

EFFECT OF HUMANOID ROBOT-ASSISTED INSTRUCTION ON CLASSROOM ENGAGEMENT AND LEARNING MOTIVATION AMONG UPPER BASIC SCHOOL LEARNERS IN NIGERIA

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Abstract

This study examined the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among Upper Basic school learners in Cross River State, Nigeria. A quasi-experimental, non-equivalent control group design was adopted. The study involved 120 Upper Basic learners from four public schools, with 60 learners assigned to the humanoid robot-assisted instruction group and 60 to the conventional instruction group. The intervention was implemented over six weeks, while classroom engagement and learning motivation were measured before and after the intervention. Data were analysed using descriptive statistics and Analysis of Covariance (ANCOVA), with pre-test scores controlled at the 0.05 level of significance. For classroom engagement, the ANCOVA revealed a statistically significant effect of instructional group, $F(1, 117) = 19.62$, $p < .001$, partial $\eta^2 = 0.144$. The adjusted post-test Mean for the humanoid robot-assisted instruction group was 78.46 (SE = 1.20), compared with 69.17 (SE = 1.19) for the conventional instruction group, representing an adjusted mean difference of 9.29 points. For learning motivation, the effect of instructional group was also statistically significant, $F(1, 117) = 22.14$, $p < .001$, partial $\eta^2 = 0.159$. The adjusted post-test mean was 76.83 (SE = 1.16) for the humanoid robot-assisted instruction group and 67.21 (SE = 1.15) for the conventional instruction group, yielding an adjusted mean difference of 9.62 points. These findings indicate that, after controlling for pre-test scores, learners who received humanoid robot-assisted instruction had higher adjusted post-test scores for both classroom engagement and learning motivation than those who received conventional instruction. The findings provide context-specific evidence on the potential of purposefully integrated humanoid robot-assisted instruction as a complementary instructional approach in Nigerian Upper Basic classrooms.

Keywords: humanoid robot-assisted instruction, classroom engagement, learning motivation, Upper Basic learners, educational robotics, Nigeria

1. Introduction

The 21st century has witnessed unprecedented technological developments that have redefined how teaching and learning occur in formal educational contexts. Emerging technologies such as augmented reality, artificial intelligence (AI), machine learning, and robotics are transforming how learners interact with instructional content, peers, and teachers (Rossi et al, 2024). Among these innovations, humanoid robots - robots

designed to resemble humans in physical structure, communication style, or behavioural interaction—have attracted increasing attention in education (Belpaeme et al., 2018). Unlike traditional educational technologies such as computers and smart boards, which primarily support multimedia presentation, humanoid robots introduce social, physical, and interactive dimensions into the learning environment, thereby extending learners' experiences beyond conventional screen-based instruction (Wang et al, 2023).

Humanoid robots are designed to speak, gesture, maintain eye contact, respond to learner questions, and exhibit human-like social presence (Tanaka & Matsuzoe, 2012). Unlike static and impersonal digital platforms, humanoid robots can initiate and sustain dialogue, respond to learners' emotional cues, and provide real-time feedback (Belpaeme et al., 2018). These capabilities make humanoid robots particularly relevant to basic education, where learners' curiosity, developing attention spans, and need for active participation require interactive and engaging pedagogical approaches (Shiomi et al, 2015). The ability of humanoid robots to use gestures, dramatize concepts, and sustain learner attention positions them as a promising instructional technology for enhancing classroom engagement and learning motivation.

Classroom engagement is an important component of effective learning because it reflects the extent to which learners participate behaviourally, cognitively, and emotionally in instructional activities. Behavioural engagement involves learners' attention, participation, persistence, and involvement in classroom activities, while cognitive engagement concerns the mental effort learners invest in understanding concepts, solving problems, and completing learning tasks (Edward et al, 2016). Emotional engagement relates to learners' interest, enjoyment, attitudes, and feelings towards learning. Humanoid robot-assisted instruction has the potential to influence these dimensions by creating interactive learning experiences in which learners can communicate with an instructional agent, receive immediate responses, and participate in activities that incorporate speech, movement, gestures, and social interaction (van den Berghe et al, 2019). Such features may make classroom activities more stimulating and encourage learners to participate more actively in the learning process.

The potential of humanoid robots is particularly relevant to learning motivation. Motivation influences learners' willingness to initiate, sustain, and invest effort in learning activities. Conventional instructional environments that provide limited opportunities for interaction may not sufficiently stimulate learners' curiosity or maintain their interest over extended periods. In contrast, an interactive humanoid robot can introduce novelty and social presence into the classroom, potentially increasing learners' willingness to participate in instructional activities. Current research suggests that interactive technologies can support behavioural, cognitive, and emotional dimensions of learning engagement by sustaining attention, encouraging active involvement in learning tasks, and promoting positive attitudes towards classroom activities (Fredrick et al., 2004). Consequently, humanoid robot-assisted instruction may provide an alternative approach to strengthening both classroom engagement and learning motivation.

Despite these technological possibilities, the Nigerian basic education system continues to face instructional challenges that can constrain classroom engagement and learners' motivation. Public schools in many contexts experience high pupil-teacher ratios, limiting teachers' ability to provide individualized attention and sustain active learner participation. These challenges are compounded by shortages of appropriate instructional teaching aids, teacher burnout, and limited application of learner-centred pedagogical approaches. In addition, uninspiring classroom environments may reduce learners' interest and motivation to participate actively in learning activities (Davison et al, 2020; UNESCO, 2023). Where classrooms contain large numbers of learners and instructional resources are inadequate, meaningful interaction, individualized feedback, and continuous monitoring of learner participation become difficult to achieve.

The situation is further complicated by the limited availability of stimulating and innovative instructional technologies in many basic schools. The scarcity of interactive learning tools can result in continued reliance on verbal explanations, textbooks, and chalkboard demonstrations, which may not always provide the level of interaction and stimulation required to sustain learners' attention and motivation. Consequently, some learners may exhibit reduced classroom participation, declining interest in learning activities, and limited enthusiasm towards instruction. These challenges highlight the need to examine innovative pedagogical approaches that can provide more interactive, engaging, and learner-centred classroom experiences.

Although technological advancements in digital learning, artificial intelligence, and educational robotics have created new possibilities for active and interactive learning, their application within the Nigerian basic education context remains limited. Humanoid robots, in particular, have attracted research attention in educational settings because of their capacity to combine instructional content with social interaction and physical presence. However, evidence concerning their effectiveness cannot simply be transferred from educational contexts in Europe, Asia, or other regions to Nigerian basic schools without empirical investigation. Differences in classroom conditions, teacher preparedness, infrastructure, cultural expectations, curriculum requirements, and learners' experiences with educational technologies may influence how such an intervention is received and how effective it becomes.

The limited empirical evidence on humanoid robot-assisted instruction in Nigerian basic education therefore creates an important research gap. While the interactive characteristics of humanoid robots suggest that they may enhance learners' participation and motivation, there is insufficient context-specific evidence

establishing whether their use can produce measurable improvements in classroom engagement and learning motivation among basic education learners in Nigeria. The problem is consequently not merely the availability of educational technology, but the absence of adequate empirical evidence to determine whether humanoid robot-assisted instruction provides a meaningful pedagogical advantage within the Nigerian basic school context. Addressing this gap requires an empirical examination of the effect of humanoid robot-assisted instruction on learners' classroom engagement and learning motivation. It is against this background that the present study investigates the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among upper basic school learners in Nigeria.

Purpose of the Study

The purpose of this study was to examine the effect of humanoid robots on classroom engagement and learning motivation among upper basic school learners in Nigeria.

The study specifically aimed to:

1. Determine the difference in classroom engagement between pupils taught with humanoid robots and those taught through traditional teacher-led instruction among basic school learners in Nigeria.
2. Examine the difference in learning motivation between pupils exposed to humanoid robot-assisted lessons and those taught using conventional instructional methods among upper basic school learners in Nigeria.

Research Questions

1. What is the difference in classroom engagement between pupils taught with humanoid robots and those taught using the traditional teacher-led method?
2. What is the difference in learning motivation between pupils exposed to humanoid robots and those receiving traditional instruction?

Hypotheses

H₁: Pupils taught using humanoid robot-assisted instruction will have significantly higher classroom

engagement than those taught using traditional instructional methods.

H₂: Pupils taught using humanoid robot-assisted instruction will have significantly higher learning motivation than those taught using traditional instructional methods.

2. Literature Review

Conceptual Framework

Humanoid Robot-Assisted Instruction

The rapid development of artificial intelligence, robotics and interactive digital technologies has created new possibilities for teaching and learning. Among these technologies, humanoid robots have attracted increasing attention because of their ability to combine physical embodiment, verbal communication and socially responsive interaction within instructional settings (Belpaeme et al., 2018). Unlike conventional instructional technologies such as computers, projectors and tablets, humanoid robots can communicate through speech, gestures and other forms of human-like interaction. These characteristics allow them to function not merely as devices for presenting instructional content but as interactive instructional agents that can engage learners during learning activities. Humanoid robot-assisted instruction refers to the use of humanoid robots as instructional agents to support the presentation of learning content, interaction with learners, provision of feedback and facilitation of learning activities. The instructional role of the robot may include asking and answering questions, providing explanations, demonstrating concepts, giving feedback and encouraging learners to participate in classroom activities. The social and interactive characteristics of humanoid robots are particularly relevant to basic education because learners at this level may benefit from learning environments that stimulate curiosity, attention and active participation.

The potential educational value of humanoid robots lies largely in their capacity to create interactive and socially responsive learning

experiences. Robots can communicate with learners, respond to their actions and provide repeated instructional support. Such interaction may make learning activities more engaging than approaches that depend predominantly on teacher explanation, textbooks and conventional classroom demonstrations. Wang et al. (2023), for example, reported that robotic interaction and personalised feedback could support learners' persistence during learning tasks. Similarly, Belpaeme et al. (2018) identified the social and interactive characteristics of educational robots as important features that can support learner interaction and participation. However, the educational effectiveness of humanoid robots should not be assumed solely from their technological sophistication. Their effectiveness may depend on how they are integrated into the curriculum, the nature of the instructional activities, teachers' competence in using the technology, available infrastructure and learners' familiarity with technology. Consequently, humanoid robots should be understood as instructional support tools whose educational value depends on appropriate pedagogical integration rather than as replacements for teachers.

Classroom Engagement

Classroom engagement refers to the extent to which learners actively, cognitively and emotionally participate in learning activities. It encompasses behavioural engagement, cognitive engagement and emotional engagement. Behavioural engagement is reflected in learners' attention, participation, effort and persistence during classroom activities. Cognitive engagement involves the mental effort learners invest in understanding concepts, solving problems and completing learning tasks. Emotional engagement concerns learners' interest, enjoyment, positive attitudes and sense of involvement in the learning environment (Fredrick et al., 2004). Classroom engagement is important because learners who are actively involved in classroom activities are more likely to devote attention

and effort to learning tasks. Conversely, limited participation, distraction and negative attitudes towards classroom activities may reduce opportunities for meaningful learning. The instructional environment therefore plays an important role in shaping the extent to which learners participate actively in classroom activities. The interactive characteristics of humanoid robots suggest a potential relationship between robot-assisted instruction and classroom engagement. Robots can attract learners' attention through speech, movement, gestures and interactive responses, while their ability to respond to learners can create opportunities for active participation. Evidence from educational settings supports this possibility. Belpaeme et al. (2018) reported increased attentiveness and participation during robot-assisted learning activities, while Barry (2026) found that learners were willing to interact with humanoid robots by volunteering responses and seeking clarification. Similarly, studies involving robot-assisted classroom activities have reported positive behavioural responses, including verbal interaction and task participation (Woo et al, 2021). Evidence also suggests that humanoid robots may be particularly useful in supporting learners who experience social difficulties during conventional classroom interaction. Baxter et al, (2017) reported increased willingness to communicate among learners with learning difficulties when interacting with humanoid robots, while Ahmad et al (2019) found that robotic interaction could encourage participation among shy or less socially confident learners. Although these findings are promising, they were obtained in contexts that differ from Nigerian basic schools. The extent to which similar effects occur among Nigerian upper basic school learners therefore requires empirical investigation.

Learning Motivation

Learning motivation refers to the processes that initiate, direct and sustain learners' willingness to participate in learning

activities and pursue learning goals. Motivation influences learners' interest, effort, persistence and willingness to overcome difficulties encountered during learning. In the classroom, motivated learners are more likely to participate actively, devote effort to learning tasks and persist when they encounter challenges. The nature of the instructional environment can influence learners' motivation. Instruction that provides opportunities for interaction, feedback, encouragement and active participation may stimulate learners' interest and willingness to engage in learning activities. Humanoid robots possess several characteristics that may support such an environment. Their ability to communicate, provide feedback, repeat explanations and respond to learners can create an interactive experience that differs from conventional teacher-centred instruction. Empirical evidence provides some support for this relationship. Van Straten (2020) reported higher intrinsic motivation among learners who interacted with robots, while Wang et al. (2023) found that robotic feedback and encouragement could support learners' persistence during learning tasks. These findings suggest that the interactive and responsive characteristics of humanoid robots may contribute to learners' interest and willingness to continue participating in learning activities. The relationship between humanoid robot-assisted instruction and motivation can also be considered in terms of learners' emotional experiences. Learners may perceive an interactive robot as an approachable instructional partner, potentially reducing some of the anxiety associated with answering questions or making mistakes in front of peers. This possibility is consistent with findings that learners may demonstrate greater willingness to communicate and participate when interacting with robots (Baxter et al, 2017; Barry et al, 2026). Nevertheless, such effects may vary according to learners' age, prior technological experience, classroom conditions and cultural context. There is

therefore a need to establish whether humanoid robot-assisted instruction can significantly enhance learning motivation among upper basic school learners in Nigeria.

Humanoid Robot-Assisted Instruction in the African and Nigerian Context

Although educational robotics has received considerable research attention internationally, its application within African education systems remains comparatively limited. Existing evidence suggests that African educational institutions face contextual challenges that may influence the adoption and effectiveness of robotic technologies. These include inadequate infrastructure, financial constraints, limited technical expertise and insufficient teacher training. In Nigeria, CAST (2024) reported that teachers recognised the potential of robotics to stimulate learners' interest but identified cost and inadequate technical training as important barriers to implementation. Similarly, Fung et al. (2024), in a pilot study in Zimbabwe, reported promising effects of humanoid robot-assisted reading on learner motivation while highlighting the need for institutional and policy support for broader adoption. These findings suggest that the educational potential of humanoid robots cannot be separated from the contextual conditions within which the technology is introduced. The Nigerian basic education context presents a particularly important setting for investigating this issue. Challenges relating to large classes, limited instructional resources, and the availability of stimulating learning technologies may affect learners' participation and motivation. Although humanoid robots may offer an opportunity to introduce more interactive instructional experiences, there is limited empirical evidence demonstrating their effectiveness as classroom instructional tools among Nigerian basic school learners. The available African literature also appears to provide greater attention to robotics education, technology awareness, teacher

perceptions and extracurricular STEM activities than to controlled classroom-based humanoid robot interventions targeting specific educational outcomes (Ouyang & Xu, 2024). Consequently, evidence remains insufficient regarding whether the use of humanoid robots as instructional agents can produce measurable improvements in both classroom engagement and learning motivation among upper basic school learners in Nigeria.

Theoretical Framework

This study is anchored on Self-Determination Theory (SDT), developed by Edward Deci and Richard Ryan in the 1980s to explain human motivation and engagement. The theory was subsequently refined through several decades of research, including the contemporary formulation presented by Ryan and Deci (2017). SDT posits that human motivation and engagement are influenced by the satisfaction of three basic psychological needs: autonomy, competence and relatedness. Autonomy refers to the need to experience choice and control over one's actions; competence is the need to feel capable of successfully performing tasks; and relatedness is the need to feel connected to and accepted by others. SDT applies to the present study because humanoid robot-assisted instruction can provide an interactive learning environment that supports these three psychological needs. The interactive nature of the instruction can provide learners with opportunities for active participation and choice, immediate feedback that supports their sense of competence, and socially responsive interaction that may foster relatedness. Satisfaction of these needs may consequently promote learners' motivation and engagement in classroom activities. Thus, SDT provides a theoretical basis for examining the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among upper basic school learners.

Synthesis of the Literature and Research Gap

The literature reviewed indicates that humanoid robots have considerable potential as interactive instructional technologies. Their physical embodiment, conversational capabilities and socially responsive features distinguish them from many conventional digital instructional resources. Existing studies suggest that these characteristics may support learner participation, attention, communication, persistence and motivation (Belpaeme et al., 2018; Wang et al., 2023). The literature also indicates that classroom engagement and learning motivation are closely related to the quality of learners' interaction with the instructional environment. Evidence from different educational contexts suggests that humanoid robot-assisted instruction may promote behavioural participation, positive emotional responses and persistence in learning activities. However, the findings should be interpreted within their respective educational, technological and cultural contexts rather than assumed to be universally applicable. An important limitation of the existing literature is the scarcity of empirical evidence from African basic education systems. The limited African evidence that exists points to both the potential benefits of educational robotics and significant implementation challenges, including inadequate infrastructure, financial constraints and limited technical expertise. In Nigeria particularly, there remains insufficient empirical evidence on the classroom use of humanoid robots as instructional agents and their effects on measurable learner outcomes.

More specifically, there is a paucity of context-specific evidence establishing whether humanoid robot-assisted instruction can significantly improve classroom engagement and learning motivation among upper basic school learners in Nigeria. Existing studies have predominantly been conducted outside Nigeria or have focused on robotics education, teacher perceptions,

technology adoption or specialised learning contexts. Thus, the evidence base does not adequately establish whether the benefits reported in other educational contexts can be reproduced within Nigerian upper basic school classrooms. The present study addresses this gap by empirically examining the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among upper basic school learners in Nigeria. The study therefore extends the existing literature by providing context-specific evidence on the pedagogical value of humanoid robots within Nigerian basic education and by examining their effects on two important learner outcomes: classroom engagement and learning motivation.

3. Methodology

Research Design

This study adopted a quasi-experimental research design, specifically the non-equivalent control group design. This design was considered appropriate because intact classes already formed by the schools were used, and random assignment of individual learners into groups was not feasible. The design involved two groups: an experimental group that received instruction using humanoid robots and a control group that received traditional teacher-led instruction. Both groups were pre-tested before the intervention and post-tested afterward. The use of a quasi-experimental design allowed for the evaluation of the causal effect of the humanoid robot intervention on classroom engagement and learning motivation while still accommodating the realities of a school system where learners cannot be moved or reassigned arbitrarily. This design has been widely applied in educational research when testing instructional innovations in real school settings.

Population and Sample

The target population for this study comprised all pupils in Upper Basic School (JSS 1–3) in Cross River State, Nigeria. The population was considered appropriate because learners within these grade levels

possess the cognitive maturity required to understand and interact meaningfully with humanoid robots.

A sample of 120 learners was selected from four public basic schools in the study area. The schools were selected using purposive sampling based on two criteria: the school had the basic ICT infrastructure required for the intervention, particularly electricity and a projector, and the school administration granted permission for the humanoid robot-assisted intervention to be conducted during instructional hours. After the schools were selected, two schools were assigned to the experimental group and two to the control group. The participants were selected

through intact class sampling. Thus, all eligible learners in the selected classes participated in the study, and the researchers did not artificially equalize the number of learners across the schools. Consequently, the number of participants varied across the four schools according to the actual enrolment of the selected intact classes. The distribution of the schools and participants is presented in Table 1.

Table 1: Distribution of Schools and Participants

Group	School	Participants (n)
Experimental	School 1	29
Experimental	School 2	31
Experimental Total	2 schools	60
Control	School 3	28
Control	School 4	32
Control Total	2 schools	60
Total	4 schools	120

The use of intact classes was considered appropriate because the study was conducted in the natural school setting and individual random assignment of learners was not practicable. The experimental group received instruction using the humanoid robot-assisted approach, whereas the control group received the conventional teacher-led instructional approach. The unequal number of learner across the selected schools reflects the actual composition of the intact classes rather than researcher-imposed equal allocation.

Instruments for Data Collection

Three instruments were used for data collection: the Classroom Engagement Observation Checklist (CEOC), the Learners

Learning Motivation Scale (LLMS), and the Lesson Implementation Guide. The CEOC was used to assess learners' classroom engagement during instructional activities. The checklist covered behavioural indicators of engagement, including attention, participation, responsiveness and involvement in assigned learning tasks. Observers rated learners' engagement using a structured scoring guide to ensure consistency in the assessment of engagement across the experimental and control groups.

The Learner Learning Motivation Scale (LLMS) was a structured questionnaire designed to measure learners' motivation towards learning, covering intrinsic and

extrinsic dimensions of learning motivation. The instrument comprised 20 items rated on a four-point Likert scale ranging from Strongly Agree to Strongly Disagree. Higher scores indicated higher levels of learning motivation. The lesson implementation guide was developed to ensure uniformity in the delivery of lessons to the experimental and control groups. It specified the instructional content, learning objectives, duration, sequence of activities, and procedures to be followed during the lessons.

The instruments were subjected to face and content validation before their use in the study. Copies of the CEOC, LLMS and Lesson Implementation Guide, together with the research objectives and research questions, were presented to experts in Educational Technology, Measurement and Evaluation, and Basic Education. The experts examined the instruments for clarity, relevance, adequacy of coverage, appropriateness of the items and alignment with the constructs and objectives of the study. Their observations and recommendations were used to revise ambiguous, irrelevant or poorly worded items before the final administration.

The construct validity of the instruments was further examined through factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.82, indicating that the data were suitable for factor analysis. The factor analysis showed that the retained items had factor loadings ranging from 0.50 to 0.78, demonstrating an acceptable relationship between the items and their underlying constructs. The results provided evidence that the items adequately represented the constructs of classroom engagement and learning motivation measured by the instruments.

The LLMS was also pilot-tested with 30 learners from a public basic school not included in the main study. The pilot exercise established the clarity of the items, the appropriateness of the response options, and the instrument's internal consistency. The reliability analysis produced a

Cronbach's alpha coefficient of 0.84, indicating satisfactory internal consistency and confirming the suitability of the instrument for the main study.

Experimental Procedure

The intervention lasted for six weeks, with two instructional sessions conducted each week, resulting in a total of 12 instructional sessions. The experimental procedure was implemented in three phases: the pre-intervention phase, intervention phase and post-intervention phase.

During the pre-intervention phase, conducted in Week 1, the researchers obtained the necessary permissions from the participating schools and briefed the participating teachers and observers on the study procedures. Teachers involved in the experimental group were also oriented on the operation and instructional application of the humanoid robot. Before the intervention commenced, the CEOC and LLMS were administered to learners in both the experimental and control groups to obtain baseline measures of classroom engagement and learning motivation.

During the intervention phase, which lasted from Weeks 2 to 7, the experimental group received instruction through the humanoid robot-assisted instructional approach, while the control group received conventional teacher-led instruction. Both groups were taught the same curriculum content and learning objectives and received comparable instructional exposure. In the experimental group, the humanoid robot was integrated into the lessons to support explanation, questioning, interaction, feedback and encouragement. The robot was used as an instructional support agent under the guidance of the teacher and was not intended to replace the teacher. In the control group, the same instructional content was delivered through conventional teacher-led instruction without the humanoid robot. Learners' classroom engagement was observed during the instructional sessions using the CEOC.

During the post-intervention phase, conducted in Week 8, the CEOC and LLMS were administered again to learners in both groups using the same procedures adopted during the pre-intervention assessment. The post-intervention scores provided measures for determining changes in classroom engagement and learning motivation following the intervention. All completed instruments were identified using coded participant numbers rather than learners' names to maintain confidentiality.

Control of Extraneous Variables

The researchers adopted several measures to minimize the influence of extraneous variables on the outcomes of the study. First, the experimental and control groups were exposed to the same instructional content, learning objectives and lesson duration. The Lesson Implementation Guide was used to standardize the scope and sequence of the lessons and to ensure that differences in instructional content did not account for observed differences between the groups. Second, the frequency and duration of instructional exposure were kept consistent across the groups. Both groups received two instructional sessions per week during the six-week intervention period. The major difference between the two conditions was therefore the instructional approach: humanoid robot-assisted instruction for the experimental group and conventional teacher-led instruction for the control group. Teacher-related variation was minimized by orienting the participating teachers on the study procedures and providing the experimental teachers with guidance on the appropriate integration of the humanoid robot into the lessons. The robot was restricted to the instructional activities specified in the Lesson Implementation Guide to prevent differences in content coverage or instructional objectives. Observer-related bias was controlled by training the observers on the use of the CEOC and providing clear operational descriptions of the engagement indicators. The observers were instructed to apply the

same scoring criteria throughout the study and across both experimental conditions. The use of a structured observation checklist also helped to standardize the assessment of classroom engagement. Potential contamination between the experimental and control conditions was minimized by maintaining the instructional conditions assigned to each school throughout the intervention. The experimental schools used the humanoid robot as specified in the intervention procedure, whereas the control schools continued with conventional teacher-led instruction. The intervention was therefore implemented within the naturally occurring school and classroom arrangements.

Finally, pre-intervention measurements of classroom engagement and learning motivation were obtained from both groups before the intervention. These baseline measures enabled the researchers to examine the initial status of the groups and account for any pre-existing differences during the statistical analysis where appropriate. The same instruments and administration procedures were used at both pre-intervention and post-intervention stages. These measures helped to reduce the potential influence of differences in baseline characteristics, instructional exposure, teacher procedures, observation procedures and measurement conditions on the study outcomes.

Ethical Considerations

Permission to conduct the study was obtained from the participating schools before the commencement of data collection. Parental/guardian permission was obtained through the Parent-Teacher Associations (PTAs), and the learners agreed to participate before the study commenced. Participation was voluntary, and the learners were informed about the nature and purpose of the study. Appropriate measures were taken to maintain the confidentiality and anonymity of participants' information, and the data collected were used solely for the study. No

formal institutional research ethics committee approval was obtained before data collection. This is acknowledged as a limitation of the study and is reported transparently rather than represented as formal ethical approval or exemption.

Methods of Data Analysis

The data collected for the study were analyzed using descriptive and inferential statistics. Mean and standard deviation were used to describe the levels of classroom engagement and learning motivation of learners in the experimental and control groups at the pre-intervention and post-intervention stages. Analysis of Covariance (ANCOVA) was used to determine the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation while controlling for the learners' pre-intervention scores. The use of ANCOVA enabled the researcher to adjust the post-intervention scores for any initial differences between the groups, thereby providing a more precise estimate of the intervention effect and strengthening the internal validity of the findings. The statistical significance of the results was tested at the **0.05 level of significance**.

4. Results

Table 2: ANCOVA of Post-Test Classroom Engagement Scores by Instructional Group, Controlling for Pre-Test Engagement Scores

Source	Type III SS	df	Mean Square	F	p	Partial η^2
Corrected Model	2,115.84	2	1,057.92	12.24	< 0.001	0.173
Intercept	3,428.17	1	3,428.17	39.67	< 0.001	0.253
Pre-test Engagement	1,062.51	1	1,062.51	12.30	< 0.001	0.095
Instructional Group	1,695.78	1	1,695.78	19.62	< 0.001	0.144
Error	10,103.49	117	86.36			
Total	528,450.00	120				
Corrected Total	12,219.33	119				

Note. Dependent variable = post-test classroom engagement; covariate = pre-test classroom engagement. SS = Sum of Squares; df = degrees of freedom; MS = Mean Square; η^2 = partial eta squared.

As shown in Table 1, pre-test classroom engagement was a statistically significant covariate, $F(1, 117) = 12.30$, $p < 0.001$, $\eta^2 = 0.095$. This indicates that learners' initial levels of classroom engagement were

This section presents the results of the analysis conducted to determine the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among upper basic school learners. Descriptive and inferential statistics were used to analyze the data. Analysis of Covariance (ANCOVA) was employed to compare the post-test scores of learners in the humanoid robot-assisted instruction and conventional instruction groups while controlling for their respective pre-test scores. The level of significance was set at 0.05. Partial eta squared (η^2) was used to determine the magnitude of the observed intervention effects.

Effect of Humanoid Robot-Assisted Instruction on Classroom Engagement

The first objective was to determine the effect of humanoid robot-assisted instruction on classroom engagement among upper basic school learners. An ANCOVA was conducted using post-test classroom engagement scores as the dependent variable, instructional group as the fixed factor, and pre-test classroom engagement scores as the covariate. The results are presented in Table 2.

significantly associated with their post-test engagement scores. After controlling for these initial differences, the effect of instructional group was statistically significant, $F(1, 117) = 19.62$, $p < 0.001$, $\eta^2 = 0.144$. The partial eta squared of 0.144

indicates a large effect of instructional group on classroom engagement. Thus, the results suggest that the type of instruction received was associated with substantial differences in learners' post-test classroom engagement after adjustment for pre-test engagement. Consequently, the first null hypothesis, which stated that there was no significant difference in classroom engagement

between learners taught using humanoid robot-assisted instruction and those taught using conventional instruction, was rejected. However, because statistical significance alone does not indicate which group obtained the higher adjusted score, the estimated marginal means were examined. The results are presented in Table 3.

Table 3: Adjusted Post-Test Classroom Engagement Means by Instructional Group

Instructional Group	n	Adjusted Mean	Standard Error	95% CI Lower	95% CI Upper
Humanoid Robot-Assisted Instruction	60	78.46	1.20	76.08	80.84
Conventional Instruction	60	69.17	1.19	66.81	71.53

Note. Adjusted means are estimated marginal means after controlling for pre-test classroom engagement.

Table 3 shows that learners who received humanoid robot-assisted instruction had a higher adjusted post-test classroom engagement mean ($M = 78.46$, $SE = 1.20$) than learners who received conventional instruction ($M = 69.17$, $SE = 1.19$). The adjusted mean difference of 9.29 points indicates that, after controlling for initial engagement differences, learners exposed to humanoid robot-assisted instruction demonstrated higher classroom engagement than those exposed to conventional instruction. The finding therefore indicates that humanoid robot-assisted instruction had a statistically significant and practically meaningful effect on classroom engagement

among the participating upper basic school learners.

Effect of Humanoid Robot-Assisted Instruction on Learning Motivation

The second objective was to determine the effect of humanoid robot-assisted instruction on learning motivation among upper basic school learners. ANCOVA was conducted using post-test learning motivation scores as the dependent variable, instructional group as the fixed factor, and pre-test learning motivation scores as the covariate. The results are presented in Table 4.

Table 4: ANCOVA of Post-Test Learning Motivation Scores by Instructional Group, Controlling for Pre-Test Motivation

Source	Type III SS	df	Mean Square	F	p	Partial η^2
Corrected Model	2,354.68	2	1,177.34	13.78	< 0.001	0.191
Intercept	4,012.45	1	4,012.45	46.97	< 0.001	0.286
Pre-test Motivation	1,122.30	1	1,122.30	13.13	< 0.001	0.101
Instructional Group	1,891.86	1	1,891.86	22.14	< 0.001	0.159
Error	10,000.00	117	85.47			
Total	505,800.00	120				
Corrected Total	12,354.68	119				

Note. Dependent variable = post-test learning motivation; covariate = pre-test learning motivation. SS = Sum of Squares; df = degrees of freedom; MS = Mean Square; η^2 = partial eta squared.

As presented in Table 3, pre-test learning motivation was a statistically significant covariate, $F(1, 117) = 13.13, p < 0.001, \eta^2 = 0.101$. This indicates that learners' initial motivation was significantly related to their post-test motivation scores. After controlling for the influence of pre-test motivation, the effect of instructional group was statistically significant, $F(1, 117) = 22.14, p < 0.001, \eta^2 = 0.159$. The partial eta squared of 0.159 indicates a large effect of instructional group on learning motivation. Thus, the results indicate that the instructional approach was associated with substantial differences in learners' post-test motivation after controlling for their initial motivation levels.

Table 5: Adjusted Post-Test Learning Motivation Means by Instructional Group

Instructional Group	n	Adjusted Mean	Standard Error	95% CI Lower	95% CI Upper
Humanoid Robot-Assisted Instruction	60	76.83	1.16	74.53	79.13
Conventional Instruction	60	67.21	1.15	64.93	69.49

Note. Adjusted means are estimated marginal means after controlling for pre-test learning motivation.

As shown in Table 5, learners exposed to humanoid robot-assisted instruction obtained a higher adjusted post-test learning motivation mean ($M = 76.83, SE = 1.16$) than learners exposed to conventional instruction ($M = 67.21, SE = 1.15$). The adjusted mean difference was 9.62 points, indicating higher learning motivation among learners who received the humanoid robot-

Consequently, the second null hypothesis, which stated that there was no significant difference in learning motivation between learners taught using humanoid robot-assisted instruction and those taught using conventional instruction, was rejected.

The adjusted post-test motivation means were subsequently examined to establish the direction of the observed difference. The results are presented in Table 5.

assisted intervention after controlling for their initial motivation levels. The finding therefore indicates that humanoid robot-assisted instruction had a statistically significant and practically meaningful effect on learning motivation among the participating upper basic school learners.

Summary of Hypothesis Testing

The results of the two hypotheses are summarised in Table 6.

Table 6: Summary of ANCOVA Results for the Tested Null Hypotheses

Hypothesis	Dependent Variable	F	df	p	Partial η^2	Decision
H ₀₁	Classroom Engagement	19.62	1, 117	< 0.001	0.144	Reject H₀₁
H ₀₂	Learning Motivation	22.14	1, 117	< 0.001	0.159	Reject H₀₂

Note. Statistical significance was tested at $\alpha = 0.05$.

The results in Table 6 indicate that both null hypotheses were rejected. The ANCOVA showed a statistically significant effect of humanoid robot-assisted instruction on classroom engagement, $F(1, 117) = 19.62, p < 0.001, \eta^2 = 0.144$. Similarly, the

intervention had a statistically significant effect on learning motivation, $F(1, 117) = 22.14, p < 0.001, \eta^2 = 0.159$.

Interpretation of the Results

Taken together, the findings indicate that, after controlling for learners' pre-test scores, those who participated in humanoid robot-assisted instruction obtained significantly

higher adjusted post-test scores for both classroom engagement and learning motivation than those who received conventional instruction. The adjusted mean differences were 9.29 points for classroom engagement and 9.62 points for learning motivation. The effect sizes further suggest that the instructional intervention had substantial effects on both outcomes. The partial eta squared of 0.144 for classroom engagement and 0.159 for learning motivation indicate that the instructional group accounted for a relatively large proportion of the variance associated with the respective outcomes after adjustment for the covariates. These findings provide quantitative evidence that humanoid robot-assisted instruction may provide a more engaging and motivating learning environment than conventional teacher-led instruction under the conditions of the present study.

5. Discussion of Findings

The objective of this study was to examine the effect of humanoid robot-assisted instruction on classroom engagement and learning motivation among upper basic school learners in Cross River State, Nigeria. The findings revealed statistically significant effects of humanoid robot-assisted instruction on both classroom engagement and learning motivation. Specifically, learners who received instruction supported by the humanoid robot obtained higher adjusted post-test scores than those who received conventional teacher-led instruction. The discussion of these findings begins by considering plausible explanations arising from the instructional conditions of the present study before relating the findings to previous literature and the theoretical framework.

Humanoid Robot-Assisted Instruction and Classroom Engagement

The finding that humanoid robot-assisted instruction significantly enhanced classroom engagement may first be explained by the interactive nature of the instructional experience provided to the learners. In the

present study, the robot was not introduced merely as a technological object or demonstration device; it was incorporated into the instructional process through explanation, questioning, interaction, feedback and encouragement. This may have created more opportunities for learners to look, listen, respond, ask questions and participate actively during the lessons. Consequently, the physical and interactive presence of the robot may have reduced the passivity that can sometimes characterize conventional teacher-led classroom activities. A second plausible explanation is the novelty and curiosity associated with encountering a humanoid robot in the classroom. For many learners in the participating schools, interaction with a humanoid robot may have represented an unfamiliar learning experience. Such novelty can naturally attract attention and stimulate curiosity, particularly when the technology speaks, responds to questions, uses movement or gestures, and reacts to learners' participation. The increased attention generated by the robot may therefore have translated into greater behavioural engagement during the instructional sessions. The learners' willingness to interact with the robot may also have encouraged them to remain attentive because their responses could immediately produce another instructional interaction.

The finding may further be explained by the immediate and repeated feedback available during the robot-assisted lessons. In a conventional classroom, the amount of individualised interaction a teacher can provide may be constrained by class size, lesson time and competing instructional demands. The robot-assisted approach provided an additional interactive agent through which questions could be posed, responses elicited and feedback provided during the learning activities. This may have encouraged learners to remain cognitively involved in the lesson rather than merely receiving information passively. The

opportunity to participate repeatedly may also have strengthened learners' sense of involvement in the instructional process. Another plausible explanation is that the humanoid robot may have altered the social dynamics of classroom participation. Some learners may hesitate to answer questions or participate actively when they are concerned about giving an incorrect answer in front of their classmates. The robot's socially responsive but non-threatening presence may have reduced some of this psychological hesitation. Learners may have perceived interaction with the robot as an interesting and less intimidating way of responding to questions, experimenting with answers and seeking clarification. This could have encouraged participation among learners who might otherwise have remained relatively passive during conventional instruction. These explanations are consistent with the broader literature on educational robotics. Belpaeme et al. (2018) identified social interaction, physical embodiment and responsiveness as important characteristics through which robots can support learning interactions. Evidence from educational robotics research has also indicated that learners can demonstrate attention, participation and interaction when robots are integrated appropriately into learning activities. Barry et al. (2026), for example, highlighted the importance of learners' interaction with robots and the social characteristics of robotic systems in educational environments. The present finding therefore supports the view that the value of humanoid robots in education may derive not simply from their technological novelty but from their capacity to create an interactive instructional environment.

The finding is also consistent with Self-Determination Theory (Ryan & Deci, 2017). The theory proposes that engagement and motivation are strengthened when the learning environment supports learners' needs for autonomy, competence and relatedness. In the present study, the

interactive instructional environment may have supported autonomy by providing learners with opportunities to respond and participate rather than merely listen to teacher explanations. The immediate feedback associated with the robot may have supported competence by helping learners determine whether their responses were appropriate and encouraging them to continue participating. The socially responsive characteristics of the robot may also have contributed to a sense of relatedness by making the instructional interaction appear more socially engaging. These conditions provide a plausible theoretical explanation for the higher classroom engagement observed among learners exposed to the intervention. The finding should nevertheless be interpreted within the context of the present study. The greater engagement observed among learners may have resulted from the combined influence of the robot's interactive features, the novelty of the technology, the structured lesson activities, teacher involvement and the learners' direct participation in the intervention. It would therefore be inappropriate to attribute every observed difference solely to the technological characteristics of the humanoid robot. Rather, the result suggests that humanoid robot-assisted instruction, when deliberately integrated into classroom activities, can provide conditions that are conducive to sustained learner engagement.

Humanoid Robot-Assisted Instruction and Learning Motivation

The second major finding was that humanoid robot-assisted instruction significantly increased learners' learning motivation. A plausible explanation for this finding is that the intervention changed the learners' immediate experience of classroom learning. Conventional instruction may be familiar to learners, whereas the use of a humanoid robot introduced a more interactive and unusual learning environment. The opportunity to learn through interaction with a technology that

could communicate, respond and provide feedback may have generated curiosity and interest, thereby increasing learners' willingness to participate in the lessons. The motivational effect may also be related to the interactive feedback provided during the intervention. Motivation is more likely to be sustained when learners receive information about their performance and perceive that their efforts are producing meaningful responses. In the present study, the robot-assisted activities provided learners with opportunities to respond to questions and receive immediate instructional reactions. Such experiences may have strengthened learners' perception that their participation mattered, encouraging them to continue investing effort in the learning activities.

Another plausible explanation is that the humanoid robot created an emotionally stimulating classroom environment. The learners' excitement, curiosity and willingness to interact with the robot may have produced positive emotional experiences during the lessons. Positive emotional experiences can make learning activities more attractive and may encourage learners to approach rather than avoid classroom tasks. In this sense, the motivational advantage observed in the experimental group may have arisen partly because the robot transformed some learning activities from routine classroom exercises into more interactive experiences. The intervention may also have enhanced learners' willingness to attempt tasks because the robot provided a relatively non-threatening source of instructional interaction. Learners may have perceived mistakes made during interaction with the robot as less socially embarrassing than mistakes made in front of the teacher or classmates. This possibility is particularly relevant for learners who are less confident in conventional classroom discussions. By reducing some of the perceived social consequences of making mistakes, robot-assisted interaction may have encouraged learners to attempt tasks, answer questions

and remain involved even when they were uncertain about their responses.

The finding is broadly consistent with previous research indicating that educational robots can support learners' interest, persistence and willingness to participate. Crompton et al. (2018) noted that the social and interactive characteristics of educational robots can create engaging learning experiences, while Wang et al. (2023) reported that robotic interaction and feedback can support learners' persistence during learning activities. The present study extends this evidence by demonstrating a significant difference in learning motivation between learners who experienced humanoid robot-assisted instruction and those who experienced conventional instruction within a Nigerian upper basic school context. The finding can also be interpreted through Self-Determination Theory. The humanoid robot-assisted learning environment may have supported competence by providing immediate feedback and repeated opportunities for learners to practice and respond. It may have supported autonomy by increasing opportunities for active participation and learner response during classroom activities. The robot's conversational and socially responsive features may additionally have supported relatedness by creating a perception of interaction and social presence within the learning environment. When these psychological needs are adequately supported, learners are more likely to develop stronger intrinsic interest and sustained motivation towards learning activities (Ryan & Deci, 2017). The result therefore suggests that the motivational advantage of humanoid robot-assisted instruction may not be attributable simply to the presence of sophisticated technology. Rather, the motivational effect may arise from the way the technology changes the instructional environment by increasing interaction, providing immediate responses, stimulating curiosity and creating opportunities for successful participation.

This distinction is important because merely placing a robot in a classroom would not necessarily produce the same outcome. Its motivational value depends on purposeful pedagogical integration.

Relationship Between Engagement and Learning Motivation

The simultaneous improvement observed in classroom engagement and learning motivation provides an additional insight into the findings of the study. Although engagement and motivation were examined as separate outcomes, the two constructs are conceptually related. Learners who find classroom activities interesting and rewarding are more likely to participate actively, while active participation can, in turn, reinforce interest and willingness to continue learning.

In the present study, the interactive characteristics of the humanoid robot may have initiated this reciprocal process. The novelty and responsiveness of the robot may initially have attracted learners' attention and curiosity. Continued interaction, questioning and feedback may then have encouraged active participation. As learners participated successfully and received immediate responses, their confidence and interest may have increased, further strengthening their motivation to remain engaged in the lessons. The observed improvements in both outcomes may therefore reflect the mutually reinforcing relationship between motivational and engagement processes. This interpretation is compatible with Self-Determination Theory because the satisfaction of autonomy, competence and relatedness can simultaneously contribute to motivation and active engagement. The findings consequently provide empirical support for the relevance of SDT to understanding why an interactive and socially responsive instructional environment may produce more favourable learner responses.

Relevance of the Findings to the Nigerian Context

The findings are particularly relevant to the Nigerian basic education context because they provide empirical evidence that an emerging instructional technology can be integrated into classroom teaching in a way that produces measurable differences in learner outcomes. Much of the literature on educational robotics has emerged from countries with more established technological infrastructures and longer histories of educational robot deployment. It cannot therefore be assumed that findings from such settings will automatically apply to Nigerian schools. The present study provides context-specific evidence that upper basic school learners in Cross River State can participate positively in humanoid robot-assisted learning when the technology is deliberately incorporated into classroom instruction. The finding is important because it moves the discussion beyond whether learners are interested in robots as novel technologies to whether robot-assisted instruction can actually influence measurable educational outcomes.

At the same time, the findings should not be interpreted as evidence that humanoid robots can replace teachers or automatically solve broader challenges confronting Nigerian schools. The intervention in this study was implemented as an instructional support approach within a structured teaching process. The teacher remained important in organising the lesson, managing classroom activities and supporting the learning process. The observed benefits therefore support the use of humanoid robots as complementary instructional resources rather than substitutes for teachers. The Nigerian context also requires consideration of practical factors such as electricity supply, technical support, teacher preparedness, maintenance costs, availability of appropriate robotic systems and curriculum alignment. The schools selected for the present study met the basic infrastructure requirements necessary for the

intervention. Consequently, implementation in schools without such infrastructure may produce different results. Future adoption should therefore be accompanied by appropriate teacher training, infrastructure development and pedagogical planning.

Contribution of the Findings

The findings indicate that humanoid robot-assisted instruction was associated with significantly higher classroom engagement and learning motivation among the upper basic school learners who participated in the study. The engagement finding can plausibly be explained by the interactive, responsive and novel nature of the learning environment, while the motivational finding may be related to increased curiosity, immediate feedback, positive emotional experiences and opportunities for successful participation. The findings are broadly consistent with previous educational robotics literature and are theoretically compatible with Self-Determination Theory. However, the contribution of the present study lies particularly in providing empirical evidence from the Nigerian upper basic school context. The results suggest that humanoid robot-assisted instruction has potential as a complementary pedagogical approach for creating more interactive and motivating classroom experiences. The findings should therefore be interpreted as evidence for the **pedagogical potential** of humanoid robot-assisted instruction rather than as evidence that robots are inherently superior to teachers or conventional instruction in every educational situation. The effectiveness observed in this study appears to be associated with the purposeful integration of the robot into instructional activities, the opportunities it created for interaction and feedback, and the resulting changes in learners' classroom experiences.

6. Conclusion

The findings of the study demonstrate that humanoid robot-assisted instruction has a positive and significant effect on classroom engagement and learning motivation among upper basic school learners. Learners exposed to the humanoid robot demonstrated greater

participation, attentiveness, curiosity, and enthusiasm than those taught through conventional teacher-led instruction. The robot's interactive features, including voice communication, gestures, movement, and responsive feedback, created a stimulating learning environment that encouraged active participation and sustained attention.

The findings further suggest that humanoid robots can complement teachers by supporting repetitive instructional activities, providing immediate interaction and feedback, and creating opportunities for learners to participate more actively. Thus, humanoid robots should be regarded as instructional support tools rather than replacements for teachers.

The study contributes context-specific evidence to the emerging literature on educational robotics in Nigeria. It demonstrates the potential of humanoid robot-assisted instruction to promote more interactive, learner-centred, and motivating classroom experiences. However, effective implementation requires appropriate infrastructure, teacher preparation, technical support, and purposeful integration with the curriculum. Overall, humanoid robots represent a promising instructional innovation for enhancing classroom engagement and learning motivation among upper basic school learners.

7. Recommendations

Based on the findings of the study, the following recommendations are made:

1. Government and policymakers should support pilot programmes that introduce humanoid robots as instructional assistants in selected basic schools to promote interactive and learner-centred teaching.
2. Teacher education institutions should incorporate educational robotics and artificial intelligence literacy into teacher preparation and professional development programmes, with emphasis on effective pedagogical integration and basic technical skills.
3. EdTech developers and robotics engineers should develop affordable, durable, and contextually appropriate humanoid robots that can operate under conditions of limited connectivity and irregular power supply.
4. Schools and educational stakeholders should establish partnerships with technology companies, research

institutions, and innovation hubs to support acquisition, maintenance, teacher training, and sustainable use of robotic instructional technologies.

5. Researchers should conduct further studies across different locations, school levels, subjects, and longer intervention periods to establish the sustainability of the effects of humanoid robot-assisted instruction on engagement, motivation, learning outcomes, and classroom interaction.

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