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# Effects of Project-Based Learning Strategy on Academic Achievement and Skill-Acquisition in Foundry and Forging among Federal College of Education (Technical) Students in Northwest Nigeria

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## Abstract

*Technical and Vocational Education and Training (TVET) plays an important role in developing skilled manpower for technological advancement and industrial productivity. However, the academic achievement and practical skill-acquisition of Foundry and Forging among College students in North-West Nigeria remain persistently low due to inadequate instructional methods and limited practical engagement. This study investigated the effects of project-based learning ($P_jBL$) on the academic achievement and skill acquisition of students in a Foundry (sand casting). This study was guided by two research questions and two null hypotheses. A quasi-experimental pre- and post-test non-equivalent control group design was adopted. The study population comprised 32 NCE Metalwork Technology students in Colleges of Education in North-West Nigeria. The Foundry Achievement Test (FAT) and Foundry Skill-Acquisition Observation Schedule (FSAOS) were used for data collection. Mean and standard deviation were used to answer the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance. The findings revealed that students taught using PjBL achieved higher mean scores in academic achievement and skill acquisition than those taught using the lecture method. The ANCOVA results showed significant differences in academic achievement ($F = 14.815$, $p = .001$, $\eta^2 = .338$) and skill acquisition ($F = 398.641$, $p = .001$, $\eta^2 = .932$) in the $P_jBL$ group. The study concluded that PjBLis more effective than the lecture method in improving students' learning outcomes in foundry (sand casting).*

**Keywords:** Project-Based Learning, Academic Achievement, Skill Acquisition, Foundry and Forging, Colleges of Education.

## Introduction

Technical and Vocational Education and Training (TVET) is a key sector for equipping learners with practical competencies that align with labor market demands and national development goals. Global organizations such as the World Bank (2023) and the International Labor Organization (2023) stress that effective TVET systems improve employability, productivity, and school-to-work transition. Similarly, Chukwu, Adegbite and Yusuf (2024) noted that TVET significantly contributes to workforce preparation, productivity, income generation, and social equity. In Nigeria, TVET is integrated into the education system through the National Policy on Education, which aims to train the workforce in applied sciences, technology, and commerce (FRN, 2013). Therefore, colleges of education, polytechnics, and universities offer therefore offer Metalwork, Electrical/Electronic, Building, and Automobile Technology programs to develop industry-relevant technical skills. Minimum standards, curriculum supervision, and quality assurance are

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maintained, through the National Commission for Colleges of Education (NCCE), especially within the Nigeria Certificate in Education (NCE) programs (NCCE, 2020). Colleges of Education (Technical) combine classroom instruction, workshop practice, and industrial experiences to produce competent and self-reliant graduates capable of contributing to national technological and economic development. Effective TVET delivery depends on modern facilities, qualified instructors, and learner-centered approaches such as project-based learning (Oviawe, Uwameiye & Uddin, 2020), in addition the inclusion of different trade areas helps prepare graduates for vocational teaching and workshop management (Paiko & Abdulrahman, 2023), particularly in metalwork technology.

Metalwork technology is a specialized area of TVET that focuses on metal fabrication, processing, and production through foundry, forging, welding, machining, and fabrication techniques National Center for Chemical Engineers, 2020). The program combines theory with practical workshop activities to develop students' technical competence, creativity, and problem-solving abilities, while also preparing prospective teachers for effective instructional delivery (Ogbuanya & Efuwape, 2019). Foundry involves producing castings by melting and pouring metal into molds, including processes such as sand casting, which remains widely used because of its versatility and low cost (Alabi & Mohammed, 2020; McClements, 2023; Khurmi & Gupta, 2023). Forging, on the other hand, involves shaping heated metal through compressive forces such as hammering or pressing (Afolabi, Oke, & Alabi, 2024). These processes help students develop competencies in heat application, tool handling, material properties, and workplace safety (Adeniyi, 2023). However, students' achievement in foundry and forging in technical colleges remains low due to inadequate facilities, obsolete equipment, poor funding, limited industrial exposure, and shortage of qualified instructors (Odesanmi & Nuhu, 2024; Olatoye & Adebisi, 2021; Okolie, Igboanugo & Nwajiaba, 2022). Traditional lecture methods further limit the practical mastery and creativity of students making learner-centered strategies such as Project-Based Learning ($P_j$BL) necessary. $P_j$BL engages students in solving real-world problems through active participation, collaboration, and project execution, thereby improving motivation, critical thinking, skill acquisition, retention, and academic achievement (Adams & Nsiah-Gyabaah, 2021; Vygotsky, 1978). Research also indicates that $P_j$BL enhances engagement, collaboration, and problem-solving skills in technical and vocational education (Lavado-Anguera, López-Serrano, & Cañabate, 2024; Goshu & Ridwan, 2024), thereby improving academic achievement. Academic achievement in Foundry and Forging within metalwork technology education reflects students' ability to combine theoretical knowledge with practical competencies in casting, molding, melting, and forging processes. It serves as an important indicator of learning outcomes and students' readiness for industrial practice and technical training. Okwelle and Okeke (2019) explained that academic achievement in technical education measures not only knowledge acquisition but also the practical skill's effective application in industrial contexts. Despite its importance, the achievement of students in Foundry and Forging has remained low. Ogundu and Wordu (2014) attributed poor achievement to inadequate equipment and conventional teaching methods. Similarly, Adamu, Hassan, Muhammad, and Ali (2024) reported that only 41% of NCE metalwork students in NW Nigeria passed Foundry examinations between 2016/2017 and 2018/2019, while 59% failed. These findings highlight the persistent low performance in Foundry and Forging and the need for innovative instructional approaches to improve academic achievement and skill acquisition.

Skill acquisition in Foundry and Forging is essential for developing competencies in pattern making, molding, core making, melting, casting, and forging, enabling students to apply theoretical knowledge to practical industrial tasks. However, studies show that students often demonstrate low practical competence due to inadequate facilities, obsolete equipment, and reliance on teacher-centered instructional methods Igharo & Obed, 2024; Pindiga 2025 identified serious deficiencies in students' practical competencies in foundry operations, while Igharo and Obed (2024) reported that limits students' hands-on experiences are limited by non-functional workshop equipment. These challenges suggest that many students graduate without adequate mastery of critical foundry and forging skills, emphasizing the need for learner-centered teaching strategies that can improve academic achievement and skill acquisition. Therefore, this study investigates the effects of project-based learning on academic achievement and skill-acquisition in foundry and forging among students in the Colleges of Education in Northwest Nigeria.

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## Statement of the problem

Students' academic achievement in Foundry and Forging in Metalwork Technology has remained consistently low among NCE students in Colleges of Education (Technical) in Northwest Nigeria. Examination records from colleges of education (technical) in the study area have shown persistently low academic achievement of students in the foundry and forging courses over the years. This persistent low achievement is a major concern because foundry and forging are the core practical components of Metalwork technology required for the development of technical competencies and mastery of practical skills among student teachers. Despite the importance of foundry and forging for industrial and technological development, students continue to perform below expectations in the Foundry and Forging examinations. Persistently low academic achievement may limit students' ability to acquire the practical competencies required for effective teaching and industrial productivity after graduation. Available records have shown a persistent decline in achievement of students in the course. Evidence from the examination offices of the colleges of education (Technical) in the foundry and forging areas revealed the results in Table 1.

**Table 1 Result of the Colleges of Education Metalwork Technology Students' Academic Achievement in Foundry and Forging from 2020 – 2024 academic sessions.**

| Academic session | No of students who sat | No of students pass | failed students | % pass | % failed |
|---|---|---|---|---|---|
| 2019/2020 | 157 | 67 | 90 | 43% | 57% |
| 2020/2021 | 136 | 60 | 76 | 44% | 56% |
| 2021/2022 | 94 | 52 | 42 | 55% | 45% |
| 2022/2023 | 124 | 53 | 71 | 43% | 57% |
| 2023/2024 | 77 | 33 | 44 | 43% | 57% |
| Total | 588 | 265 | 323 | 46% | 54% |

**Source: Examination offices of the Colleges of Education (Technical), North-West Nigeria, 2024.**

Table 1 highlights a declining trend in academic achievement in Foundry and Forging, which has been partly attributed to inadequate teaching methods that fail to equip students with both cognitive knowledge and practical skills in metalwork technology (Igrubia, Shetima & Paul, 2021; Eze & Osuyi, 2020; Osuyi & Abusomwan, 2021). This situation underscores the need for instructional approaches that enhance skill acquisition, motivation, and retention, as low student motivation has been identified as a key factor influencing academic performance (Mahmud, 2023). Innovative strategies such as Project-Based Learning (PjBL) have been recommended to address these challenges as they engage students in hands-on, real-world projects, improve problem-solving abilities, enhance skill mastery, and foster long-term knowledge retention (Ahmed & Bello, 2022). Despite its potential, there is limited empirical evidence on the effectiveness of PjBL in Foundry and Forging in Metalwork Technology Education in Northwest Nigeria, prompting this study to examine its effects on students' academic achievement and skill acquisition.

## Research Questions

The following research questions were answered:

1. What is the mean difference in the academic achievement scores of students taught Foundry (sand casting) using Project-Based Learning and those taught using lecture methods among colleges of education, in North-West Nigeria?
2. What is the mean difference in skill acquisition scores of students taught Foundry (sand casting) using Project-Based Learning and those taught using lecture methods among the colleges of education, North-West Nigeria?

## Null Hypotheses

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

**$Ho_1$.** There was no significant difference in the mean academic achievement scores of the foundry (sand casting) taught by students using Project-Based Learning and those taught using the lecture method among colleges of education in North-West Nigeria.

**$Ho_2$.** There was no significant difference in the mean skill acquisition scores of the Foundry (sand casting) using Project-Based Learning and those taught using the lecture method among colleges of education in North-West Nigeria.

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## Literature Review

Project-based learning ($P_jBL$) is a learner-centered instructional strategy that promotes active student participation through practical projects, collaborative learning, problem-solving activities, and real-life task engagement, thereby enhancing meaningful understanding and practical competence among learners. Empirical studies have shown that PjBL and other learner-centered instructional approaches significantly improve academic achievement and skill acquisition in technical and vocational education due to increased participation, hands-on experiences, and active involvement in workshop activities (Adams & Nsiah-Gyabaah, 2021; Ahmed & Bello, 2022; Goshu & Ridwan, 2024). Studies also revealed that practical engagement and project-oriented instruction strengthen students' understanding of technical concepts and improve long-term retention and psychomotor performance in metalwork technology (Ogbuanya & Efuwape, 2019; Oviawe, Uwameiye, & Uddin, 2020). Project-based instructional approaches enhance creativity, critical thinking, teamwork, and problem-solving abilities among technical education students, particularly in practical trades such as foundry and forging (Lavado-Anguera, López-Serrano, & Cañabate, 2024; Adeniyi, 2023). However, despite the growing evidence supporting PjBL in technical and vocational education, studies focusing specifically on its effects on students' academic achievement and skill acquisition in Foundry and Forging among colleges students in North-West Nigeria remain limited.

**Theoretical Framework**

This study is anchored on Vygotsky's Social Constructivist Theory and Walberg's Theory of Educational Productivity, which collectively explain how PjBL enhances students' academic achievement and skill acquisition through collaboration, active participation, and instructional effectiveness. Vygotsky's Social Constructivist Theory (1978) Social Constructivist Theory explains learning as a social process in which knowledge is constructed through interaction, collaboration, and guided participation. In PjBL students work collaboratively on practical foundry and forging tasks, share ideas, solve problems, and learn from peers and instructors, thereby improving understanding, critical thinking, and practical competence in metalwork technology (Vygotsky, 1978; Oviawe, Uwameiye, & Uddin, 2020). Walberg's Theory of Educational Productivity (1981) emphasizes that instructional quality, motivation, and learning environment. Influence learning outcomes. In PjBL, students engage in practical projects, collaborative activities, and real-world problem-solving tasks that improve instructional effectiveness, learner motivation, and practical performance. The theory further explains that meaningful learning occurs when students are actively involved in the learning process using appropriate instructional strategies and supportive learning environments. Together, these theories provide a strong foundation for the study by explaining how Project-Based Learning improves students' academic achievement and skill acquisition in Foundry and Forging among college students in NW Nigeria.

## Research Methodology

This study adopted a non-equivalent, non-randomized, quasi-experimental design with pre- test and post- tests. The independent variable, Project-Based Learning, was manipulated to determine its effect on students' academic achievement and skill acquisition in Foundry and Forging. A pretest was administered to both the experimental and control groups to determine the equivalence of the groups in terms of prior knowledge and ability before the treatment. After the treatment, a post-test was administered to both groups to determine the effectiveness of the treatment and to measure academic achievement and skill acquisition of the students in foundry and forging. The data obtained from both the experimental and control groups were analyzed using descriptive and inferential statistics respectively. The descriptive statistics of mean and standard deviation were used to answer the research questions. Inferential statistics, specifically analysis of covariance (ANCOVA), were used to test the hypotheses the 0.05 level of significance using Statistical Package for Social Sciences (SPSS) version 21.

## Presentation of the Results

**Research Question 1:** What is the mean difference in the academic achievement scores of students taught Foundry (sand casting) using Project-Based Learning and those taught using lecture methods among the colleges of Education in North-West Nigeria?

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**Table 5: Pre and Post-test Mean Scores of Academic Achievement of Foundry (sand casting) Metalwork Students Taught Using Project Based Learning and Those Taught Using Lecture**

| Groups | | Post-test | | | | |
|---|---|---|---|---|---|---|
| | N | $\bar{\chi}$ | SD | $\bar{\chi}$ | SD | Mean Gain |
| Experimental Group | 16 | 9.81 | 3.06 | 19.31 | 3.17 | 9.5 |
| Control Group | 16 | 10.56 | 2.45 | 15.06 | 1.76 | 4.5 |
| Mean Difference | | 0.75 | | 4.25 | | 5.0 |

The result presented in Table 5 shows that the experimental group that were taught Foundry (sand casting) using PjBL had a mean score of 9.81 and SD of 3.06 in the pretest and a mean score of 19.31 and SD of 3.17 in the post-test making a pre and post-test mean gain in this experimental group to be 9.5. The control group that was taught using lecture method had a mean score of 10.56 and SD of 2.45 in the pre-test and a mean score of 15.06 and SD of 1.76 in the post-test making pre-test and the post-test mean gain was 4.5. The mean gain difference of 5.0 was in favored of the experimental group taught using $P_jBL$. These results indicate that both project-based learning and lecture the methods are effective in enhancing the academic achievement of sand-casting students. However, the results indicated that the effect of $P_jBL$ on the academic achievement of metalwork in sand casting is higher than that of the lecture method. Therefore, $P_jBL$ is more effective than the lecture method.

**Hypothesis 1:** There is no significant difference in the mean academic achievement scores of Foundry (sand casting) taught by students using Project-Based Learning and those taught using the lecture method among colleges of education in North-West Nigeria.

**Table 6: Analysis of Covariance (ANCOVA) of the Test of Significance Difference of Student Academic Achievement of Students Taught Foundry (sand casting) metalwork Using Project Based Learning and Those Taught Using Lecture Method**

| Source | Type III sum of squares | Df | Mean Square | F | Sig. | Partial eta squared |
|---|---|---|---|---|---|---|
| Corrected Model | 136.087[a] | 2 | 68.043 | 10.924 | .000 | .430 |
| Intercept | 864.990 | 1 | 864.990 | 138.872 | .000 | .827 |
| PRETEST | 27.305 | 1 | 27.305 | 4.384 | .045 | .131 |
| GROUP | 92.278 | 1 | 92.278 | 14.815 | .001 | .338 |
| Error | 180.632 | 29 | 6.229 | | | |
| Total | 9463.000 | 32 | | | | |
| Corrected Total | 316.719 | 31 | | | | |

a. R Squared = .430 (adjusted R Squared = .390)

The result presented in the Table 6 show that the pretest value had a type III sum of square of 27.305 at df of 1 with an F-calculated value of 4.384 and a significance value of .045, which is less than 0.05. This implies that the pretest had a significant influence on the students post-test scores and was therefore controlled using ANCOVA. The result further shows that the type III sum of square for group is 92.278 at df of 1, F-calculated value is 14.815 with a significance of F at .001 which is less than 0.05. The results revealed that a significant difference between the effects of treatments (project-based learning and lecture method) on the academic achievement of metalwork students in the Foundry (sand casting). Therefore the null hypothesis is rejected at the 0.05 level of significance. Therefore, there is a significant difference in the mean academic achievement scores of metalwork students taught Foundry (sand casting) using PjBL and those taught using lecture methods in favor of the PjBL group.

**Research Question 2:** What is the Skill-Acquisition scores of students taught Foundry (sand casting) using Project-Based Learning and those taught using lecture methods among the colleges of education in North-West Nigeria?

| Groups | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| | N | $\bar{\chi}$ | SD | $\bar{\chi}$ | SD | Mean Gain |
| Experimental Group | 16 | 14.13 | 1.26 | 32.19 | 2.56 | 18.06 |
| Control Group | 16 | 14.06 | 1.24 | 24.13 | 2.22 | 10.07 |
| Mean Difference | | 0.07 | | 8.06 | | 7.99 |

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**Table 7: Mean Scores for skill acquisition of students taught Foundry (sand casting) using Project-Based Learning and those taught using lecture method methods**

The result presented in Table 7 show that the experimental group taught foundry (sand casting) using PjBL had a mean score of 14.13 with a standard deviation of 1.26 and a post-test mean score of 32.19 with a standard deviation of 2.56, resulting in a mean gain of 18.06. The control group taught using the lecture method had a pre-test mean score of 14.06 with a standard deviation of 1.24 and a mean score of 24.13 with a standard deviation of 2.22, resulting in a mean gain of 10.07. The mean difference between the post-test scores of the two groups was 8.06 in favor of the experimental group. This implies that students in the Foundry (sand casting) classes taught using PjBL acquired more practical skills than those taught using the lecture method among the colleges of education in NW Nigeria.

**Hypothesis 2:** There is no significant difference in the mean skill-acquisition scores of the Foundry (sand casting) taught by students using PjBL and those taught using the lecture method among the colleges of education in North-West Nigeria.

**Table 8: Analysis of Covariance (ANCOVA) of the Test of Significance Difference of Students' Skill-Acquisition of Metalwork Students Taught Foundry (sand casting) Using Project-Based Learning and Those Taught Using Lecture Method**

| Source | Type III sum of squares | Df | Mean Square | F | Sig. | Partial eta squared |
|---|---|---|---|---|---|---|
| Corrected Model | 655.405a | 2 | 327.702 | 258.145 | .001 | .947 |
| Intercept | 4.033 | 1 | 4.033 | 3.177 | .085 | .099 |
| SKILL_PRE | 135.373 | 1 | 135.373 | 106.640 | .001 | .786 |
| GROUP | 506.054 | 1 | 506.054 | 398.641 | .001 | .932 |
| Error | 36.814 | 29 | 1.269 | | | |
| Total | 26061.000 | 32 | | | | |
| Corrected Total | 692.219 | 31 | | | | |

The results presented in Table 8 show that the pre-test value had a Type III sum of squares of 135.373 at a degree of freedom of 1 with an F-calculated value of 106.640 and significance value of .001, which is less than 0.05. This implies that the pre-test significantly influenced the post-test skill acquisition scores of the students and was therefore controlled using AoC. The result further revealed that the Type III sum of squares for the group was 506.054 at a degree of freedom of 1 with a F-calculated value of 398.641 and a significance value of .001, which is less than 0.05. The results indicate that there was a significant difference between the effects of PjBL and lecture method on students' skill acquisition in Foundry (sand casting) among colleges of education in NW Nigeria. Therefore, the null hypothesis was rejected at the 0.05 level of significance. This implies that students who were taught Foundry (sand casting) using Project-Based Learning acquired significantly more practical skills than those taught using lecture method.

## Discussion of the Findings

The findings of Research Question 1 revealed that students taught Foundry (sand casting) using PjBL demonstrated higher academic achievement compared to those taught using the conventional lecture method. This indicates that PjBL provides learners with opportunities to improve their understanding of concepts through active participation and problem-solving activities. This finding is consistent with previous studies that reported that PjBL enhances students' academic achievement in technical and vocational subjects.

Hypothesis 1 further a revealed that there is a significant difference in the mean academic achievement scores of students taught Foundry (sand casting) using PjBL and those taught using the lecture method, in favor of the PjBL group. This indicates that learner-centered and activity-based instruction enhances the understanding of Foundry students of technical concepts.

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The findings of Research Question 2 showed that students taught Foundry (sand casting) using PjBL acquired higher practical skills than those who were taught using the conventional lecture method. This implies that active participation in project-based tasks enhances practical competence and improves psychomotor performance. Hypothesis 2 further revealed a significant difference in the mean skill acquisition scores of students taught Foundry (sand casting) using PjBL and those taught using the lecture method, in favor of the Project-Based Learning group. Overall, the findings of this study indicate that PjBL is more effective than the lecture method in improving students' academic achievement and skill acquisition in foundry (sand casting).

## Conclusions

Based on the findings of this study, the following conclusions were drawn:

1. Students who were taught Foundry (sand casting) using Project-Based Learning demonstrated higher academic achievement than those who were taught using the lecture method.
2. Project-Based Learning significantly enhanced the skill acquisition of students in the Foundry (sand casting) compared to the lecture method.
3. Project-Based Learning was more effective in improving the academic achievement and skill acquisition of Foundry (sand casting) students than the lecture method among students in the Colleges of Education in North-West Nigeria.
4. Overall, PjBL proved to be a more effective instructional strategy for improving students' learning outcomes in Foundry (sand casting) than the lecture method.

## Recommendations

Based on the findings of this study, the following recommendations were made:

1. Project-Based Learning should be adopted as a major instructional strategy for teaching Foundry (sand casting) in the colleges of education.
2. Regular training and professional development programs should be organized for metalwork lecturers to equip them with the skills required for the effective implementation of PjBL strategies.
3. Government and college administrators should provide adequate workshop facilities, tools, equipment, and instructional materials necessary for the effective implementation of PjBL in metalwork workshops.
4. The curriculum for technical and vocational education should be reviewed to strengthen the integration of PjBL approaches.
5. Collaborative and interactive learning environments should be encouraged in colleges of education to promote students' active participation, teamwork, and practical competence.

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