic kits	50	3.39	0.94	Agree
11	Inability to sponsor lecturers for capacity building on robotics education	50	3.92	0.29	Agree
12	Fear of job displacement by robots	50	3.75	0.58	Agree
Cluster Average			**3.69**	**0.62**	**Agree**

The analysis of Table 3 highlights significant lecturer-based factors that inhibit the integration of educational robots in teaching computer education courses in secondary schools in Akwa Ibom State. All the items evaluated received mean scores above the benchmark of 2.50, indicating consensus among respondents that these factors are critical barriers. The findings reveal that incompetent robotics skills by lecturers (Mean = 3.78) and limited accessibility of robotics tools (Mean = 3.76) are major inhibiting factors. These results suggest that many lecturers lack the necessary technical expertise and practical exposure to utilize educational robots effectively in their teaching. Additionally, poor funding for capacity building of lecturers (Mean = 3.52) and inadequate training on robotics discipline (Mean = 3.48) further exacerbate the problem, limiting opportunities for teachers to acquire the skills required to integrate robotics into their pedagogy.

Other significant barriers include ill-equipped robotics labs (Mean = 3.74) and non-possession of robotic kits (Mean = 3.72), which indicate that even when lecturers are willing to innovate, they face infrastructural and resource constraints. Furthermore, resistance to change (Mean = 3.60) and fear of job displacement by robots (Mean = 3.75) highlight attitudinal challenges, where lecturers may view robotics as a threat rather than a tool to enhance teaching effectiveness.

The cluster mean of 3.69 ± 0.62 reflects a general agreement among respondents that lecturer-based factors significantly hinder the integration of educational robots. The standard deviation values indicate that respondents' opinions were closely aligned, reinforcing the reliability of these findings. In summary, the lecturer-based factors inhibiting the integration of educational robots include a lack of technical skills, insufficient funding, inadequate infrastructure, and resistance to adopting innovative technologies.

What are the students-based factors inhibiting the integration of educational robots in learning Robotics in secondary schools in Akwa Ibom State?

Table 4: Student-Based Factors Inhibiting the Integration of Educational Robots in Learning Computer Education Courses in Universities

S/N	Item	N	Mean ($\bar{X}$)	SD	Decision
13	Non-availability/poorly equipped robotics laboratories	150	3.67	0.58	Agree
14	Programming in robotics is a difficult task for students	150	3.75	0.55	Agree
15	Poor access to robotics tools	150	3.77	0.43	Agree
16	Negative attitude towards robotics as a discipline	150	3.45	0.86	Agree
17	Fear of writing robotics programs/codes	150	3.68	0.58	Agree
18	Non-possession of robotic kits	150	3.59	0.60	Agree
19	Poor access to robotics laboratories for practical purposes	150	3.58	0.73	Agree
20	Nonchalant attitudes towards online self-learning in robotics disciplines	150	3.67	0.64	Agree
21	Programming in robotics is a difficult task for students	150	3.26	0.87	Agree

Cluster Average	**3.60**	**0.65**	**Agree**

The analysis of Table 4 reveals critical student-based factors inhibiting the integration of educational robots in learning robotics in secondary schools in Akwa Ibom State. All the items evaluated have mean scores above the benchmark of 2.50, indicating strong agreement among respondents that these factors pose significant challenges to students' ability to engage with robotics technology effectively. The findings highlight poor access to robotics tools (Mean = 3.77) and non-availability or poorly equipped robotics laboratories (Mean = 3.67) as major barriers. These results suggest that students lack access to the necessary tools and facilities required for hands-on learning in robotics. Without these essential resources, it becomes challenging to develop practical skills and engage with robotics effectively.

In addition, programming in robotics is a difficult task for students (Mean = 3.75) and fear of writing robotics programs/codes (Mean = 3.68) emphasize the technical difficulties faced by students. This suggests that robotics programming, which is a core component of robotics education, presents a significant learning curve for many students, possibly due to inadequate foundational knowledge, limited guidance, or lack of exposure to programming concepts. Another key factor is non-possession of robotic kits (Mean = 3.59), which further compounds the issue of accessibility. Students may not have the opportunity to explore or practice robotics outside the classroom, limiting their understanding and skill development. Additionally, negative attitudes towards robotics as a discipline (Mean = 3.45) and nonchalant attitudes toward online self-learning in robotics (Mean = 3.67) reflect a lack of interest and motivation among students, which can hinder their willingness to explore robotics independently.

The cluster mean of 3.60 ± 0.65 indicates a general consensus among respondents that these factors significantly inhibit students' ability to learn robotics effectively. The standard deviation values show that respondents' opinions were closely aligned, reinforcing the reliability of the results. In summary, the student-based factors inhibiting the integration of educational robots include poor access to robotics tools and laboratories, difficulties with robotics programming, lack of robotic kits, and low motivation to engage with robotics education.

Discussion of findings

The findings reveal that there is limited availability of robotics tools for teaching in secondary schools in Akwa Ibom State, with only the Python Tutorial Package (60%) and the Temperature Sensor (53.3%) available to more than half of the respondents. This indicates that these tools, likely due to their affordability and ease of integration, are the most accessible for teachers and students. However, the availability of just these tools is inadequate to support comprehensive robotics education, which requires a broader range of equipment to provide students with hands-on learning experiences and to develop critical STEM skills.

The limited availability of advanced robotics tools, such as Lego Mindstorm Education EV3 (33.3%), Arduino Kits (40%), and Raspberry Pi (30%), further highlights the significant gap in resources. The low availability of these essential tools indicates that many schools lack the infrastructure necessary to teach robotics effectively. For instance, tools like Scratch (46.7%) and Ultrasonic Sensors (43.3%) are integral to interactive and practical robotics education, but their limited presence suggests that students are deprived of the opportunities to engage in project-based and experiential learning activities.

These findings align with research highlighting that educational robotics, though transformative, is underutilized in Nigerian schools due to inadequate availability of kits (Eguchi, 2010; Armstrong, 2020). Robotics kits such as LEGO Mindstorms and Arduino have been recognized globally as pivotal in promoting hands-on learning (Benitti, 2012). However, their scarcity in Akwa Ibom secondary schools reflects systemic challenges, including funding constraints and limited policy emphasis on integrating robotics into the curriculum.

This situation underscores the need for targeted interventions to bridge the resource gap. Investments in robotics tools, funding for schools, and collaborations with private organizations can enhance resource availability. Without these efforts, the potential of robotics education to develop students' cognitive, programming, and problem-solving skills—identified as critical for the 21st-century workforce—remains untapped.

The analysis of Table 2 highlights a significant challenge in the utilization of robotics tools in teaching robotics in secondary schools in Akwa Ibom State. Despite the presence of some robotics tools, their overall utilization is generally low, with a cluster average of 1.81 ± 0.59. Only two tools—Python Tutorial Package (Mean = 2.27) and Temperature Sensor (Mean = 2.20)—were utilized to a moderate extent, reflecting their relative accessibility and familiarity among teachers.

These tools may align more closely with existing teaching practices and resource availability, making them more feasible for use in classrooms.

The low utilization of other essential tools, such as Lego Mindstorm Education EV3 (Mean = 1.27), Arduino Kits (Mean = 1.83), and Raspberry Pi (Mean = 1.43), suggests significant barriers to hands-on learning and practical skill development. Robotics education thrives on tools that enable experiential learning, as they help students develop critical STEM skills like programming, problem-solving, and creativity (Eguchi, 2010). The underutilization of Scratch (Mean = 1.63) and PIR Motion Sensor (Mean = 1.97) further underscores the missed opportunities to introduce students to interactive and block-based programming, which are foundational for developing computational thinking skills (Benitti, 2012).

The limited utilization of these tools aligns with findings from other studies, which attribute low usage to several factors. For example, Armstrong (2020) highlighted that a lack of teacher training in advanced robotics tools significantly limits their use. Teachers may be unfamiliar with the functionalities of these tools or lack the confidence to integrate them effectively into their teaching practices. Furthermore, insufficient infrastructure, as identified by Fagbola (2019), and inadequate funding for robotics education (Ajith & Hemalatha, 2020) exacerbate the problem, preventing schools from fully harnessing the benefits of these technologies.

Moreover, the underutilization of robotics tools contradicts the growing global emphasis on using robotics to improve STEM education outcomes. Studies by Riedo et al. (2012) and Nnadi (2019) have demonstrated the potential of robotics tools to enhance students' learning experiences by fostering active engagement and teamwork. However, when tools remain underused, students are deprived of these opportunities, limiting their ability to gain practical experience and develop the skills needed for the 21st-century workforce.

These findings call for targeted interventions to increase the utilization of robotics tools in secondary schools. Efforts should focus on professional development for teachers to improve their competencies in using robotics tools, coupled with investments in infrastructure and resources to ensure that these tools are accessible. By addressing these barriers, schools in Akwa Ibom State can maximize the potential of robotics education to transform learning experiences and prepare students for future STEM careers.

The analysis of Table 3 identifies critical lecturer-based factors inhibiting the integration of educational robots in teaching computer education courses in secondary schools in Akwa Ibom State. All the evaluated items recorded mean scores above the threshold of 2.50, indicating widespread agreement among respondents that these challenges are significant. The cluster mean of 3.69 ± 0.62 further validates this consensus, demonstrating the reliability of these findings. One of the most pressing issues is lecturers' lack of robotics skills (Mean = 3.78), which aligns with findings by Eguchi (2010) and Armstrong (2020) that technical expertise is essential for the successful implementation of robotics education. Lecturers' limited exposure to and training in robotics technologies restrict their ability to incorporate these tools into their teaching effectively. Additionally, the issue of limited accessibility to robotics tools (Mean = 3.76) compounds this challenge, as even technically competent lecturers may lack the necessary resources to integrate robotics into the classroom.

Poor funding for capacity building (Mean = 3.52) and inadequate training on robotics (Mean = 3.48) were also identified as major barriers. These findings align with Ajith and Hemalatha (2020), who emphasized the importance of funding for teacher development programs to build capacity in emerging educational technologies. Without targeted investments in training, lecturers cannot acquire the skills necessary to utilize robotics tools, leaving the potential of these technologies largely untapped.

Infrastructural limitations were another significant factor, with respondents highlighting ill-equipped robotics labs (Mean = 3.74) and non-possession of robotic kits (Mean = 3.72). These findings corroborate Riedo et al. (2012), who identified the availability of infrastructure and tools as key enablers of robotics education. Without adequate facilities and kits, teachers are unable to provide students with the hands-on learning experiences that are essential for robotics education.
Resistance to change (Mean = 3.60) and fear of job displacement by robots (Mean = 3.75) highlight attitudinal challenges among lecturers. These findings are consistent with the observations of Fagbola (2019), who noted that educators often perceive emerging technologies as threats rather than tools for enhancing their teaching practices. Such resistance can further delay the integration of robotics education, especially in contexts where technology adoption is already lagging.

Overall, the lecturer-based factors inhibiting the integration of educational robots are multifaceted, encompassing technical, infrastructural, financial, and attitudinal barriers.

Addressing these challenges will require a comprehensive approach, including targeted training programs, increased funding for infrastructure and robotics tools, and awareness campaigns to shift lecturers' perceptions about robotics. By tackling these issues, schools in Akwa Ibom State can create a more conducive environment for integrating educational robots into teaching and learning, ultimately enhancing STEM education outcomes.

The findings from Table 4 highlight several critical student-based factors that hinder the integration of educational robots in learning robotics in secondary schools in Akwa Ibom State. All the evaluated items received mean scores above the 2.50 benchmark, demonstrating broad agreement among respondents that these challenges significantly impede students' engagement with robotics technology. A major barrier is poor access to robotics tools (Mean = 3.77) and non-availability or poorly equipped robotics laboratories (Mean = 3.67). These findings align with the observations of Benitti (2012) and Armstrong (2020), who emphasized that access to resources is fundamental for robotics education. Without adequate tools and facilities, students are deprived of opportunities to engage in hands-on learning, which is critical for developing practical skills in robotics. The lack of access also prevents students from experimenting and solving real-world problems, which robotics education is designed to address.

Programming in robotics is a difficult task for students (Mean = 3.75) and the fear of writing robotics programs/codes (Mean = 3.68) indicate that students face significant technical challenges. These findings are supported by Bliskstein (2013), who identified the complexity of programming as a primary hindrance to students' success in robotics education. The difficulty in understanding programming concepts and applying them to robotics tasks is exacerbated by the lack of foundational knowledge and insufficient teacher guidance.

Another factor, non-possession of robotic kits (Mean = 3.59), further underscores the issue of accessibility. This finding is consistent with Fagbola (2019), who noted that the inability of students to access robotics kits outside the classroom limits their capacity for self-directed learning and skill development. Robotics kits are essential for fostering creativity and innovation, but their absence creates a significant gap in the learning process.

The study also highlights attitudinal challenges, including negative attitudes towards robotics as a discipline (Mean = 3.45) and nonchalant attitudes toward online self-learning in robotics (Mean = 3.67). These findings reflect a lack of interest and motivation among students, which is a recurring theme in the literature. According to Riedo et al. (2012), fostering interest in robotics requires engaging teaching methods and resources that make learning enjoyable and relevant. Without addressing these motivational barriers, students are unlikely to invest time and effort in learning robotics independently. The cluster mean of 3.60 ± 0.65 reflects a general consensus among respondents that these student-based factors significantly hinder the integration of robotics into their education. The closely aligned responses, indicated by the standard deviation values, reinforce the reliability of these findings.

Generally, the student-based factors inhibiting the integration of educational robots include poor access to tools and laboratories, difficulties with programming, lack of kits, and low motivation. Addressing these barriers will require investments in infrastructure, provision of robotics kits, and the development of programs that make robotics education accessible and engaging for students. Targeted interventions, such as incorporating project-based learning and offering introductory programming courses, could help bridge these gaps and empower students to excel in robotics education.

Conclusion

The conclusion of the study emphasizes that the integration of educational robots into teaching and learning in secondary schools in Akwa Ibom State faces significant challenges, both from lecturer-based and student-based factors. These barriers include inadequate access to robotics tools and laboratories, insufficient technical skills among lecturers, limited funding for capacity building, and students' difficulties in programming and lack of motivation to engage with robotics education.

The findings highlight that while some tools, like the Python Tutorial Package and Temperature Sensors, are moderately utilized, the overall availability and use of robotics tools are low. This insufficiency limits the potential of robotics education to enhance STEM learning and skill development in the region. Lecturers' resistance to change and fear of job displacement by robots further exacerbate the problem, while students struggle with negative attitudes toward robotics as a discipline and the absence of practical tools for learning.

Addressing these issues will require comprehensive strategies, including increased funding, professional development for teachers, improved access to robotics resources, and initiatives to foster students' interest and engagement in robotics. By tackling these challenges, secondary schools in Akwa Ibom State can better integrate robotics technology into their curriculum, thereby preparing students for future STEM opportunities and equipping them with the critical skills needed in the modern workforce.

Recommendations

1. Improve Access to Robotics Tools and Laboratories: The government and school management should provide adequate funding for the procurement of robotics tools and the establishment of well-equipped robotics laboratories. Partnerships with private organizations and NGOs should be encouraged to donate robotics kits to schools.
2. Capacity Building for Teachers: Comprehensive and regular training programs should be organized for teachers to enhance their robotics skills and technical expertise. Incentives should be provided for teachers to attend professional development workshops on robotics education.
3. Curriculum Development: Introduce robotics as a distinct subject in the school curriculum to ensure systematic and consistent exposure for students. Develop teaching materials and lesson plans that incorporate robotics tools in alignment with the national education framework.
4. Student Engagement and Motivation: Implement hands-on robotics competitions, workshops, and clubs to stimulate students' interest in robotics. Incorporate beginner-friendly programming platforms like Scratch to reduce the intimidation students feel toward robotics programming.
5. Address Attitudinal Challenges Among Teachers and Students: Conduct awareness campaigns to emphasize the benefits of robotics in education and dispel misconceptions about job displacement. Encourage a positive mindset by showcasing success stories of educators and students excelling in robotics.
6. Increased Funding for Robotics Education: Government agencies should allocate specific funds for robotics education within the education budget. Adhere to the UNESCO recommendation of allocating at least 26% of the national budget to education, with a portion dedicated to STEM innovations like robotics.

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