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EFFECT OF INQUIRY-BASED LEARNING ON STUDENTS' PERFORMANCE IN ELECTRICAL/ELECTRONIC TECHNOLOGY EDUCATION IN PUBLIC UNIVERSITIES IN NORTH CENTRAL NIGERIA

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ABSTRACT
This study evaluated the effect of Inquiry-Based Learning (IBL) on students' performance in Electrical/Electronic Technology Education (EETE) in public universities in North Central Nigeria. The study focused on four dimensions of performance: cognitive performance, practical skills, problem-solving ability, and practical problem-solving skills. A quasi-experimental non-equivalent pre-test–post-test control-group design was adopted. The participants comprised 120 EETE students at the 300 level from six selected public universities, consisting of 61 students in the experimental group and 59 in the control group. The experimental group was taught using inquiry-based learning, whereas the control group received traditional instructional methods. Data were collected using the Electrical/Electronic Technology Performance Test (EETPT), Practical Skills Assessment Checklist (PSAC), Electrical/Electronic Technology Education Problem-Solving Ability Test (EETE-PSAT), and Practical Problem-Solving Ability Assessment Checklist (PSAAC), the technologist were also used also check practical skills. Means and standard deviations were used for descriptive analysis. ANCOVA was employed to test the null hypotheses at the 0.05 significance level. The instruments were trial-tested, and their reliability coefficients were 0.74, 0.83, 0.73, 0.72, and 0.81. The findings revealed that students taught using Inquiry-Based Learning (IBL) performed better than those taught using traditional instructional methods in all four dimensions examined. Specifically, IBL enhanced students' cognitive performance, practical skills, problem-solving ability, and practical problem-solving skills. The study also established significant differences in performance between students exposed to IBL and those taught using traditional instructional methods, in favour of the IBL group.

Keywords: inquiry-based learning, electrical/electronic technology education, cognitive performance, practical skills, and problem-solving.

Introduction

Electrical/Electronic Technology Education (EETE) is an important practical component of Technical and Vocational Education and Training (TVET), designed to equip students with the theoretical knowledge, practical competence and technical problem-solving abilities required in contemporary technological and industrial environments. Successful learning in EETE extends beyond the recall of technical concepts to include the interpretation of circuit diagrams, circuit construction, electrical measurements, experimentation, troubleshooting, fault diagnosis, electronics prototyping, safety practices and the development of appropriate technical solutions. Consequently, effective instructional approaches in EETE should provide students with meaningful opportunities to integrate theoretical principles with authentic practical activities (Tembrevilla et al., 2024; Tokatlidis et al., 2024). Tokatlidis et al. (2024) emphasised the importance of hands-on and virtual laboratory experiences in developing students' knowledge and skills in electronic circuit learning. Their findings reinforce the need for instructional practices that connect conceptual understanding with practical experimentation and technical competence.

The growing complexity of electrical and electronic technologies demands instructional approaches that encourage active participation, independent reasoning, creativity, critical thinking and problem-solving. However, conventional teacher-centred instruction, particularly when dominated by lectures, may limit students' opportunities to investigate technical problems independently, manipulate laboratory equipment, test hypotheses and construct knowledge through practical experiences. Although direct instruction remains valuable for explaining foundational principles, an excessive dependence on lecturer-directed activities may restrict the development of investigative and practical competencies. De Jong et al. (2023) emphasised the importance of integrating inquiry-based and direct instructional approaches to create effective learning opportunities. This suggests that instructional practices in EETE should move beyond the exclusive transmission of theoretical information towards approaches that actively engage students in applying knowledge to practical technological situations.

Inquiry-Based Learning (IBL) provides a learner-centred instructional orientation in which students engage with questions, investigate problems, collect and interpret evidence, test explanations, construct solutions and reflect on their learning experiences. The approach encourages students to participate actively in knowledge construction rather than function merely as passive recipients of information. Pedaste et al. (2015) identified orientation, conceptualisation, investigation, conclusion and discussion as interconnected phases of the inquiry-learning cycle. de Jong et al. (2024) highlighted the importance of appropriately designed learning opportunities that integrate inquiry activities with instructional guidance to support meaningful conceptual understanding and scientific reasoning. Within this perspective, the lecturer assumes the role of facilitator, providing the guidance, resources and feedback necessary for students to investigate problems and develop evidence-based solutions.

The relevance of IBL to Electrical/Electronic Technology Education is particularly significant because electrical and electronic concepts frequently require students to move between abstract scientific principles and practical applications. For instance, students investigating a malfunctioning electrical circuit must identify the problem, formulate possible explanations, select appropriate measuring instruments, conduct tests, interpret measurements and determine suitable corrective actions. These activities correspond closely with the inquiry cycle and provide opportunities for developing cognitive performance, practical skills and technical problem-solving competence. Corral-Barraza et al. (2024) investigated inquiry-based

learning in electronics engineering classrooms and demonstrated its relevance to students' motivation to design technological solutions. Similarly, Tokatlidis et al. (2024) examined hands-on and virtual laboratory experiences in electronic circuit learning, highlighting their contribution to conceptual knowledge, inquiry skills and measurement competencies. These studies provide contemporary evidence supporting the integration of investigative and practical learning experiences into electrical and electronics instruction.

Furthermore, inquiry-oriented instruction provides opportunities for students to develop higher-order cognitive and practical competencies through active engagement with meaningful learning tasks. In electrical technology education, students are expected not only to understand established principles but also to apply their knowledge in unfamiliar technical situations. Chrismondari et al. (2025) investigated the implementation of project-based inquiry learning in electrical motor installation and provided further evidence of the relevance of investigative instructional approaches to vocational electrical education. Similarly, Orji (2025) examined problem-based intervention among Electrical/Electronic Technology Education students and demonstrated its relevance to students' engagement and practical skills acquisition. These findings suggest that instructional approaches incorporating investigation, experimentation and authentic technical problems offer considerable potential for improving learning outcomes in EETE.

Theoretical framework

Inquiry-Based Learning (IBL) in Electrical/Electronic Technology Education is grounded in constructivist, social constructivist and experiential learning perspectives. Piaget's Constructivist Learning Theory emphasises that learners actively construct knowledge through interaction with their environment (Piaget, 1970). This supports IBL by encouraging students to explore concepts, investigate problems and develop understanding through active participation. Similarly, Vygotsky's Social Constructivist Theory highlights the role of collaboration, social interaction and instructional guidance in learning (Vygotsky, 1978). This is reflected in IBL activities where students share ideas and work together to investigate technical problems.

Kolb's Experiential Learning Theory explains learning through concrete experience, reflection, conceptualisation and active experimentation (Kolb, 1984). These processes are relevant to EETE practical activities such as circuit construction, electrical measurements and fault diagnosis. Furthermore, Deci and Ryan's Self-Determination Theory explains how autonomy, competence and relatedness promote learning motivation (Deci & Ryan, 1985). IBL supports these needs by allowing students to make decisions, develop technical competence and collaborate. Collectively, these theories provide a foundation for using IBL to enhance students' cognitive performance, practical skills and problem-solving abilities in EETE.

Statement of problem

Despite growing support for learner-centred instructional approaches, there remains a need for context-specific evidence on the effectiveness of Inquiry-Based Learning (IBL) across different dimensions of students' performance in Electrical/Electronic Technology Education (EETE). Although previous studies have examined inquiry-oriented instruction, laboratory experimentation and problem-based learning in related technical disciplines, their findings do not sufficiently establish the effectiveness of IBL among undergraduate EETE students in public universities in North Central Nigeria. In particular, evidence is needed on its influence on students' cognitive achievement, practical competence and ability to apply theoretical knowledge to electrical and electronic problems.

Against this background, the study examined the effect of IBL, compared with the traditional lecture method, on students' cognitive performance, practical skills, problem-solving ability and practical problem-solving skills. Using a quasi-experimental, non-equivalent pre-test–post-test control-group design involving 120 undergraduate students from six public universities, the study sought to provide empirical evidence to inform instructional improvement, curriculum implementation and pedagogical practices in university-based EETE.

Purpose of the study

The purpose of the study was to evaluate the effect of Inquiry-Based Learning on students' performance in Electrical/Electronic Technology Education in public universities in North Central Nigeria. The specific objectives of the study were to:

1. Determine the effect of inquiry-based learning on students' cognitive performance in Electrical/Electronic Technology Education compared with traditional teaching methods.
2. Examine the effect of inquiry-based learning on students' practical skills in Electrical/Electronic courses.
3. Assess the effect of inquiry-based learning on students' problem-solving ability in Electrical/Electronic Technology Education.
4. Examine the effect of inquiry-based learning on students' practical problem-solving skills in Electrical/Electronic courses.

Research questions

The following research questions guided the study:

1. What effect does inquiry-based learning have on students' cognitive performance in EETE?
2. What effect does inquiry-based learning have on students' practical skills in EETE?
3. What effect does inquiry-based learning have on students' problem-solving ability in EETE?
4. What effect does inquiry-based learning have on students' practical problem-solving skills in EETE?

Hypotheses

The following null hypotheses were tested at the 0.05 significance level:

1. There is no significant difference in the cognitive performance of students taught EETE using IBL and those taught using traditional methods.
2. There is no significant difference in the practical skills of students taught EETE using IBL and those taught using traditional methods.
3. There is no significant effect of IBL on students' problem-solving ability in EETE.
4. There is no significant effect of IBL on students' practical problem-solving skills in EETE.

Methodology

Research design

The study adopted a quasi-experimental, non-equivalent pre-test–post-test control-group design because intact groups were used without individual random assignment. The study consists of 120 students in 300-level from six selected public universities in North Central Nigeria, comprising 61 students in the experimental group and 59 in the control group. Three universities were assigned to each condition.

The intervention lasted four weeks and consisted of eight lessons jointly delivered by the researcher and EETE lecturers. The experimental group received Inquiry-Based Learning (IBL),

involving questioning, investigation of technical problems, experimentation, evidence interpretation and the development of practical solutions, with guidance and feedback from the instructors. The control group received the traditional lecture method, characterised by lecturer explanations, presentations, note-taking and classroom discussions.

To minimise contamination, the two groups were taught in separate universities, at different times and locations, with instructional materials restricted to their respective groups. Both groups completed pre-tests before the intervention and post-tests afterwards to assess the effects of the instructional approaches on the study outcomes. A retention test was administered two weeks after the post-test to determine knowledge retention.

The researcher approval was obtained from the relevant university authorities. Students gave informed consent after the study procedures were explained. Participation was voluntary, confidentiality was maintained, and all collected information was used solely for research purposes.

Area of the study

The study was conducted in North Central Nigeria, comprising Benue, Kogi, Kwara, Nasarawa, Niger and Plateau State and the Federal Capital Territory (FCT), Abuja. The study covered six public universities offering Electrical/Electronic Technology Education (EETE) or related programmes within the zone. The area was considered suitable because of the availability of relevant programmes and undergraduate students for evaluating the effect of Inquiry-Based Learning on students' cognitive performance, practical skills and problem-solving abilities.

Population of the study

The population comprised 120 undergraduate EETE students at 300 level from six selected public universities in North Central Nigeria. Sixty-one students constituted the experimental group, while 59 constituted the control group. The experimental group received inquiry-based instruction, whereas the control group received traditional instruction.

Sample and sampling technique

The census sampling technique was used. Involving including every student in the study rather than selecting a subset of the population. Of the 120 students, 61 constituted the experimental group and received instruction through Inquiry-Based Learning (IBL), while 59 constituted the control group and received instruction through the traditional lecture method. The use of the entire accessible population was considered appropriate because the population was manageable and all eligible students were available for participation.

Instrument for data collection

Four instruments were used in this study: Electrical/Electronic Technology Performance Test (EETPT); Practical Skills Assessment Checklist (PSAC); Electrical/Electronic Technology Education Problem-Solving Ability Test (EETE-PSAT); and Practical Problem-Solving Ability Assessment Checklist (PSAAC). The practical assessment included circuit identification, tool selection, circuit construction, measurement, troubleshooting, hypothesis testing, safety, fault correction, explanation of solutions, work organization, and timely task completion. Six laboratory technologists participated in the rating of practical skills and practical problem-solving performance. The instruments were trial-tested, and their reliability coefficients were, for Performance Test (EETPT) Cronbach's Alpha produced a reliability coefficient of 0.74, indicating strong internal consistency. Practical Skills Checklist (PSAC) Cronbach's Alpha was used and yielding 0.83, Problem-Solving Ability Test (PSAT) reliability was established using Pearson Correlation and obtained is 0.73, so the essay questions are considered to be reliable for

the study, indicating strong internal consistency. PSAAC reliability was also Cronbach's Alpha is a suitable alternative, yielding 0.72, which is considered very good agreement.

Assessment of practical problem-solving skills

The Practical skills and problem-solving skills of the students were also assessed by six laboratory technologists using the Practical Skills Assessment Checklist and Practical Problem-Solving Assessment Checklist. The raters evaluated students' performance based on the specified assessment criteria, which covered their ability to identify electrical and electronic problems, select appropriate tools and procedures, carry out practical tasks, diagnose faults and develop appropriate solutions. The use of multiple raters provided an opportunity for students' practical performance to be assessed from different professional perspectives. The ratings were used to determine students' Practical skills and practical problem-solving skills.

Method of data analysis

The data collected for the study were analysed using descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions and summarise students' performance and responses across the study groups. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at the 0.05 level of significance, with the relevant pre-test scores included as covariates to adjust for initial differences between the experimental and control groups. Before conducting ANCOVA, its underlying assumptions were examined. Normality of the model residuals was assessed using Shapiro–wilk test and/or normal Q–Q plots, while the homogeneity of variance assumption was examined using Levene's test. The homogeneity of regression slopes assumption was assessed by testing the interaction between the pre-test scores and instructional group. A non-significant interaction indicated that the relationship between the pre-test and post-test scores did not differ significantly across the groups, supporting the use of ANCOVA. The ANCOVA results were reported using adjusted group means, F-values, degrees of freedom and probability values. Partial eta squared (ηp^2) was also reported to indicate the magnitude of the instructional effect. All hypotheses were tested at the 0.05 level of significance.

Results

Research question 1

What is the effect of inquiry-based learning on students' cognitive performance in Electrical/Electronic Technology Education?

To answer the research question, the data collected were analysed, and Table 1 shows the mean and standard deviation of the students' scores in the experimental and control groups. There were 61 students in the experimental group and 59 in control group.

Table 1: ***Mean and Standard Deviation of Pre-test score and Post-test score on Effect of inquiry-based learning on students' cognitive performance in Electrical/Electronic Technology Education***

	Group of respondents	N	Mean	Std. Deviation
Pre-test score	Experimental Group	(61)	5.78	5.47
	Control Group	(59)	5.57	6.16
	Difference		0.21	
Post-test score	Experimental Group	(61)	30.54	8.53
	Control Group	(59)	22.08	10.98
	Difference		8.46	

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Results in Table 1 showed that at pre-test, the experimental group had a mean score of 5.78 and a standard deviation of 5.47, whereas the control group recorded a mean of 5.57 and a standard deviation of 6.16. The relatively small difference of 0.21 indicated comparable starting levels. Following the intervention, the experimental group obtained a post-test mean of 30.54 and a standard deviation of 8.53, compared with 22.08 and a standard deviation of 10.98, for the control group. The observed mean difference was 8.46 points in favour of the experimental group.

Research question 2

What effect does inquiry-based learning have on students' practical skills in Electrical/Electronic Technology Education? To answer the research question 2, for practical skills in Electrical/Electronic Technology Education, data collected were analysed using the mean, and standard deviation.

Table 2: ***Mean and Standard Deviation of Pre-test score and Post-test score on of inquiry-based learning on students' practical skills in Electrical/Electronic Technology Education***

	Group of respondents	N	Mean	Std. Deviation
Pre-test score	Experimental Group	(61)	1.13	0.30
	Control Group	(59)	1.12	0.27
	Difference		0.01	
Post-test score	Experimental Group	(61)	3.44	0.77
	Control Group	(59)	2.16	0.83
	Difference		1.28	

Results in Table 2 showed that, the experimental group recorded a pre-test mean of 1.13 and a standard deviation of 0.30, while the control group recorded 1.12 and a standard deviation of 0.27. Following the intervention, the experimental group achieved a mean of 3.44 and a standard deviation of 0.77, compared with 2.16 and a standard deviation of 0.83 for the control group. The post-test mean difference was 1.28 points, IBL was favoured.

Research question 3

What effect does inquiry-based learning have on students' problem-solving ability in Electrical/Electronic Technology Education?

To answer research question three, Table 3 presents the Mean and Standard deviation of students' problem-solving ability before and after the instructional intervention.

Table 3:*Mean and Standard Deviation of Pre-test score and Post-test score on effect of inquiry-based learning on students' problem-solving ability in Electrical/Electronic Technology Education*

	Group of respondents	N	Mean	Std. Deviation
Pre-test score	Experimental Group	(61)	15.93	7.30
	Control Group	(59)	9.13	2.17
	Difference		6.79	
Post-test score	Experimental Group	(61)	85.39	10.31
	Control Group	(59)	47.54	6.77
	Difference		37.85	

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Results in Table 3 show that the experimental group recorded a pre-test mean score of 15.93 (SD = 7.30), while the control group obtained 9.13, and the standard deviation is 2.17, indicating an initial mean difference of 6.80 points. This suggests that the groups differed in problem-solving ability before the intervention. Consequently, pre-test scores were included as a covariate in the ANCOVA to adjust for the initial difference. At post-test, the experimental group recorded a mean score of 85.39 and the standard deviation is 10.31, compared with 47.54 and standard deviation is 6.77 for the control group, yielding a mean difference of 37.85 points in favour of the experimental group. This indicates better problem-solving performance among students taught using inquiry-based learning than those taught using the traditional lecture method.

Research question 4

What effect does inquiry-based learning have on students' practical problem-solving skills in Electrical/Electronic Technology Education? To answer Research Question four the mean, and standard deviation students' practical problem-solving skills in Electrical/Electronic Technology Education.

Table 4: ***Mean and Standard Deviation of Pre-test score and Post-test score on the effect of inquiry-based learning on students' practical problem-solving skills in Electrical/Electronic Technology Education***

	Group of respondents	N	Mean	Std. Deviation
Pre-test score	Experimental Group	(61)	1.65	0.24
	Control Group	(59)	1.46	0.19
	Difference		0.19	
Post-test score	Experimental Group	(61)	3.96	0.24
	Control Group	(59)	2.60	0.42
	Difference		1.36	

The results in Table 4 indicate that the experimental group recorded a pre-test mean score of 1.65 and a standard deviation of 0.24, while the control group obtained 1.46 and standard deviation of 0.19, giving an initial mean difference of 0.19 points. Although the difference was smaller than that observed in problem-solving ability, the pre-test scores were still included as a covariate in the ANCOVA analysis to adjust for initial differences between the groups. At post-test, the experimental group obtained a mean score of 3.96 and a standard deviation of 0.24, compared with 2.60 and standard deviation of 0.42 for the control group, representing a mean difference of 1.36 points in favour of the experimental group.

Hypothesis 1

There is no significant difference in the cognitive performance of students taught Electrical/Electronic Technology Education using inquiry-based learning and those taught using traditional methods. To test the hypothesis, ANCOVA was used and the-results are presented in

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Table 5: ***Analysis of Covariance (ANCOVA) for test of significance difference in the cognitive performance of students taught Electrical/Electronic Technology Education using inquiry-based learning and those taught using traditional methods***

Dependent Variable: PostEETPT					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2497.578[a]	2	1248.789	13.272	.000
Intercept	36997.062	1	36997.062	393.200	.000
PreEETPT	352.935	1	352.935	3.751	.055
Group	2112.352	1	2112.352	22.450	.000
Error	11008.789	117	94.092		
Total	97036.000	120			
Corrected Total	13506.367	119			

a. R Squared = .185 (Adjusted R Squared = .171)

Table 5 shows that, after controlling for students' pre-test cognitive performance scores, there was a statistically significant difference in the post-test cognitive performance of students taught using Inquiry-Based Learning (IBL) and those taught using the traditional instructional method, $F(1, 117) = 22.45$, $p < .001$, $\eta p^2 = 0.161$. The effect size indicates that instructional method accounted for approximately 16.1% of the variance in students' post-test cognitive performance after adjusting for pre-test scores. This suggests that the instructional approach had a substantial effect on students' cognitive performance. Therefore, the null hypothesis, which stated that there was no significant difference in the cognitive performance of students taught using IBL and those taught using the traditional instructional method, was rejected.

Hypothesis 2

There is no significant difference in the practical skills of students taught Electrical/Electronic courses using inquiry-based learning and those taught using traditional methods. To test the hypothesis, ANCOVA was used and the results are presented in Table 6

Table 6: ***Analysis Of Covariance (ANCOVA) for test of significance difference in the practical skills of students taught Electrical/Electronics courses using inquiry-based learning and those taught using traditional methods***

Dependent Variable: postPSAC					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	48.80[a]	2	24.40	37.38	0.00
Intercept	58.88	1	58.88	90.21	0.00
PrePSAC	0.00	1	0.00	0.007	0.93
Group	48.78	1	48.78	74.74	0.00
Error	76.36	117	0.65		
Total	1075.17	120			
Corrected Total	125.16	119			

a. R Squared = .390 (Adjusted R Squared = .379)

below:

Table 6 shows that, after controlling for students' pre-test practical skills scores, there was a statistically significant difference in post-test practical skills between the Inquiry-Based Learning and traditional-instruction groups, reading the ANCOVA table using the row heading 'Group', we have F (1, 117) = 74.74, p<.001. R^2 = 0.390 and Adjusted R^2 = 0.379, which means that the overall ANCOVA model explains approximately 39% of the variance in post-test practical skills scores. The result indicates that the observed difference in students' practical skills between the two instructional groups was statistically significant at the 0.05 level. Therefore, the null hypothesis, which stated that there was no significant difference in the practical skills of students taught using Inquiry-Based Learning and those taught using traditional instructional methods, was rejected.

Hypothesis 3

There is no significant effect of inquiry-based learning on students' problem-solving ability in Electrical/Electronic Technology Education. To test the hypothesis, ANCOVA was used and the results are presented in Table 7 below:

Table 7: ***Analysis of Covariance (ANCOVA) for test of significance effect of inquiry-based learning on students' problem-solving ability in Electrical/Electronic Technology Education*****.**

Dependent Variable: posttestPSAT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	43171.99[a]	2	21586.00	285.75	0.00
Intercept	75261.69	1	75261.69	996.29	0.00
PrePSAT	202.83	1	202.83	2.68	0.10
Group	28122.47	1	28122.47	372.27	0.00
Error	8838.36	117	75.54		
Total	587212.00	120			
Corrected Total	52010.36	119			

a. R Squared = .830 (Adjusted R Squared = .827)

Table 7 shows that, after controlling for students' pre-test problem-solving scores, there was a statistically significant effect of instructional method on students' post-test problem-solving ability in Electrical/Electronic Technology Education, F(1, 117) = 372.27, p < .001, ηp^2 = 0.761. The partial eta squared indicates that instructional method accounted for approximately 76.1% of the variance in students' post-test problem-solving scores after adjusting for their pre-test scores. This represents a very large effect. The result suggests that students taught using Inquiry-Based Learning performed significantly better in problem-solving than those taught using the traditional instructional method. Therefore, the null hypothesis, which stated that there was no significant effect of Inquiry-Based Learning on students' problem-solving ability in Electrical/Electronic Technology Education, was rejected at the 0.05 level of significance.

Hypothesis 4

There is no significant effect of inquiry-based learning on students' practical problem-solving skills in Electrical/Electronic Technology Education. To test the hypothesis, ANCOVA was used and the results are presented in Table 8 below:

Table 8: ***Analysis of Covariance (ANCOVA) for test of significance effect of inquiry-based learning on students' practical problem-solving skills in Electrical/Electronic Technology Education***

Dependent Variable: postPSAAC

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	55.26[a]	2	27.63	230.77	0.00
Intercept	23.22	1	23.22	193.96	0.00
PrePSAAC	0.02	1	0.02	0.22	0.63
Group	47.88	1	47.88	399.93	0.00
Error	14.00	117	.120		
Total	1374.97	120			
Corrected Total	69.27	119			

a. R Squared = .798 (Adjusted R Squared = .794)

Table 8 shows that, after controlling for students' pre-test practical problem-solving skills, there was a statistically significant effect of instructional group on post-test practical problem-solving skills, reading the ANCOVA table using the row heading 'Group', we have F(1, 117) = 399.93, p<001.R^2 = 0.798 and Adjusted R^2 = 0.794, which means that the overall ANCOVA model explains approximately 80% of the variance in post-test practical problem-solving skills, after accounting for pre-test performance, associated with instructional group membership. Therefore, the null hypothesis, which stated that there was no significant effect of Inquiry-Based Learning on students' practical problem-solving skills in Electrical/Electronic Technology Education, was rejected at the 0.05 level of significance.

Discussion of findings

The findings revealed that Inquiry-Based Learning (IBL) significantly improved students' cognitive performance compared with the traditional lecture method. Despite comparable pretest performance, students exposed to IBL achieved higher post-test scores, suggesting that active investigation, questioning and evidence-based reasoning enhanced their understanding of electrical and electronic concepts. This finding aligns with Riantoni et al. (2024), who demonstrated the relevance of inquiry-based learning to students' application of electrical circuit concepts, and de Jong et al. (2023), who emphasised the value of combining inquiry with appropriate instructional guidance. Similarly, Mohammad Hussain et al. (2023) reported improved academic achievement through inquiry-based blended learning in Industrial Electronics Equipment Problem-Solving. These findings suggest that engaging students in actively constructing and applying knowledge may be more effective for conceptual learning than relying predominantly on lecturer-centred instruction.

IBL also enhanced students' practical skills, indicating that active investigation and experimentation can strengthen technical competency in EETE. Through engagement in practical activities, students had opportunities to construct circuits, perform electrical measurements, manipulate components and apply theoretical principles to technical tasks. This finding is consistent with Tokatlidis et al. (2024), who emphasised the contribution of hands-on and virtual laboratory experiences to knowledge and skills acquisition in electronic circuits, and Edevwie et al. (2024), who reported improved practical skills through reflective inquiry in electrical

installation and maintenance. Related evidence from Corral-Barraza et al. (2024) and Chrismondari et al. (2025) further demonstrates the value of inquiry-oriented and project-based learning experiences in electronics engineering and electrical installation. Collectively, these findings reinforce the importance of integrating practical investigation into EETE instruction to bridge the gap between theoretical knowledge and technical performance.

The study further established that IBL improved students' problem-solving ability. Students exposed to inquiry-based instruction demonstrated stronger capacity to identify problems, analyse information, evaluate possible solutions and apply electrical and electronic principles to problem situations. This finding is consistent with Riantoni et al. (2024) and Yu and Zin (2023), who highlighted the importance of inquiry- and problem-oriented learning experiences in developing conceptual application and critical-thinking competencies. Although problem-based learning differs from IBL, both approaches engage students in reasoning, investigating problems and evaluating solutions. The finding therefore suggests that inquiry-oriented instruction can move students beyond memorisation towards deeper understanding and the application of technical knowledge in solving electrical and electronic problems.

IBL also improved students' practical problem-solving skills, demonstrating its contribution to students' ability to apply problem-solving processes during technical activities. Students' engagement in fault diagnosis, instrument selection, measurement, testing and corrective procedures may have provided opportunities to develop more effective practical approaches to resolving electrical and electronic problems. This finding is supported by Orji (2025), who reported positive outcomes associated with problem-based instruction in practical skills acquisition among Electrical/Electronic Technology Education students. Tokatlidis et al. (2024) and Tembrevilla et al. (2024) similarly emphasised the role of laboratory engagement and experiential learning in developing practical and engineering competencies. These findings highlight the value of providing students with opportunities to investigate technical faults, test possible solutions and make evidence-informed decisions during practical instruction.

Taken together, the findings demonstrate the superiority of IBL over the traditional lecture method across cognitive performance, practical skills, problem-solving ability and practical problem-solving skills. The results reinforce constructivist and experiential learning perspectives by demonstrating the value of active knowledge construction, investigation and learning through practical experience. Beyond supporting existing evidence, the study contributes context-specific findings from public universities in North Central Nigeria, highlighting the potential of structured inquiry and guided experimentation to strengthen both conceptual understanding and technical competence in EETE. The findings therefore suggest that lecturers should integrate inquiry-based activities into electrical and electronics instruction to promote deeper learning, independent reasoning and the application of knowledge to authentic technological problems.

Conclusion

The study provides empirical evidence that inquiry-based instruction was associated with higher student outcomes than traditional instruction across cognitive performance, practical skills, problem-solving ability, and practical problem-solving skills. The findings were statistically significant after controlling for relevant pre-test measures. In the context of EETE, the results support instructional practices that combine questioning, investigation, experimentation, practical activity, collaboration, troubleshooting, and reflection.

Recommendations

1. EETE lecturers should incorporate structured and guided inquiry activities into appropriate theoretical and practical courses.
2. Universities should strengthen laboratory resources to support experimentation, prototyping, measurement, and troubleshooting.
3. Continuous professional development should be provided to enable EETE lecturers to design, facilitate, and assess inquiry-based learning.
4. Curriculum planners should create opportunities for authentic technical investigation and problem-solving within EETE programmes.
5. Further studies should compare different forms of inquiry, including structured, guided, and open inquiry, using larger samples and multiple institutions.
6. Future research should examine the use of hands-on inquiry in combination with computer simulation for difficult electrical/electronic concepts.

References

Chrismondari, Simatupang, W., Waskito, Fadillah, R., & Rianto, B. (2025). Implementation of a project-based inquiry learning model for electrical motor installation: Evaluating its effectiveness in vocational education. *Data and Metadata,* 4, Article 1079. https://doi.org/10.56294/dm20251079

Corral-Barraza, L., Gómez-Elizalde, J., Morán-Soto, G., Godínez-García, F., & González Peña, O. I. (2024). Transforming electronics engineering classrooms: Fostering students' motivation to design technological solutions through inquiry-based learning. *IEEE Access*, 12, 88585–88595. https://doi.org/10.1109/ACCESS.2024.3413011

de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedinger, K. R., Krajcik, J. S., Kyza, E. A., Linn, M. C., Pedaste, M., Scheiter, K., & Zacharia, Z. C. (2023). Let's talk evidence—The case for combining inquiry-based and direct instruction. *Educational Research Review,* 39, Article 100536. https://doi.org/10.1016/j.edurev.2023.100536

de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedinger, K. R., Krajcik, J. S., Kyza, E. A., Linn, M. C., Pedaste, M., Scheiter, K., & Zacharia, Z. C. (2024). Beyond inquiry or direct instruction: Pressing issues for designing impactful science learning opportunities. *Educational Research Review,* 44, Article 100623. https://doi.org/10.1016/j.edurev.2024.100623

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum Press

Edevwie, L. O., Obi, M. N., & Okoye, P. I. (2024). Effect of reflective inquiry instructional strategy on students' practical skills in electrical installation and maintenance works in technical colleges, Delta State. *NAU Journal of Technology and Vocational Education, 9*(1). https://journals.unizik.edu.ng/index.php/naujtved/article/view/4780

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Li, J., & Liang, W. (2024). Effectiveness of virtual laboratory in engineering education: A meta-analysis. *PLOS ONE, 19*(12), Article e0316269. https://doi.org/10.1371/journal.pone.0316269

Mohammad Hussain, M. A., Ahmat Zainuri, N., Mohd Zulkifli, R., & Abdul Rahman, A. (2023). Effect of an inquiry-based blended learning module on electronics technology students' academic achievement. *Journal of Technical Education and Training*, 15(2), 21–32. https://journal.uthm.edu.my/index.php/JTET/article/view/11871

Orji, C. T. (2025). Efficacy of problem-based intervention on engagement and practical skills acquisition among electrical/electronic technology education students. *Discover Education*, 4, Article 522. https://doi.org/10.1007/s44217-025-00736-8

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., &Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review,* 14, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Piaget, J. (1970). *Science of education and the psychology of the child* (D. Coltman, Trans.). Orion Press.

Riantoni, C., Rusdi, R., Maison, M., & Yelianti, U. (2024). An analysis of students' concept application in problem-solving of electrical circuits through inquiry-based learning.

Indonesian Journal of Science and Mathematics Education, 7(3), 451–465. https://doi.org/10.24042/ijsme.v7i3.22874

Tembrevilla, G., Phillion, A., &Zeadin, M. (2024). Experiential learning in engineering education: A systematic literature review. *Journal of Engineering Education*, 113(1), 195–218. https://doi.org/10.1002/jee.20575

Tokatlidis, C., Tselegkaridis, S., Rapti, S., Sapounidis, T., & Papakostas, D. (2024). Hands-on and virtual laboratories in electronic circuits learning—Knowledge and skills acquisition. *Information,* 15(11), Article 672. https://doi.org/10.3390/info15110672

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press.

Yu, L., & Zin, Z. M. (2023). The critical thinking-oriented adaptations of problem-based learning models: A systematic review. *Frontiers in Education,* 8, Article 1139987. https://doi.org/10.3389/feduc.2023.1139987