



Teacher's Perception of Using Robots in Teaching Science Technology Engineering Mathematics Subjects in Secondary School in Nsukka Local Government Area, Enugu State, Nigeria

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Abstract

The purpose of this study was to determine Teacher's Perceptions of Using Robots in Teaching Science, Technology, Engineering and Mathematics Subjects in Secondary Schools in Nsukka Local Government Area, Enugu State, Nigeria. Four specific purposes and four research questions were raised to guide the study. The population for this study is 135 teachers teaching STEM subjects across the schools which include Physics, Chemistry, Biology, Mathematics, Computer Studies, Basic Science and Basic Technology. A total sampling technique was used to select a sample of 135, however only 120 respondents successfully completed and returned the questionnaire. The reliability coefficient obtained using Cronbach's Alpha method was 0.94. Mean and Standard Deviation were used for data analysis. The result shows a widespread recognition among teachers of the transformative potential of robotics in enhancing student engagement and skill development across STEM subjects. However, challenges such as limited resources and inadequate training opportunities were identified as barriers to effective integration. These results underscore the importance of establishing comprehensive support systems and policies to address these challenges, highlighting the need for ongoing professional development programs, investment in infrastructure and resources, and fostering partnerships with industry and community organisations to facilitate the seamless integration of robotics into STEM education in Nsukka Local Government Area.

Keywords: Robots; Teaching; STEM; Secondary Schools; Nsukka

Introduction

Education plays a pivotal role in shaping individuals' knowledge, skills, and competencies, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM). With the rapid advancement of technology, there is a growing recognition of the importance of integrating innovative tools and resources into educational practices to enhance learning outcomes. One such innovation is the use of robots in teaching and learning processes. Robots, characterised by their ability to perform tasks autonomously or semi-autonomously, have emerged as promising educational tools capable of engaging students in interactive and experiential learning experiences (Liu et al., 2024). Incorporating robots into educational settings offers unique opportunities to foster creativity, critical thinking, problem-solving skills, and student collaboration (Antunes et al., 2023). Moreover, robots can serve as effective teaching aids in delivering complex concepts, particularly in STEM

subjects, by providing real-world applications and simulations (Ubando et al., 2024).

The literature on using robotics in STEM education highlights their transformative potential in fostering student engagement, critical thinking, and problem-solving skills through hands-on, interdisciplinary learning experiences (Singh & Sandu, 2024). Initially conceptualised as industrial tools, robots have evolved into dynamic educational resources, enhancing STEM instruction by bridging theoretical concepts with practical applications (Darmawansah et al., 2023). Robots in education align with constructivist pedagogy principles, emphasising active engagement, hands-on learning, and student-centred approaches (Golightly et al., 2023). By interacting with robots, students gain practical experience in applying STEM principles in real-world scenarios, catering to diverse learning styles and promoting inclusive and equitable learning environments. Research in educational robotics has demonstrated the efficacy of using robots as

educational tools across various educational levels, from primary schools to higher education institutions. Studies have shown that students exhibit increased motivation, engagement, and learning retention when exposed to robot-assisted instruction (Ao & Yu, 2022; De Haas et al., 2020). For instance, Tlili et al. (2020) found that students participating in robot-mediated learning activities showed significantly improved understanding of mathematical concepts compared to traditional instruction methods.

Furthermore, programmable robots enable students to learn computer programming languages such as Scratch, Python, or Blockly interactively, developing computational thinking skills and gaining insights into algorithmic logic and problem-solving strategies (Evripidou et al., 2020; Fanchamps et al., 2024). Robots equipped with sensors, actuators, and artificial intelligence capabilities can adapt their behaviour based on environmental stimuli or user interactions, allowing for personalised learning experiences tailored to individual students' needs and preferences. Additionally, robots facilitate collaborative learning activities, where students work together to program, control, or troubleshoot robotic systems, fostering teamwork and communication skills (Jawaid et al., 2020).

Despite the potential benefits, several challenges have been identified which hinder the effective integration of robots into teaching and learning processes. These challenges include technical issues such as the cost of acquisition, maintenance, and programming expertise required to operate robots, which may pose barriers to widespread adoption, particularly in resource-constrained educational settings (Bademosi & Issa, 2021; Flechsig et al., 2022). Moreover, concerns regarding data privacy, cybersecurity, and ethical considerations in robot-human interactions need to be carefully addressed to safeguard students' well-being and privacy (Neupane et al., 2024).

In the context of Enugu State, Nigeria, Nsukka emerges as a significant locality with its unique cultural, social, and educational landscape. As the home of the University of Nigeria, Nsukka boasts a rich intellectual heritage and serves as a hub for academic activities in the region. Secondary schools in Nsukka play a pivotal role in shaping the educational experiences and opportunities available to students, particularly in STEM education. However, despite the importance of STEM disciplines, secondary schools in Nsukka face challenges in delivering quality education, including limited resources, infrastructure deficiencies, and teacher shortages (Ugwu et al., 2021). These challenges underscore the need for innovative

approaches and interventions to enhance STEM education outcomes and ensure that students in Nsukka are equipped with the necessary knowledge and skills for success in an increasingly technology-driven world.

Incorporating robots into STEM education in Nsukka holds immense potential for enhancing teaching and learning experiences in secondary schools. Educational robots offer many benefits, including promoting active engagement, fostering critical thinking skills, and providing hands-on learning opportunities. By interacting with robots, students can explore complex STEM concepts in tangible and interactive ways, thereby deepening their understanding and retention of subject matter (Alam & Mohanty, 2024; Hu et al., 2024). However, technical issues, such as the cost of acquiring and maintaining robotic hardware and software, as well as the need for technical support and expertise, may pose barriers to widespread adoption in resource-constrained educational settings (Bademosi & Issa, 2021; Flechsig et al., 2022). Moreover, concerns related to curriculum alignment, teacher training, and pedagogical approaches may arise when incorporating robots into existing educational practices (Tang et al., 2023). Yet, little is known about teachers' perceptions of this emerging technology in teaching. Their perception may significantly impact teaching and students' learning of STEM subjects.

Grounded in Papert's Constructionism, robotics education emphasises active participation, enabling students to apply science, technology, engineering, and mathematics concepts in real-world contexts while promoting teamwork, creativity, and innovation (Papert, 1980; 1993). However, integrating robotics into classrooms faces significant challenges, including inadequate resources, insufficient teacher training, and limited institutional support, which hinder equitable access and effective implementation (Heyns, 2023). Cultural perceptions further shape the acceptance of robotics in education, underscoring the need for context-specific strategies. While existing studies document robotics' cognitive and motivational benefits, research focusing on teachers' perceptions remains underexplored, particularly in specific cultural and socio-economic contexts.

Therefore, this study addresses this gap by examining secondary school teachers' perceptions of robotics in teaching STEM subjects in Nsukka Local Government Area, Enugu State, Nigeria, providing insights into the practical and contextual factors influencing their adoption. Specifically, it seeks to determine teachers' perceived roles of robots in STEM education, factors shaping teachers'

perceptions, perceived benefits, and perceived challenges faced by teachers in incorporating robots into their teaching practices.

Methodology

Design of the Study

This study adopted a descriptive survey design to investigate teachers' perceptions of integrating robotics into STEM education within secondary schools in Nsukka, Enugu State. This approach is chosen to capture the complex nature of these perceptions, allowing for quantitative analysis of the data collected. The population under study comprises 135 private secondary school teachers in Nsukka engaged in teaching STEM subjects, including Mathematics, Physics, Chemistry, Biology, Basic Science, Basic Technology, and Computer Science. A total sampling technique was utilised due to the manageable size of the population, ensuring comprehensive representation. A 29-item structured questionnaire titled "Teachers' Perceived Role of Robotics in STEM Education Questionnaire

(TPROSEQ)", developed by the researchers was used for data collection. The questionnaire includes personal biodata in Section A and four clusters in Section B addressing specific research questions: the perceived role of robotics, factors influencing perceptions, perceived challenges, and benefits of using robotics in STEM education. Responses are recorded on a 4-point rating scale, facilitating systematic data collection and analysis.

The reliability of TPROSEQ was determined using the Cronbach Alpha method, yielding high internal consistency across four clusters with an overall reliability index of 0.94. The researcher administered the instrument with the help of four research assistants. However, only 120 teachers successfully completed and returned the questionnaires. The collected data was analysed using mean scores and standard deviations. Items scoring a mean of 2.50 and above on the rating scale are considered Agreed. At the same time, those below 2.50 are classified as Disagreed, providing clear insights into teachers' perceptions of robotics integration in STEM education.

Results

Research Question 1

What are teachers' perceived roles of robotics in STEM education in the Nsukka Local Government Area?

Table 1: Mean Ratings and Standard Deviation of the Response of Teachers on their Perceived Role of Robotics in STEM Education

S/N	Items Statement	N	\bar{x}	SD	Decision
1	Robotics enhances students' interest and engagement in STEM subjects.	120	3.82	0.44	Agreed
2	Using robotics in education helps to improve students' problem-solving skills.	120	3.52	0.55	Agreed
3	Robotics integration into the curriculum makes STEM subjects more applicable to real-life situations.	120	3.50	0.55	Agreed
4	The use of robotics in teaching STEM subjects significantly improves students' academic performance.	120	3.34	0.63	Agreed
5	Robotics can effectively bridge the theory-practice gap in STEM education.	120	3.42	0.61	Agreed
Cluster A Mean		120	3.52	0.27	Agreed

Source: Researcher's Fieldwork (2024)

Key: N = Number of respondents, \bar{x} = Mean, SD = Standard Deviation, $\bar{x} \geq 2.50$ = Agreed, $\bar{x} < 2.50$ = Disagreed.

Results in Table 1 show that all the items on teachers' perceived role of Robotics in STEM education had their mean ratings above 2.5, meaning they agreed to all the item statements. With an average cluster mean of 3.52 and a standard deviation

of 0.27, teachers consistently agree on the positive impact of robotics on student engagement, problem-solving skills, real-life applicability of STEM subjects, academic performance, and bridging the theory-practice gap.

Research Question 2

What are Teacher’s Perceived factors that influence the use of Robots in STEM Education?

Table 2: Mean Ratings and Standard Deviation of the Response of Teachers on Perceived Factors that Influence the Use of Robots in STEM Education

S/N	Items Statement	N	\bar{x}	SD	Decision
6	I believe that my level of technical expertise with robotics influences my perception of its value in education.	120	3.54	0.68	Agreed
7	Access to ongoing professional development affects my ability to use robotics in teaching.	120	3.32	0.69	Agreed
8	The availability of resources and infrastructure for robotics plays a crucial role in my perception of its integration into STEM education.	120	3.48	0.62	Agreed
9	Student enthusiasm and engagement with robotics impact my perception of its importance in STEM education.	120	3.36	0.60	Agreed
10	The perceived relevance of robotics to the local job market and future career opportunities for students influences my view on its importance in education.	120	3.26	0.64	Agreed
11	Experiences shared by other educators within or outside Nsukka LGA impact my perception of robotics in STEM education.	120	3.26	0.67	Agreed
12	I believe that the overall cost and maintenance of robotics equipment influence my perception of its feasibility for classroom integration.	120	3.32	0.66	Agreed
13	Cultural attitudes towards science and technology in Nsukka LGA influence my perceptions and attitudes towards robotics in education.	120	3.16	0.89	Agreed
Cluster B Mean		120	3.33	0.32	Agreed

Source: Researcher’s Fieldwork (2024)

Key: N = Number of respondents, \bar{x} = Mean, SD = Standard Deviation, $\bar{x} \geq 2.50$ = Agreed, $\bar{x} < 2.50$ = Disagreed.

Results from Table 2 show that all the item statements were perceived as factors that influence the use of Robotics for STEM Education by teachers in the Nsukka Local Government Area, with their mean ratings all above 2.5. An overall cluster mean of 3.33 and a standard deviation of 0.32, indicating general agreement among respondents. The teaches

agreed that their level of technical expertise with robotics affects their perception of its educational value (mean=3.54, SD=0.68). Access to ongoing professional development (mean=3.32, SD=0.69) and the availability of resources and infrastructure (mean=3.48, SD=0.62) were all agreed upon as important factors.

Research Question 3

What are Teachers’ Perceived benefits of using robotics in STEM education in Nsukka Local Government Area?

Table 3: Mean Ratings and Standard Deviation of the Response of Teachers on Perceived Benefit of Using Robotics in STEM Education

S/N	Items Statement	N	\bar{x}	SD	Decision
14	Robotics makes STEM subjects more engaging and interesting for students.	120	3.72	0.58	Agreed
15	Using robotics in teaching helps to develop critical thinking and problem-solving skills in students.	120	3.56	0.58	Agreed
16	Robotics integration encourages students to pursue STEM careers.	120	3.36	0.60	Agreed
17	Robotics teaching tools facilitate hands-on learning and practical application of theoretical concepts.	120	3.42	0.58	Agreed
18	Incorporating robotics into the curriculum improves students' technological literacy.	120	3.52	0.58	Agreed

19	Robotics as a teaching tool is effective for accommodating diverse learning styles and abilities.	120	3.44	0.62	Agreed
20	Using robotics in the classroom increases student attendance and participation in STEM subjects.	120	3.40	0.64	Agreed
21	Robotics education promotes creativity and innovation among students.	120	3.64	0.53	Agreed
Cluster C Mean		120	3.51	0.28	Agreed

Source: Researcher's Fieldwork (2024)

Key: N = Number of respondents, \bar{x} = Mean, SD = Standard Deviation, $\bar{x} \geq 2.50$ = Agreed, $\bar{x} < 2.50$ = Disagreed.

Results in Table 3 show that STEM teachers in Nsukka Local Government Area perceived the use of robotics in STEM education as beneficial since all the items had their mean ratings above the criterion mean of 2.5. Teachers agree that robotics makes STEM subjects more engaging (mean=3.72, SD=0.58) and develops critical thinking skills (mean=3.56, SD=0.58). They also believe robotics

encourages STEM career pursuit (mean=3.36, SD=0.60), facilitates hands-on learning (mean=3.42, SD=0.58), improves technological literacy (mean=3.52, SD=0.58), accommodates diverse learning styles (mean=3.44, SD=0.62), increases participation (mean=3.40, SD=0.64), and promotes creativity (mean=3.64, SD=0.53).

Research Question 4

What are the perceived challenges faced by teachers in incorporating robotics into their teaching practices in Nsukka Local Government Area?

Table 4: Mean Ratings and Standard Deviation of Teachers on Perceived Challenges of Using Robotics in STEM Education

S/N	Items Statement	N	\bar{x}	SD	Decision
22	There is insufficient access to robotics kits and tools for classroom use.	120	3.64	0.53	Agreed
23	Lack of adequate training and professional development opportunities makes it difficult to integrate robotics in teaching.	120	3.48	0.65	Agreed
24	The current curriculum does not provide enough flexibility to include robotics in a meaningful way.	120	3.38	0.70	Agreed
25	There is a significant challenge in aligning robotics activities with the learning objectives of STEM subjects.	120	3.14	0.93	Agreed
26	The school's infrastructure (e.g., internet access, space) is not conducive to implementing robotics education.	120	3.40	0.76	Agreed
27	There is a lack of administrative and community support for integrating robotics into the curriculum.	120	3.20	0.70	Agreed
28	It is challenging to assess students' learning outcomes from robotics activities in line with standardised tests and assessments.	120	3.28	0.76	Agreed
29	Concerns about the rapid pace of technological change make it difficult to choose which robotics concepts and skills should be taught.	120	3.18	0.80	Agreed
Cluster D Mean		120	3.34	0.42	Agreed

Source: Researcher's Fieldwork (2024)

Key: N = Number of respondents, \bar{x} = Mean, SD = Standard Deviation, $\bar{x} \geq 2.50$ = Agreed, $\bar{x} < 2.50$ = Disagreed.

Table 4 presents the perceived challenges faced by teachers in incorporating robotics into STEM education in Nsukka Local Government Area.

The result shows that Nsukka Local Government Area teachers face notable challenges in incorporating robotics into their teaching. These

include insufficient access to robotics kits (mean=3.64, SD=0.53) and inadequate training opportunities (mean=3.48, SD=0.65). Additionally, the current curriculum's lack of flexibility (mean=3.38, SD=0.70), difficulties in aligning robotics with learning objectives (mean=3.14, SD=0.93), and inadequate school infrastructure (mean=3.40, SD=0.76) are major barriers. Furthermore, a lack of support from administration and the community (mean=3.20, SD=0.70), challenges in assessing student outcomes (mean=3.28, SD=0.76), and concerns about technological changes (mean=3.18, SD=0.80) also hinder effective integration.

Discussion of Findings

Findings from research question one show that secondary school teachers in Nsukka Local Government Area perceive robotics as a transformative tool in STEM education, emphasising its ability to enhance student interest, engagement, and proficiency across science, technology, engineering, and mathematics subjects. This aligns with prior research emphasising robotics' potential to revolutionise teaching methodologies through hands-on, interactive learning experiences that stimulate student curiosity and motivation (Ao & Yu, 2022; De Haas et al., 2020; Golightly et al., 2023). The study also identifies technical proficiency, access to resources, professional development opportunities, and alignment with local job markets as critical factors influencing teachers' adoption of robotics in education. These findings underscore the complex interplay of factors shaping teachers' perceptions and practices regarding robotics integration into STEM curricula, highlighting the need for supportive infrastructures and ongoing professional development to facilitate effective technology adoption. Moreover, teachers overwhelmingly recognised robotics's educational benefits in cultivating students' critical thinking skills, problem-solving abilities, technological literacy, and creativity. This result agrees with Singh and Sandu (2024), Evripidou et al. (2020), and Fanchamps et al. (2024), who showed that using Robotics in STEM education has the benefits of developing students' critical thinking abilities, computational thinking and problem-solving abilities. However, the study also reveals significant challenges such as limited access to resources, inadequate training opportunities, curriculum constraints, assessment difficulties, and concerns about technological advancements, which agrees with (Bademosi & Issa, 2021; Flechsig et al., 2022; Neupane et al., 2024).

These findings suggest that secondary school teachers in Nsukka Local Government Area perceive robotics as a valuable educational tool because it enhances student engagement, fosters critical thinking, and improves proficiency in STEM subjects. This positive perception likely stems from robotics's interactive and practical nature, which aligns with pedagogical approaches that emphasise experiential and problem-based learning. However, the challenges identified, such as limited resources, insufficient training, and curriculum constraints, reflect systemic barriers common in under-resourced educational contexts. These findings highlight the dual reality of robotics integration. While teachers recognise its potential to revolutionise STEM education and prepare students for technology-driven futures, the lack of adequate support systems hampers its full adoption.

Conclusion and Recommendations

Integrating robotics in STEM education is a transformative approach with significant implications and challenges. This study reveals that secondary school teachers recognise robotics as pivotal for enhancing students' engagement and proficiency in science, technology, engineering, and mathematics. Despite its potential benefits, educators face obstacles such as limited resources, inadequate training opportunities, and curriculum constraints. Therefore, strategic investments in technology and infrastructure are recommended to support equitable access to robotics education. Continuous professional development for teachers is crucial to enhance their technical proficiency and pedagogical skills. Partnerships with industry and community stakeholders can further enrich educational experiences through real-world applications and mentorship programs. Addressing these recommendations can maximise the impact of robotics in preparing students for the digital age.

Future Research Direction

Longitudinal studies should be carried out to assess the sustained impact of robotics on student outcomes over time. Also, comparative studies exploring different instructional strategies for integrating robotics into STEM curricula should be conducted, examining approaches such as project-based learning or inquiry-based methods. Investigating the role of parental and community involvement in supporting robotics initiatives could also provide insights into enhancing engagement and overcoming barriers.

Compliance with Ethical Standard

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Ethical Approval: This study was conducted under the declaration of Helsinki. Hence, all ethical considerations were strictly complied with.

Statement of Informed Concern: Informed consent was obtained from participants before conducting this study.

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