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Effect of Competency-Based Instructional Approach on Graduate Students Academic Performance in Sand-Casting Foundry Practice in Rivers State Universities

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ABSTRACT

This study examined the effect of competency-based instructional approach on graduate students' academic performance in sand-casting foundry practice in Rivers State Universities. Four research questions were answered with corresponding null hypotheses formulated and tested at 0.05 level of significance. The study employed Quasi-Experimental design. The study has a population of 84 all registered students of industrial technology education 2025\2026 academic section in Rivers State owned universities. The sample for the study was 28 Mechanical technology education master degree students were selected using purposive sampling technique. The instrument used for data collection was Sand-Casting Performance Test (SCPT), developed by the researcher and tested for reliability using test-retest method. Data collected were analyzed and reliability coefficient of 0.82 was established for the study. Mean and standard deviation were used to answer research questions while hypotheses were tested using Analysis of Covariance (ANCOVA). Findings from the study revealed amongst others that students taught mould making, core setting, molten metal pouring, cooling and shake felting using competency based instructional approach performed better than those taught using conventional lecture method. Based on the findings, the recommendation made amongst others includes that competency based instructional approach should be encouraged as this would help students to master tasks at their own pace.

Keywords: Competency-Based Instruction, sand casting skill domain, academic performance**.**

INTRODUCTION

Nigeria, a nation richly endowed with both human and material resources, continues to pursue technological transformation through a structured system of technical education that spans from technical colleges to tertiary institutions: Universities, Polytechnics, Monotechnics, and Colleges of Education (Technical), with universities occupying the apex of academic and research-driven manpower development. In the Nigerian context, Universities are established not only to advance knowledge through teaching, research, and community service but also to produce high-level technical and professional manpower capable of driving innovation and industrial competitiveness, under the regulatory supervision

of the National Universities Commission (NUC) which ensures quality assurance, programme accreditation, and academic standards. Unlike Polytechnics whose mandate traditionally emphasizes technician and technologist training, Universities are structured to integrate theoretical depth with advanced practical exposure, thereby preparing graduates for leadership roles in engineering, technology, and industrial education.

Scholars have consistently argued that University-based technical and technology education programmes are expected to turnout graduates who possess analytical competence, research capability, and applied technical skills necessary for solving complex industrial problems and promoting sustainable development. Consequently, programmes within Faculties of Engineering, Technology, and Industrial Technology Education in Nigerian Universities are designed to cultivate high-level competencies in areas such as Mechanical Engineering, Metallurgical and Materials Engineering, Manufacturing Processes, Industrial Technology Education and Foundry Technology, ensuring that graduates are not merely knowledgeable but are academically and technically proficient to contribute meaningfully to national technological advancement.

Foundry Technology is a core component of metal-based industrial and technology education programmes. This is especially true in Industrial Technology Education, Mechanical, Metallurgical and Materials Engineering disciplines. It serves as the foundation for metal casting processes that are essential to manufacturing and industrial production. Foundry Technology is a branch of manufacturing that deals with the science and art of producing metal components. This is done through the melting and pouring of molten metal into prepared moulds. The metal then solidifies into desired shapes for engineering applications (Kalpakjian & Schmid, 2018). Scholars in manufacturing education describe casting as one of the oldest yet most versatile production processes. It is widely used in industries such as automotive, aerospace, construction, and heavy machinery. This is because of its capacity to produce complex geometries economically and efficiently. Within this broad field, Sand-Casting remains the most widely used moulding process. This is due to its relative simplicity, adaptability, and cost-effectiveness. It is used in both small-scale and large-scale production environments (Idibia, Thomas, & Ugoji, 2020).

According to Kanondu, Deebom and Dokubo (2023), foundry work is highly versatile. This is because it accommodates both ferrous and non-ferrous metals. It also supports the production of intricate geometries. Such shapes may be difficult or uneconomical to achieve through other forming methods. Standard production stages include pattern preparation, mould making, core setting where necessary, melting and pouring. Others are solidification, shake-out, fettling, inspection, and defect correction. Each stage demands precise technical knowledge and psychomotor skill. These are needed to ensure dimensional accuracy, structural integrity, and surface quality.

In university foundry laboratories, Sand-Casting is not taught only as a theoretical concept. It is also taught as a performance-oriented practical exercise. Students are required to demonstrate competence in sand preparation, gating system design, temperature control, defect diagnosis such as blowholes and shrinkage cavities, and adherence to safety standards. Because of its process-driven and skill-intensive nature, mastery of Sand-Casting requires structured instructional strategies that emphasize measurable learning outcomes, hands-on engagement, and demonstrable proficiency, thereby reinforcing the need to critically examine instructional approaches that can enhance graduate students' academic and practical performance in this vital area of Foundry Technology.

However, the effectiveness of this training depends significantly on the instructional approach adopted, as foundry processes such as Sand-Casting are skill-intensive, performance-based, and require measurable demonstration of competence rather than passive acquisition of knowledge, thus establishing a logical pathway toward examining competency-based instructional strategies in the teaching and learning of Sand-Casting within Foundry Technology programmes. Competency-based instructional approach is a learner-centred teaching approach that emphasizes the acquisition and demonstration of clearly defined knowledge, skills, attitudes, and competencies required for successful performance in a particular discipline or occupation. Unlike the conventional lecture method, which often emphasizes the completion of course content within a specified period, competency-based instruction organizes learning into clearly

defined competencies that are broken down into specific tasks and performance objectives. Complex practical activities are systematically divided into smaller, sequential learning units, enabling learners to acquire one competency at a time. The instructor identifies the expected learning outcomes, demonstrates each task, provides guided practice, and allows learners sufficient opportunities to perform each activity repeatedly until the required standard of competence is achieved. Progression from one competency to another is based on demonstrated mastery rather than time spent in the classroom. Throughout the instructional process, continuous assessment is used to evaluate learners' performance against predetermined competency standards. Constructive feedback is provided immediately after each learning activity to identify areas of strength and weakness, while corrective instruction, additional demonstrations, remediation, and repeated practice are offered whenever learners fail to attain the expected level of competence. This cycle of instruction, practice, assessment, feedback, correction, and reassessment continues until learners demonstrate satisfactory mastery of each competency before advancing to the next learning task.

The competency-based instructional approach is particularly suitable for technical and vocational education because it integrates theoretical knowledge with practical performance and ensures that learners develop competencies that meet industry standards. In foundry practice, for instance, competencies such as interpreting job specifications, preparing moulding sand, producing patterns, assembling moulds, melting metals, pouring molten metal safely, removing castings, fettling, inspecting finished products, and observing workshop safety procedures can be taught as separate but interconnected competency units. Learners are expected to demonstrate proficiency in each of these tasks before progressing to subsequent operations, thereby minimizing learning gaps and promoting mastery of practical skills. Regular formative assessment, timely feedback, and corrective instruction enhance students' confidence, improve skill retention, reduce errors during practical exercises, and encourage independent learning. By ensuring that every learner achieves mastery of each competency before moving to the next stage, competency-based instruction promotes higher academic performance, practical competence, problem-solving ability, and workplace readiness. Consequently, the approach is increasingly recognized as an effective instructional strategy for improving learning outcomes in skill-oriented disciplines such as mechanical technology, where successful performance depends on the mastery of practical competencies rather than the completion of instructional time alone.

The Competency-Based Instructional (CBI) Approach represents a paradigm shift, prioritizing the demonstrable acquisition of specific skills, knowledge, and attitudes over traditional time-bound or theory-heavy instruction. Unlike conventional methods that measure learning through attendance and rote memorization, CBI emphasizes outcomes and performance, ensuring that learners can competently execute tasks and solve real-world problems relevant to their field of study. In the context of technical education and foundry technology, this approach aligns learning objectives directly with industrial competencies, such as pattern making, sand preparation, gating design, and molten metal handling in sand casting, thereby fostering both psychomotor mastery and cognitive understanding. Alt, Naamati-Schneider and Weishut, (2023), argue that CBI enhances student engagement and retention because it provides clear benchmarks for success, continuous assessment, and immediate feedback, allowing learners to progress only upon demonstrating proficiency. Competency-based methods not only improve practical skill acquisition but also enhance academic performance, as students develop confidence, problem-solving ability, and readiness for industry-specific challenges (UNESCO-UNEVOC, 2020). By centering instruction on clearly defined competencies rather than rigid curricula or lecture hours, CBI creates a learning environment where mastery, relevance, and accountability drive both teaching and assessment, making it particularly suitable for skill-intensive programmes such as Sand-Casting within Foundry Technology (UNESCO, 2020).

Teaching approach in sand casting, as a core component of Foundry Technology, encompasses a sequence of technically intricate operations that require the integration of conceptual understanding, procedural accuracy, safety consciousness, and refined psychomotor coordination. The complexity of pattern design, mould preparation, gating and riser configuration, melting control, pouring techniques,

solidification management, and defect diagnosis demands not only exposure but demonstrable mastery if universities are to produce competent foundry technologists capable of contributing meaningfully to industrial development.

The adoption of a Competency-Based Instructional (CBI) approach in teaching Sand-Casting may ensure that instruction is outcomes-focused, measurable, and tailored to the mastery of specific skills, rather than purely content-driven. Through structured learning activities, continuous assessment, and performance evaluation, CBI allows students to demonstrate their ability to perform each stage of Sand-Casting independently and proficiently, bridging the gap between theoretical knowledge and industrial practice. Kanondu, Deebom, and Dokubo (2023) indicates that when Sand-Casting instruction aligns with mastery frameworks, learners show improved skill retention, enhanced problem-solving ability, and higher academic performance, thereby producing graduates who are both technically adept and industry-ready.

Rasul, Abd Rauf, and Rashid (2019) as well as Okoye and Okwelle (2021) affirmed that competency-based instructional models enhance skill retention, academic performance, learner autonomy, and workplace readiness because assessment emphasizes performance and mastery rather than examination-centered evaluation. Within the context of sand casting, this perspective implies that graduate students must not merely describe moulding procedures or casting defects but should competently execute mould preparation, control pouring parameters, analyze casting flaws, and apply corrective measures under supervised and assessed conditions. Therefore, embedding a competency-based instructional approach in the teaching of Sand-Casting at the university level becomes not merely a pedagogical preference but an academic and industrial necessity. By structuring learning around clearly articulated task, observable performance indicators, continuous formative assessment, and mastery validation, universities can better ensure that graduates of Industrial Technology Education possess the practical and analytical capabilities required for effective professional practice.

The quality of graduates produced by technical education institutions depends largely on the effectiveness of the instructional approaches employed during teaching and learning. Traditionally, technical education has relied on conventional teaching methods in which instruction is organized around predetermined course content and fixed instructional time. Under this approach, lecturers are primarily responsible for transmitting knowledge through lectures, demonstrations, and practical exercises, while students are expected to complete learning activities within the scheduled period regardless of differences in their learning pace or level of understanding. Assessment is often conducted at the end of instruction to determine students' achievement, with limited opportunities for remediation before learners progress to subsequent topics. Although the conventional teaching method facilitates curriculum coverage, it may not adequately address individual learning needs or ensure that every learner acquires the practical competencies required for effective performance in skill-based disciplines such as foundry practice.

In response to these limitations, Competency-Based Instruction (CBI) has gained increasing recognition as a learner-centred instructional approach that emphasizes the demonstration of clearly defined competencies rather than the completion of instructional content within a specified period. According to Bloom (1968), mastery learning, which underpins competency-based instruction, is founded on the principle that nearly all learners can attain high levels of achievement when they are provided with adequate learning time, continuous formative assessment, timely feedback, and corrective instruction before progressing to subsequent learning tasks. Bloom (1976) further explained that learners should demonstrate mastery of one competency before advancing to another, Başar, Tekkol, & Gelbal, (2016) argued that mastery learning commonly requires learners to attain 90–95% mastery before progression, thereby reducing learning deficiencies and improving overall academic performance. Through continuous assessment and immediate feedback, competency-based instruction enables instructors to identify learners' weaknesses early, provide corrective learning experiences, reinforce successful performance, and allow repeated practice until the required competency level is achieved. Recent evidence by Rasul, Raufand and Masran (2025) further indicates that competency-based training significantly improves technical skills mastery and workplace readiness because learners advance only after demonstrating competence in each prescribed task. Consequently, competency-based instruction is considered

particularly appropriate for practical courses such as foundry practice, where competencies in pattern making, mould making, core making, core setting, melting and temperature control, pouring molten metal, cooling and shakeout, fettling and finishing, as well as defect identification and correction, are sequential and interdependent, requiring learners to master one competency before progressing to the next.

METHODOLOGY

This study adopted a quasi-experimental research design, specifically using the pretest–posttest non-equivalent control group design. This design enabled the researcher to compare pretest and posttest scores within and between groups in order to determine the effect of competency-based instruction on students' academic performance in sand casting. Additionally, by incorporating both pretest and posttest measures, the design helped to control for initial group differences and provided a more accurate estimate of the instructional effect. The adoption of the pretest–posttest non-equivalent control group design in this study ensured study maintained methodological rigor while reflecting the realities of educational practice, thereby enhancing the validity and applicability of the findings within the context of technical education in Rivers State universities.

The sand-casting performance test (SCPT) instrument was used for both pre-test and post-test, with proper supervision to ensure standard conditions. Other instruments are sand casting skill domain's blue print and lessons plans use as teaching guideline. The instruments were validated using test retest and reliability of 0.82 coefficient was obtained. The data collection process was carried out in three main stages: pretest administration, instructional treatment, and posttest administration. The data collected were analyzed using simple percentage, mean and standard deviation to answer the research questions while analysis for covariance (ANCOVA) was used to analyzed null hypotheses. Decision rule for research question was mean gain; if the mean gain is positive result will be accepted but if the mean gain is negative the result will not be accepted and zero mean gain is neutral while decision rule for null hypotheses was F-calculated for the two teaching methods; if the F- calculated is greater than 0.05 significant level the null hypotheses will be rejected but if the F-calculated is lower than the 0.05 significant level the null hypotheses will be accepted.

Research Question: *What is the difference in the mean academic performance scores of graduate students taught mould making using the competency-based instructional approach and those taught using the conventional instructional approach?*

Table 1: Mean Difference in Performance Scores of Graduate Students Taught Mould Making using Competency-Based Approach and those Taught using the Conventional Approach

Groups	N	Pretest Pre-test Mean (M_1)	S.D.	Posttest Post-Test Mean (M_2)	S.D.	Mean Difference
Experimental	15	37.07	8.60	90.07	5.663	**53.00**
Control	13	35.54	8.73	71.69	9.681	**36.15**
Mean Difference		**1.53**		**18.37**		**16.85**

Table 1 shows the mean scores of the experimental group taught pattern making, using competency-based instructional approach and those taught mould making, using the conventional instructional approach in Rivers State universities. The table shows a pre-test mean score of $\overline{x_1}$ = 37.07 for the experimental group and a pre-test mean score of $\overline{x_1}$ = 35.54 for the control group. This shows a difference of 1.53 in favour of the experimental group. This slight difference in the mean scores of the two groups could be attributed to extraneous variables. The table also reveals a mean difference of 53.00 for the experimental group and

a mean difference of 36.15 for the control group between pretest and posttest scores. This indicates that the mean score in mould making for the two groups improved after being taught using the competency-based and conventional instructional approaches. It is however observed from the table that the mean post-test score for the experimental group ($\overline{x_2}$ = 90.07) was higher than that of the control group ($\overline{x_2}$ = 71.69) by a difference of just 18.37. This implies that students taught mould making using competency-based instructional approach performed better than students taught using the conventional instructional approach.

Research Question 2: *What is the difference in the mean academic performance scores of graduate students taught core setting using the competency-based instructional approach and those taught using the conventional instructional approach?*

Table 2: Mean Difference in Performance Scores of Graduate Students Taught Core Setting using Competency-Based Approach and those Taught using the Conventional Approach

Groups	N	Pretest Pre-Test Mean (M_1)	S.D.	Posttest Post-Test Mean (M_2)	S.D.	Mean Difference
Experimental	15	37.00	7.57	89.13	4.809	**52.13**
Control	13	33.69	7.22	67.77	9.593	**34.08**
Mean Difference		**3.31**		**21.36**		**18.06**

Table 2 shows the mean scores of the experimental group taught core setting, using competency-based instructional approach and those taught core setting, using the conventional instructional approach in Rivers State universities. The table shows a pre-test mean score of $\overline{x_1}$ = 37.00 for the experimental group and a pre-test mean score of $\overline{x_1}$ = 33.69 for the control group. This shows a difference of 3.31 in favour of the experimental group. This slight difference in the mean scores of the two groups could be attributed to extraneous variables. The table also reveals a mean difference of 52.13 for the experimental group and a mean difference of 34.08 for the control group between pretest and posttest scores. This indicates that the mean score in core setting for the two groups improved after being taught using the competency-based and conventional instructional approaches. It is however observed from the Table 2 that the mean post-test score for the experimental group ($\overline{x_2}$ = 89.13) was higher than that of the control group ($\overline{x_2}$ = 67.77) by a difference of just 21.36. This implies that students taught core setting using competency-based instructional approach performed better than students taught using the conventional instructional approach.

Research Question 3: *What is the difference in the mean academic performance scores of graduate students taught pouring molten metal using the competency-based instructional approach and those taught using the conventional instructional approach?*

Table 3: Mean Difference in Performance Scores of Graduate Students Taught Pouring Molten Metal using Competency-Based Approach and those Taught using the Conventional Approach

Groups	N	Pretest Pre-Test Mean (M_1)	S.D.	Posttest Post-Test Mean (M_2)	S.D.	Mean Difference
Experimental	15	37.20	6.21	90.33	5.525	**53.13**
Control	13	31.54	7.52	70.92	9.656	**39.38**
Mean Difference		**5.66**		**19.41**		**13.75**

Table 3 shows the mean scores of the experimental group taught molten metal, using competency-based instructional approach and those taught pouring of molten metal, using the conventional instructional approach in Rivers State universities. The table shows a pre-test mean score of $\overline{x_1}$ = 37.20 for the experimental group and a pre-test mean score of $\overline{x_1}$ = 31.54 for the control group. This shows a difference of 5.66 in favour of the experimental group. This slight difference in the mean scores of the two groups could be attributed to extraneous variables. The table also reveals a mean difference of 53.13 for the experimental group and a mean difference of 39.38 for the control group between pretest and posttest scores. This indicates that the mean score in pouring of molten metal for the two groups improved after being taught using the competency-based and conventional instructional approaches. The result, however, shows that the mean post-test score for the experimental group ($\overline{x_2}$ = 90.33) was higher than that of the control group ($\overline{x_2}$ = 70.92) by a difference of just 19.41. This implies that students taught pouring of molten metal using competency-based instructional approach performed better than students taught using the conventional instructional approach.

Research Question 4: *What is the difference in the mean academic performance scores of graduate students taught cooling and shakeout using the competency-based instructional approach and those taught using the conventional instructional approach?*

Table 4: Mean Difference in Performance Scores of Graduate Students Taught Cooling and Shaking-Out using Competency-Based Approach and those Taught using the Conventional Approach

Groups	N	Pretest Pre-Test Mean (M_1)	S.D.	Posttest Post-Test Mean (M_2)	S.D.	Mean Difference
Experimental	15	31.20	6.96	90.07	4.788	**58.87**
Control	13	32.00	5.93	69.54	7.479	**37.54**
Mean Difference		**0.80**		**20.53**		**21.33**

Table 4 shows the mean scores of the experimental group taught cooling and shakeout, using competency-based instructional approach and those taught cooling and shakeout, using the conventional instructional approach in Rivers State universities. The table shows a pre-test mean score of $\overline{x_1}$ = 31.20 for the experimental group and a pre-test mean score of $\overline{x_1}$ = 32.00 for the control group. This shows a

difference of 0.80 in favour of the control group. This slight difference in the mean scores of the two groups could be attributed to extraneous variables. The table also reveals a mean difference of 58.87 for the experimental group and a mean difference of 37.54 for the control group between pretest and posttest scores. This indicates that the mean score in cooling and shakeout for the two groups improved after being taught using the competency-based and conventional instructional approaches. The result, however, shows that the mean post-test score for the experimental group ($\overline{x_2}$ = 90.07) was higher than that of the control group ($\overline{x_2}$ = 69.54) by a difference of just 20.53. This implies that students taught cooling and shakeout using competency-based instructional approach performed better than students taught using the conventional instructional approach.

Hypothesis 1: There is no significant difference in the mean academic performance scores of graduate students taught mould making using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Table 5: ANCOVA for Performance Scores of Graduate Students Taught Mould Making using Competency-Based Approach and those Taught using the Conventional Approach

Sources of Variance	Sum of Squares	df	Mean Square	F	p-value
Corrected Model	2360.050[a]	2	1180.025	18.851	0.000
Intercept	9753.940	1	9753.940	155.822	0.000
Pre Test	8.788	1	8.788	0.140	0.711
Method	2357.925	1	2357.925	37.669	0.000
Error	1564.915	25	62.597		
Total	190071.000	28			
Corrected Total	3924.964	27			

a. R Squared = .601 (Adjusted R Squared = .569)

The results from Table 5 show that after controlling for the difference in pre-test scores, the difference in posttest scores between the two groups was statistically significant at 0.05 level of significance. This is evident by F (1,25) = 37.699, p<0.05. With this result, the hypothesis was rejected. This implies that there was a significant difference in the mean academic performance scores of graduate students taught mould making using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Hypothesis 2: There is no significant difference in the mean academic performance scores of graduate students taught core setting using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Table 6: ANCOVA for Performance Scores of Graduate Students Taught Core Setting using Competency-Based Approach and those Taught using the Conventional Approach

Sources of Variance	Sum of Squares	df	Mean Square	F	p-value
Corrected Model	3180.944a	2	1590.472	27.888	0.000
Intercept	6996.733	1	6996.733	122.68	0.000
Pre Test	2.271	1	2.271	0.04	0.843
Method	3054.919	1	3054.919	53.566	0.000
Error	1425.77	25	57.031		
Total	180304	28			
Corrected Total	4606.714	27			

a R Squared = .691 (Adjusted R Squared = .666)

The results from Table 6 show that after controlling for the difference in pre-test scores, the difference in posttest scores between the two groups was statistically significant at 0.05 level of significance. This is evident by F (1,25) = 53.566, p<0.05. With this result, the hypothesis was rejected. This implies that there was a significant difference in the mean academic performance scores of graduate students taught core setting using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Hypothesis 3: There is no significant difference in the mean academic performance scores of graduate students taught pouring molten metal using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Table 7: ANCOVA for Performance Scores of Graduate Students Taught Pouring Molten Metal using Competency-Based Approach and those Taught using the Conventional Approach

Sources of Variance	Sum of Squares	df	Mean Square	F	p-value
Corrected Model	2629.426a	2	1314.713	21.333	0.000
Intercept	6850.727	1	6850.727	111.16	0.000
Pre Test	5.575	1	5.575	0.09	0.766
Method	2306.252	1	2306.252	37.423	0.000
Error	1540.681	25	61.627		
Total	189339	28			
Corrected Total	4170.107	27			

a R Squared = .631 (Adjusted R Squared = .601)

The results from Table 7 show that after controlling for the difference in pre-test scores, the difference in posttest scores between the two groups was statistically significant at 0.05 level of significance. This is evident by F(1.25) = 37.423, p<0.05. With this result, the hypothesis was rejected. This implies that there was a significant difference in the mean academic performance scores of graduate students taught pouring molten metal using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Hypothesis 4: There is no significant difference in the mean academic performance scores of graduate students taught cooling and shakeout using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

Table 8: ANCOVA for Performance Scores of Graduate Students Taught Cooling and Shakeout using Competency-Based Approach and those Taught using the Conventional Approach

Sources of Variance	Sum of Squares	df	Mean Square	F	p-value
Corrected Model	3012.179a	2	1506.089	41.16	0.000
Intercept	5407.588	1	5407.588	147.78	0.000
Pre Test	77.378	1	77.378	2.115	0.158
Method	2983.685	1	2983.685	81.541	0.000
Error	914.786	25	36.591		
Total	185535	28			
Corrected Total	3926.964	27			

a R Squared = .767 (Adjusted R Squared = .748)

The results from Table 8 show that after controlling for the difference in pre-test scores, the difference in posttest scores between the two groups was statistically significant at 0.05 level of significance. This is evident by $F(1.25) = 81.541$, $p<0.05$. With this result, the hypothesis was rejected. This implies that there was a significant difference in the mean academic performance scores of graduate students taught cooling and shakeout using the competency-based instructional approach and those taught using the conventional instructional approach in Rivers State Universities.

DISCUSSION OF THE FINDING

The result of the test of hypothesis one, which corresponds to research question one, revealed that the difference in the mean performance scores in mould making between the two groups was statistically significant at the 0.05 level of significance.

The observed significant difference in favour of the competency-based instructional approach suggests that the approach was more effective in facilitating the acquisition of the practical knowledge and technical skills required for mould making. Mould making is a critical stage in sand-casting that demands precision in sand preparation, ramming, pattern withdrawal, gating system formation, and mould assembly.The implication of this finding is that effective instruction in practical foundry operations such as mould making requires instructional strategies that emphasize competency acquisition rather than mere completion of course content. University lecturers and curriculum developers should therefore integrate competency-based instructional principles into foundry practice courses to ensure that students acquire the practical competencies expected by industry. The present finding also corroborates the findings of Kimario and Otieno (2022), who reported that the implementation of the competency-based curriculum significantly improved students' educational achievement through learner-centred instructional strategies such as practical activities, collaborative learning, classroom discussions, exhibitions, and problem-solving tasks. The finding is further consistent with that of Adamu, Hassan, Muhammad, and Ali (2024), who found that students taught using a learner-centred problem-based learning approach obtained significantly higher academic performance than those taught through the conventional lecture method in metal foundry. Their study demonstrated that active participation in practical foundry tasks enhanced students' competence and learning outcomes. Furthermore, the finding is consistent with John Dewey's Learning by Doing Theory (1938) because mould making is a practical activity that requires active learner participation rather than passive observation. Through repeated engagement in authentic workshop tasks, students construct meaningful knowledge and improve practical competence.

Research question two sought to ascertain the difference in the mean academic performance scores of graduate students taught core setting using the competency-based instructional approach and those taught using the conventional instructional approach. The finding showed that students exposed to instruction using the competency-based instructional approach had higher academic performance scores in core setting than their counterparts exposed to instruction using the conventional instructional approach. The result of the test of hypothesis two, which corresponds to research question two, revealed that the difference in the mean performance scores in core setting between the two groups was statistically significant at the 0.05 level of significance.

The finding indicates that the competency-based instructional approach enhanced students' mastery of core setting more effectively than the conventional instructional approach. This outcome may be because competency-based instruction emphasizes the sequential development of practical competencies through demonstration, guided practice, performance assessment, and immediate corrective feedback. By allowing students to repeatedly practise each stage of the process until competency is demonstrated, the instructional approach minimized errors, strengthened procedural understanding, and improved students' ability to transfer theoretical knowledge into practical performance. Consequently, students developed greater precision, confidence, and competence in core setting, which translated into higher academic performance. The finding corroborates Dreyfus and Dreyfus' Skill Acquisition Model (1980), which explains that learners develop from novice to competent performers through repeated practice and practical experience. Students in the competency-based instructional group had more opportunities to practise core setting tasks, thereby facilitating progression through the stages of skill acquisition.This result is consistent with the result of Ogunbote, Bilau, Dawodu, Adenuga, and Obe (2026), who found that competency-based education significantly enhanced graduates' technical skill acquisition, workplace readiness, problem-solving ability, and overall employability. The researchers established a statistically significant positive relationship between competency-based education and graduate outcomes, concluding that competency-based education effectively develops industry-relevant competencies

Research question three sought to ascertain the difference in the mean academic performance scores of graduate students taught pouring molten metal using the competency-based instructional approach and those taught using the conventional instructional approach. The finding showed that students exposed to instruction using the competency-based instructional approach had higher academic performance scores in pouring molten metal than their counterparts exposed to instruction using the conventional instructional approach. The result of the test of hypothesis four, which corresponds to research question four, revealed that the difference in the mean performance scores in pouring molten metal between the two groups was statistically significant at the 0.05 level of significance.

The significant improvement in the academic performance of students taught using the competency-based instructional approach may be attributed to the practical and performance-oriented nature of the approach. Pouring molten metal is one of the most critical operations in sand casting because it requires learners to demonstrate competence in maintaining the correct pouring temperature, handling molten metal safely, controlling pouring speed, and ensuring proper filling of the mould cavity without introducing casting defects. The competency-based instructional approach provides students with structured practical experiences, close supervision, performance monitoring, and opportunities to correct mistakes before advancing to the next competency. This systematic process likely enabled students to acquire the confidence, technical precision, and procedural understanding necessary for successful pouring operations, thereby resulting in significantly higher academic performance than students taught through the conventional instructional approach.

An important implication of this finding is that practical operations involving high levels of technical precision and safety should be taught using instructional approaches that prioritize competency demonstration and mastery rather than passive knowledge acquisition. The result therefore supports the incorporation of competency-based instructional strategies into university foundry practice courses to enhance students' technical competence, reduce operational errors during practical exercises, and improve learning outcomes. It also emphasizes the need for institutions to provide adequate workshop facilities

and sufficient opportunities for repeated practical exercises that enable students to attain the required competencies before assessment.

This finding corroborates that of Deepan and Djabbarova (2025), who found that competency-based education positively influenced students' academic performance by allowing learners to demonstrate mastery of learning outcomes before progressing to subsequent competencies. Their study further revealed that competency-based education enhanced students' self-directed learning, critical thinking, intrinsic motivation, and ability to apply knowledge in authentic learning situations. Although their study examined higher education generally, the present study extends this evidence to the practical task of pouring molten metal in foundry practice, demonstrating the effectiveness of competency-based instruction in technical skill acquisition.

The present finding also agrees with the findings of Kanondu, Deebom, and Dokubo (2023), who reported that students taught using a sand-casting instructional aid achieved significantly higher posttest mean scores than those taught through the conventional lecture method. The researchers observed that the instructional intervention enhanced students' understanding of practical sand-casting processes, including pattern preparation, mould making, metal melting, pouring, and casting inspection, thereby improving both conceptual understanding and practical competence.

Research question four sought to ascertain the difference in the mean academic performance scores of graduate students taught cooling and shakeout using the competency-based instructional approach and those taught using the conventional instructional approach. The finding showed that students exposed to instruction using the competency-based instructional approach had higher academic performance scores in cooling and shakeout than their counterparts exposed to instruction using the conventional instructional approach. The result of the test of hypothesis four, which corresponds to research question five, revealed that the difference in the mean performance scores in cooling and shakeout between the two groups was statistically significant at the 0.05 level of significance.

This result suggests that competency-based instruction is highly effective in developing students' competence in cooling and shakeout operations. Cooling and shakeout require learners to understand the appropriate cooling duration for different castings, apply correct shakeout procedures, and safely separate the casting from the mould without causing damage to the finished product. These practical tasks require precision, sound judgment, and strict adherence to operational procedures. The competency-based instructional approach likely enhanced students' performance by emphasizing competency demonstration, repeated practical exercises, immediate performance feedback, and continuous assessment until mastery was achieved. Through this process, students developed a better understanding of the principles governing cooling and shakeout and acquired the practical skills necessary to execute the operations accurately and safely.

This finding implies that competency-based instructional approaches should be adopted for teaching practical operations that require procedural accuracy and technical judgment in foundry practice. The finding indicates that when students are given sufficient opportunities to practise practical tasks under close supervision and are assessed based on demonstrated competence rather than mere theoretical knowledge, they achieve higher levels of academic performance. Consequently, departments offering foundry practice should strengthen competency-based practical training by providing adequate workshop facilities, appropriate equipment, and structured performance-based assessments that encourage mastery of each stage of the casting process.

CONCLUSION

Based on the findings of this study, it was concluded that the Competency-Based Instructional Approach (CBIA) is significantly more effective than the conventional instructional approach in improving graduate students' academic performance in sand-casting foundry practice in universities in Rivers State. Students who were taught using the competency-based instructional approach consistently achieved higher academic performance across all the major competency areas of sand casting, namely: mould making, core setting, pouring molten metal, cooling and shakeout. The statistical analyses further confirmed that

these improvements were significant, indicating that the observed differences in students' academic performance were attributable to the instructional approach rather than chance.

Suggestion for Further Studies

The study provides empirical evidence supporting the effectiveness of competency-based instructional approaches in university-level foundry education. This implies that researchers in Technical and Vocational Education should further investigate the application of competency-based instruction in other practical courses and engineering trades, using larger samples, different educational contexts, and additional outcome variables such as skill retention, occupational competence, innovation, entrepreneurial readiness, and workplace performance.

RECOMMENDATIONS

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

1. Considering that students exposed to the Competency-Based Instructional Approach achieved significantly higher academic performance in mould making, university curriculum developers and lecturers should integrate competency-based learning activities into mould-making instruction. Adequate workshop time should also be allocated to enable students to repeatedly practise mould-making operations until competency is attained.
2. Since the Competency-Based Instructional Approach significantly enhanced students' academic performance in core setting, universities should organize regular capacity-building programmes for lecturers on competency-based teaching methods and performance-based assessment techniques. This will strengthen lecturers' ability to effectively facilitate practical competency development during foundry instruction.
3. Based on the finding that students taught pouring molten metal through the Competency-Based Instructional Approach performed significantly better than those taught using the conventional method, university management should provide modern foundry equipment, safety facilities, and instructional materials that support competency-based practical training. Adequate practical resources will enable students to acquire the required competencies in metal pouring under realistic workshop conditions.
4. Since students exposed to competency-based instruction achieved significantly higher academic performance in cooling and shakeout operations, lecturers should adopt continuous competency assessment and immediate feedback mechanisms during practical instruction. This will enable students to identify and correct errors promptly while progressively mastering each practical operation.

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