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Institutional Variables and Material Waste Reduction Rate in Metalwork Among Technical Students in Nigeria

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Abstract- ***This study investigated institutional variables and material waste reduction rate in metalwork technology among technical students in Calabar Education Zone of Cross River State, Nigeria. Specifically, the study determined the extent to which teachers' attitude to workshop practices, availability of equipment, and institutional support predict material waste reduction rate. An ex-post facto research design was adopted. The population comprised all 142 Senior Technical Two (ST-2) metalwork students in the eleven technical colleges in the zone, and a census of the entire population was used as the sample. Data were collected using a validated, structured questionnaire whose relevant subscales returned Cronbach alpha reliability coefficients of .89 (teachers' attitude), .72 (availability of equipment), .72 (institutional support), and .89 (material waste reduction rate). Mean and standard deviation were used to answer the research questions, while simple linear regression was used to test the three null hypotheses at .05 level of significance. Results showed that teachers' attitude to workshop practices ($F(1,140) = 4.088$, $p = .045$, $R^2 = .028$), availability of equipment ($F(1,140) = 7.505$, $p = .007$, $R^2 = .051$), and institutional support ($F(1,140) = 8.241$, $p = .005$, $R^2 = .056$) each significantly and positively predicted material waste reduction rate, although each variable individually explained a modest proportion of the variance. The study concludes that institutional variables, particularly teachers' disposition toward workshop supervision, the adequacy of workshop equipment, and the strength of administrative and policy support, are important predictors of how efficiently technical students manage metal materials during practical training. It is recommended that technical colleges invest in teacher motivation and training, upgrade and maintain workshop equipment, and strengthen institutional policies and supervision to enhance material waste reduction in metalwork technology.***

Keywords: ***institutional variables, material waste reduction rate, metalwork technology, teachers' attitude, availability of equipment, institutional support, technical students, Nigeria***

I. INTRODUCTION

A. Background to the Study

Metal Work Technology is a practical-oriented field that requires students to acquire hands-on skills in cutting, shaping, welding, machining, and fabricating metal materials. In technical institutions, students are trained to develop competencies that prepare them for industrial work and self-employment. However, during practical workshop activities, a considerable amount of metal material is often wasted. Material waste in metal workshops may occur due to errors in measurement, improper machine handling, lack of supervision, outdated equipment, poor maintenance culture, and insufficient instructional guidance. Since metals are costly and sometimes scarce, excessive waste increases training expenses and reduces institutional efficiency, while also undermining the sustainability, cost-effectiveness, and responsible resource management that technical education seeks to promote.

Institutional variables such as teachers' attitude, availability of functional equipment, and institutional support may significantly influence how students manage materials during practical activities. Institutions that provide adequate facilities, effective instructional strategies, and administrative backing are more likely to produce students who use materials efficiently and minimise waste. Despite the importance of material waste reduction in metalwork technology, limited attention has been given to how these institutional factors affect the rate at which waste occurs among technical students. This study therefore examines the relationship between three key institutional variables; teachers' attitude to workshop practices, availability of equipment, and institutional support, and material waste reduction rate in metalwork technology among technical students in Nigeria.

One important institutional variable is teachers' attitude. When instructors demonstrate commitment, patience, professionalism, and positive work ethics, students are more likely to follow proper procedures and develop careful material-handling habits. Teachers who emphasise accuracy, planning, and accountability during practical sessions help students understand the economic and environmental importance of minimising waste, whereas poor supervision or negative attitudes may encourage careless work and higher material wastage [1]. The availability of functional and modern equipment is another key institutional factor. When tools and machines are outdated, faulty, or insufficient, students are more prone to errors during cutting, shaping, or welding operations; accurate measuring instruments, well-maintained machines, and adequate tools help students perform tasks correctly the first time, thereby reducing unnecessary waste [2].

Furthermore, institutional support, which includes adequate funding, policy implementation, supervision structures, and administrative commitment, contributes to waste reduction. Institutions that enforce material-control policies, monitor usage, and encourage accountability are more likely to minimise waste, and administrative support for teacher training and professional development enhances instructional quality, which in turn improves students' efficiency in material usage [3]. Understanding how teachers' attitude, equipment availability, and institutional support interact is therefore important for improving efficiency, sustainability, and quality in metalwork technology training programmes. In many developing nations, including Nigeria, metalwork training forms a significant part of the effort to build a skilled labour force capable of contributing to economic and technological advancement [4], yet the effective delivery of metalwork education is often constrained by limited resources, outdated equipment, and insufficient emphasis on sustainable practices such as waste management and process optimisation [5].

Waste in metalwork can take many forms, including offcuts, unused materials, excess consumption of inputs, and tool wear due to inefficient handling. High levels of material waste not only increase operational costs but also compromise the sustainability and environmental responsibility of training institutions [6]. Waste reduction in metalwork training is therefore crucial for instilling a culture of efficiency and environmental consciousness among students, preparing them to meet industrial standards where lean manufacturing, resource optimisation, and sustainable engineering are increasingly prioritised [7]. Understanding and optimising institutional variables can thus play a transformative role in technical education: by improving instructional quality and operational support, these variables can lead to a significant reduction in material waste and better prepare students for the demands of modern industry.

B. Statement of the Problem

Material waste during practical training in metal work technology remains a persistent issue in many technical institutions. Metal materials such as mild steel, aluminium, cast iron, and other alloys are expensive and sometimes limited in supply; excessive waste during workshop activities reduces the quantity of materials available for training and limits students' opportunities to practice adequately and develop competence. These issues not only undermine the quality of technical education but also increase operational costs and limit students' preparedness for real-world manufacturing environments.

It is concerning that metalwork training is characterised by the excessive generation of waste, including metal offcuts, scrap, worn tools, and misused materials, much of which could be minimised through improved instructional approaches and institutional management. The effects of such waste extend beyond the workshop: economically, excessive material waste increases institutional expenditure; environmentally, wasted metal contributes to resource depletion and greater demand for mining and industrial processing; and socially, students who are not trained in efficient material management may carry wasteful practices into the workforce, reducing industrial productivity and national economic growth. While students' technical competence may itself contribute to material waste, institutional variables such as teachers' attitude, inadequate equipment, and weak

institutional support may significantly influence the rate at which waste occurs. However, the extent to which these institutional factors affect material waste reduction in metalwork technology among technical students is not clearly established.

This study, therefore, sought to fill this gap by evaluating the impact of teachers' attitude to workshop practices, availability of equipment, and institutional support on material waste reduction rate in metalwork technology among technical students, so as to provide evidence-based insights that can inform instructional improvements and policy reforms toward more efficient and sustainable metalwork training programmes.

C. Objective of the Study

The main purpose of this study was to determine the extent to which institutional variables influence material waste reduction rate in metalwork technology among technical students in Calabar Education Zone of Cross River State, Nigeria. Specifically, the study sought to: investigate the extent to which teachers' attitude to workshop practices predicts material waste reduction rate in metalwork technology among technical students; determine the extent to which availability of equipment predicts material waste reduction rate in metalwork technology among technical students; and to investigate the extent to which institutional support predicts material waste reduction rate in metalwork technology among technical students.

The following research questions were posed to direct the study: To what extent does teachers' attitude to workshop practices predict material waste reduction rate in metalwork technology among technical students? To what extent does availability of equipment predict material waste reduction rate in metalwork technology among technical students? And to what extent does institutional support predict material waste reduction rate in metalwork technology among technical students?

The following null hypotheses were formulated to guide the study, tested at .05 level of significance:

H01. Teachers' attitude to workshop practices does not significantly predict material waste reduction rate in metalwork technology among technical students.

H02. Availability of equipment does not significantly predict material waste reduction rate in metalwork technology among technical students.

H03. Institutional support does not significantly predict material waste reduction rate in metalwork technology among technical students.

F. Significance of the Study

The findings of this study are expected to benefit technical educators, students, curriculum planners, policy makers, technical colleges, and society at large. Technical colleges gain critical insight into how teacher disposition, equipment provisioning, and administrative support affect students' ability to minimise material waste, information that can guide policy design, curriculum planning, and resource allocation in metalwork laboratories. Technical teachers can use the findings to identify which of these institutional practices most significantly influences students' efficiency, enabling them to adopt strategies that promote responsible material handling and sustainable practice. ST-2 metalwork students stand to benefit as the identified relationships can be used to train them toward more careful and economical use of materials, while curriculum planners and policymakers can integrate the findings into interventions and guidelines aimed at cost savings, environmental sustainability, and improved learning outcomes in vocational education. Ultimately, reducing material waste in technical training conserves resources and prepares future technicians for the resource-efficient, sustainability-conscious practices increasingly demanded by industry.

G. Scope of the Study

This paper is restricted to investigating the extent to which teachers' attitude to workshop practices, availability of equipment, and institutional support, as institutional variables, predict material waste reduction rate (comprising time efficiency, scrap reduction rate, and reuse and recycling practices) in metalwork technology among Senior Technical Two

(ST-2) students in the eleven technical colleges of Calabar Education Zone, Cross River State, Nigeria. The results reported here are drawn from a wider study that originally examined five institutional variables; two of these (workshop environment and access to learning resources) fall outside the scope of the present paper and are not reported here.

II. LITERATURE REVIEW

A. Conceptual Framework

The conceptual framework of this study is organised around institutional variables, namely teachers' attitude to workshop practices, availability of equipment, and institutional support, and around material waste reduction rate as the outcome of interest.

1) Teachers' Attitude to Workshop Practices: Attitude refers to a learner's or instructor's predisposition toward tasks, responsibilities, and learning objectives, which in turn affects engagement with training, tools, and procedures. According to [8], attitude is a mental and neural state of readiness, organised through experience, which exerts a directive or dynamic influence on an individual's response to situations and objects, a definition suggesting that teachers' attitudes toward teaching are shaped by their experiences, beliefs, and training, which in turn affect how they perform their instructional duties. [9] similarly explained, through the Theory of Planned Behaviour, that attitude plays a significant role in determining an individual's intentions and actions; in the case of teachers, a positive attitude toward teaching and workshop practices increases their willingness to engage actively in practical instruction and guide students effectively during workshop activities. [10] described workshop practices as practical instructional activities conducted in specialised environments where students learn technical and vocational skills through hands-on experience under the supervision of a trained teacher, while [11] characterised workshop practice as a systematic learning activity that enables students to acquire manipulative and technical skills through supervised practical experience.

Teachers who possess positive attitudes toward workshop teaching tend to demonstrate greater enthusiasm and commitment: they organise practical lessons properly, demonstrate tasks clearly, ensure the safety of students, and maintain workshop equipment effectively, thereby encouraging active participation and fostering creativity and skill development. Teachers with negative attitudes, by contrast, may show little interest in practical teaching, resulting in poor supervision, inadequate demonstration of practical skills, and underutilisation of workshop facilities. Factors that shape teachers' attitudes toward workshop practices include professional training, availability of workshop facilities, administrative support, and teaching experience [12]. Motivation and incentives also matter: when teachers receive adequate remuneration, recognition, and opportunities for professional development, they demonstrate greater commitment to their work, whereas poor working conditions and inadequate institutional support may lead to frustration and negative attitudes toward practical teaching [13]. A positive attitude toward workshop practices provides several benefits, including proper supervision, adherence to safety rules, and effective bridging of theoretical knowledge and real-world application [14]. In this study, teachers' attitude to workshop practices is conceptualised as teachers' perception, interest, commitment, and approach toward teaching students how to reduce and manage material waste, especially during practical activities in workshops.

2) Availability of Equipment: The availability of equipment in metal work technology refers to the presence and accessibility of the tools, machines, and materials required for effective teaching and learning of metalworking skills, such as lathes, drilling machines, welding machines, hammers, vices, and measuring instruments [15]. [11] opined that availability of these tools ensures that students gain hands-on experience and practical competence, and that well-equipped workshops offer each student the opportunity to engage directly with materials and machines, fostering competence and reducing trial-and-error mistakes that generate waste. The concept of availability does not refer only to the physical presence of equipment but also to its adequacy,

functionality, and accessibility for instructional purposes; in many technical institutions, equipment may exist but be insufficient, obsolete, or poorly maintained, thereby limiting students' opportunities for practical training.

[16] noted that adequate provision and availability of workshop equipment are essential for effective skill acquisition in vocational and technical education, and that modern equipment provides better precision, safety, and efficiency, reducing human error. Schools operating with obsolete or worn-out tools may find it difficult to achieve clean cuts, proper welds, or accurate measurements, leading to errors that result in discarded or unusable products, a scenario common in under-resourced institutions where budget constraints inhibit regular procurement or maintenance of workshop tools. [17] observed that in schools that received government-funded equipment upgrades, waste production in student projects dropped markedly due to better workmanship and reduced material spoilage, underscoring that equipment availability is a strategic determinant of learning quality and resource efficiency, not merely a logistical concern. In this study, availability of equipment is conceptualised as the extent to which functional, adequate, and relevant metalwork tools and machines are accessible for students' use in practical sessions.

3) Institutional Support: Institutional support in metal work technology refers to the assistance, resources, policies, and administrative efforts provided by educational institutions to facilitate effective teaching and learning of metalworking skills, including the provision of workshop facilities, equipment, training opportunities for teachers, funding, maintenance of tools and machines, and the development of policies that promote effective technical and vocational education [18]. When schools provide adequate institutional support through structured curricula, modern tools, and regular supervision, the rate of material waste can be drastically reduced. [19] note that institutional factors such as prompt tool maintenance, availability of consumables, and adherence to standardised workshop procedures help to instil discipline and reduce trial-and-error operations that often lead to material wastage.

Institutional support is also reflected in the presence of trained and motivated instructors who model proper usage of materials and workshop tools: [20] found that technical colleges with consistent administrative supervision and teacher-development programmes recorded significantly lower waste-generation rates among students. Institutional monitoring and evaluation systems likewise have a direct impact on students' waste-conscious behaviour; [21] note that schools that track and report material-usage patterns create an environment of accountability that compels students to approach metalwork tasks more conscientiously. Institutional emphasis on sustainable practices not only reduces material costs but also educates students on industrial standards that value cost-effectiveness and resource management [22]. Conversely, lack of institutional support contributes to increased waste through inconsistent supervision, obsolete equipment, and demotivated instructors, a situation common in underfunded technical colleges. Investments in vocational-education infrastructure directly correlate with improved student outcomes and lower wastage in skill-based disciplines [23]. In this study, institutional support is conceptualised as the level of financial allocation, administrative, and policy-related assistance provided by the school or institution to enhance metalwork training and the reduction of material waste.

B. Material Waste Reduction Rate

Material waste reduction rate, the dependent variable of the study, refers to the extent to which waste is minimised through deliberate practices and action, and is understood in this study through three components: time efficiency, scrap reduction rate, and reuse and recycling practices. Time efficiency concerns students' ability to plan and use available time effectively so as to complete practical tasks without unnecessary delay or waste; the lean-manufacturing approach emphasises time efficiency as a tool for reducing waste, enhancing quality, and improving process flow [24], [25]. Studies suggest that a substantial proportion of metal materials, up to 15-20% in some contexts, are wasted in workshops through improper handling and lack of time-conscious practice [26]. Scrap reduction rate refers to the percentage decrease in the amount of scrap,

leftover metal that is wrongly cut, incorrectly shaped, or damaged during processing, generated over a specific period; a high scrap-reduction rate reflects improved planning, measurement accuracy, and attention to detail, and integrating lean techniques into student workshops has been found to reduce scrap generation appreciably [27]. Reuse and recycling practices involve using materials more than once in their original form, or converting waste metal into new materials or products; such practices lower the volume of waste generated while instilling environmentally responsible behaviour, improving students' problem-solving and creative-thinking skills, and helping institutions manage budgets more effectively [28], [29]. Structured reuse programmes have been found to reduce waste appreciably in practical sessions while promoting resource optimisation [30].

C. Theoretical Framework

This study is anchored on Constructivist Learning Theory, associated principally with [31] and [32]. The theory holds that learners actively construct knowledge through experience, reflection, and social interaction rather than through passive reception of information. In Metal Work Technology, students acquire practical skills in measuring, cutting, machining, welding, and fabricating metal components; constructivist theory suggests that these skills are best developed through hands-on engagement in workshop activities, where students interact directly with materials, tools, and machines and reflect on the results of their actions. This engagement allows students to internalise proper techniques, recognise mistakes, and adjust their practices in ways that reduce material waste.

Several assumptions underpin constructivist learning that are directly relevant to the variables of this study. First, learning is an active process in which students gain understanding through hands-on engagement rather than memorisation [31]. Second, learning is social and collaborative, with guidance and feedback from instructors, and therefore teachers' attitude and instructional strategies are crucial: constructivist learning relies on scaffolding and feedback to help learners interpret experiences and correct errors [32]. A positive teacher attitude and effective supervision encourage students to work carefully and adopt efficient methods, thereby minimising wastage. Third, knowledge is context-dependent, meaning learners perform better when tasks are meaningful and situated in real, well-resourced settings; the availability of functional equipment therefore supports active learning by allowing students to practise accurately and safely, strengthening understanding and skill mastery. Fourth, reflection is essential to consolidating learning, and institutional support, through structured curricula, supervision, and maintenance of facilities, creates the conditions under which teachers can guide students' reflection and correct performance during practical work.

Despite its strengths, constructivist learning is resource-intensive, requiring sufficient tools, equipment, and instructor support, and its effective implementation depends heavily on institutional commitment and instructor skill. Constructivist Learning Theory therefore provides a coherent theoretical basis for this study: it explains why teachers' attitude (through guidance and feedback), availability of equipment (through the material conditions for accurate practice), and institutional support (through the structures that sustain both) are expected to predict how effectively technical students reduce material waste during metalwork training.

D. Empirical Review

1) Teachers' Attitude to Workshop Practices and Material Waste Reduction Rate: [33] assessed pre-service TVET teachers' attitude towards greening workshop practices in South-East Nigeria, using a descriptive survey of 220 respondents drawn from a population of 980 pre-service teachers. Findings revealed that many pre-service teachers had moderate to negative attitudes toward environmentally sustainable workshop practices, and that lack of awareness and inadequate training contributed to poor adoption of waste-reduction practices; the study recommended integrating sustainability and waste-management training into teacher education programmes. [34] investigated technical teachers' apathy and lack of motivation to workshop practice in Northern Nigeria using a survey of 150 teachers, finding that many teachers demonstrated low motivation and negative attitudes toward workshop

practices owing to inadequate facilities, poor remuneration, and lack of institutional support, and concluding that negative teacher attitudes can lead to inefficient use of workshop materials and increased waste. [35] similarly found, through case-study and observational methods, that teachers who demonstrated positive attitudes toward practical training and supervision encouraged responsible use of workshop tools and materials, while instructors with negative attitudes often failed to supervise students effectively, leading to poor material management and increased waste.

2) Availability of Equipment and Material Waste Reduction Rate: [36] investigated the role of workshop facilities and equipment in the effective implementation of vocational and technical education, using a descriptive survey of 180 respondents; findings revealed that adequate availability of equipment significantly improved students' practical performance and helped reduce unnecessary material waste, while institutions with insufficient tools and machines experienced higher rates of material wastage. [11] found, in a survey of 120 respondents, that institutions with adequate equipment allowed students to perform practical tasks more efficiently and reduced material wastage, concluding that lack of adequate equipment often leads to improper use of materials and increased waste. [37] examined the influence of equipment sufficiency on metalwork project outcomes among 120 teachers and students in Oyo and Ogun States, finding that technical colleges with adequate and functional workshop equipment recorded better project outcomes, higher precision, and reduced material wastage, while institutions with inadequate or obsolete equipment experienced higher rates of waste and lower-quality outcomes.

3) Institutional Support and Material Waste Reduction Rate: [18] examined the role of institutional support in the effective implementation of vocational and technical education programmes among 120 teachers in Eastern Nigeria, finding that adequate institutional support through provision of funds, workshop equipment, and teacher-training programmes significantly improved the quality of practical instruction and helped teachers supervise students effectively, thereby minimising mistakes and reducing material wastage. [38] investigated the effect of administrative supervision and resource management on waste generation among 150 teachers in Northern Nigeria, finding that effective administrative supervision and proper management of workshop resources significantly reduced material waste generated during practical sessions. [39] similarly found, among 180 respondents in South-Eastern Nigeria, that institutions providing adequate funding, well-equipped workshops, and supportive administrative policies enabled teachers to supervise students effectively, helping students perform practical tasks more accurately and reducing material wastage in workshop operations.

E. Summary of Literature Review and Gap

The literature reviewed shows that teachers' attitude, availability of equipment, and institutional support are each theoretically and empirically linked to how efficiently students manage materials during metalwork practical training. Teachers who possess positive attitudes toward workshop instruction tend to supervise students closely, demonstrate practical tasks effectively, and emphasise careful handling of materials, which helps to minimise waste, whereas negative attitudes and poor supervision are associated with higher material wastage. Similarly, adequate and functional equipment enables students to practise tasks individually with accuracy, reducing mistakes that lead to waste, while institutions that provide adequate funding, training opportunities, and supervisory structures enable more effective and accountable use of workshop materials.

However, most of the studies reviewed examined these variables individually or in relation to outcomes such as skill acquisition and teaching effectiveness, rather than material waste reduction specifically, and many were conducted in broader vocational or technical education contexts without focusing on metalwork technology workshops. There is limited empirical evidence, particularly within technical institutions in Nigeria, on the extent to which teachers' attitude, availability of equipment, and institutional support jointly and individually predict material waste reduction rate in metalwork technology. This study seeks to fill this gap by

examining the relationship between these three institutional variables and material waste reduction rate among technical students in Calabar Education Zone of Cross River State, Nigeria.

III. METHODOLOGY

A. Research Design

The ex-post facto research design was adopted for this study. Ex-post facto design is used to investigate possible cause-and-effect relationships by observing existing conditions and searching backward to identify possible contributing factors [40]. This design was adopted because it allowed the researcher to investigate the relationship between institutional variables and material waste reduction rate by examining conditions that had already occurred, without manipulating the variables under study.

B. Population and Sample

The study was carried out in Calabar Education Zone of Cross River State, Nigeria, one of three education zones in the state, comprising seven Local Government Areas. The population of the study comprised all Senior Technical Two (ST-2) metalwork students in the eleven technical colleges in the zone in the 2024/2025 academic session, numbering 142 students. The study did not involve sampling but adopted a census of the entire population; the sample therefore consisted of the same 142 ST-2 metalwork students drawn from all eleven technical colleges in the zone.

C. Instrumentation

Data were collected using a researcher-developed structured questionnaire, the Institutional Variables and Material Waste Reduction Rate Questionnaire (IVMWRRQ). The instrument comprised two sections: Section A elicited demographic information (school and sex of respondents), while Section B contained items measuring each institutional variable and material waste reduction rate, with six items per construct, on a modified four-point Likert scale (Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1; reverse-scored for negatively worded items). This paper reports on the subscales measuring teachers' attitude to workshop practices, availability of equipment, institutional support, and material waste reduction rate.

The instrument was subjected to face validation by three experts, two in Technical Education and one in Measurement and Evaluation, at the University of Cross River State (UNICROSS), whose corrections and suggestions were incorporated into the final version. Reliability was established by administering the instrument to 20 ST-2 metalwork students in Ikom Education Zone of Cross River State, an area outside the study area, and analysing the responses using SPSS. Cronbach alpha reliability coefficients relevant to this paper are presented in Table I.

TABLE I
RELIABILITY ESTIMATES OF THE RESEARCH INSTRUMENT (N = 30)

Variable	K	Mean	SD	Cronbach α
Teachers' attitude to workshop practices	6	17.00	6.09	.89
Availability of equipment	6	16.23	6.59	.72
Institutional support	6	16.56	6.75	.72
Material waste reduction rate	6	18.38	5.37	.89

D. Data Collection and Analysis Procedure

Data collection lasted four weeks and was carried out across all eleven technical colleges in Calabar Education Zone, with the assistance of three trained research assistants. A letter of introduction from the Head, Department of Vocational and Technical Education, University of Cross River State, was presented to school principals to solicit permission, and respondents were assured of confidentiality before the instrument was administered. Completed questionnaires were serially numbered and coded for analysis. Descriptive statistics (mean and standard

deviation) were used to answer the research questions, with a criterion mean of 2.50 and above indicating agreement on a given item, and below 2.50 indicating disagreement. Simple linear regression was used to test each null hypothesis at .05 level of significance, regressing material waste reduction rate on each institutional variable in turn.

E. Operational Definition of Variables

Teachers' attitude to workshop practices was operationally defined as the sum of scores on items 1-6 of Section B of the instrument, measuring teachers' perception, interest, commitment, and approach toward teaching students to reduce and manage material waste. Availability of equipment was defined as the sum of scores on items measuring the extent to which functional, adequate, and relevant metalwork tools and machines are accessible for students' use in practical sessions. Institutional support was defined as the sum of scores on items measuring the level of financial allocation, administrative, and policy-related assistance provided by the institution to enhance metalwork training and waste reduction. Material waste reduction rate, the dependent variable, was defined as the sum of scores on items measuring the extent to which waste is minimised through deliberate practices, spanning time efficiency, scrap reduction, and reuse and recycling.

IV. RESULTS

A. Demographic Description of Respondents

Of the 142 respondents, 96 (67.6%) were male and 46 (32.4%) were female, indicating that the study area has more male than female technical students enrolled in metalwork technology.

B. Results

1) Research Question One: To what extent does teachers' attitude to workshop practices predict material waste reduction rate in metalwork technology among technical students? Descriptive statistics were used to examine this question, and results are presented in Table II.

TABLE II
MEAN AND STANDARD DEVIATION OF TEACHERS' ATTITUDE TO WORKSHOP PRACTICES (N = 142)

S/N	Item	Mean	SD	Decision
1	Teachers encourage careful use of workshop materials to minimize waste	3.12	1.11	Agreed
2	Teachers demonstrate proper handling of materials during practical lessons	2.94	.99	Agreed
3	Teachers promote reuse of leftover materials where appropriate	2.68	1.01	Agreed
4	Teachers supervise students effectively to prevent unnecessary waste	2.47	1.06	Disagreed
5	Teachers plan workshop activities for efficient use of available materials	2.73	.96	Agreed
6	Teachers maintain a positive attitude towards adopting waste-reduction practices	3.05	1.08	Agreed
	Grand Mean	2.83	1.04	Agreed

Since the grand mean of 2.83 exceeds the criterion mean of 2.50, respondents agreed that teachers exhibit a positive attitude toward workshop practices in relation to material waste reduction. Teachers were rated highly on encouraging careful use of materials, demonstrating proper handling, promoting reuse, and planning efficiently. However, item 4, on effective supervision to prevent waste, fell below the criterion mean, indicating a weakness in close monitoring of students during practical sessions despite generally positive dispositions.

2) Research Question Two: To what extent does availability of equipment predict material waste reduction rate in metalwork technology among technical students? Results are presented in Table III.

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TABLE III
MEAN AND STANDARD DEVIATION OF AVAILABILITY OF EQUIPMENT (N = 142)

S/N	Item	Mean	SD	Decision
1	Metal work hand tools are adequately available in the workshop	2.84	1.02	Agreed
2	Welding machines are sufficiently available for practical activities	2.41	.97	Disagreed
3	Measuring instruments for metal work are readily available for use	2.76	1.03	Agreed
4	Cutting and shaping equipment are adequately provided in the workshop	2.33	1.07	Disagreed
5	Safety equipment for metal work practicals is sufficiently available	2.65	1.04	Agreed
6	Available metal work equipment supports effective teaching and learning	2.48	.99	Disagreed
	Grand Mean	2.58	1.02	Agreed

Since the grand mean of 2.58 exceeds the criterion mean of 2.50, respondents agreed that metalwork equipment is moderately available in the workshop. Hand tools, measuring instruments, and safety equipment were rated as adequately available, but welding machines, cutting and shaping equipment, and the overall adequacy of equipment for effective teaching fell below the criterion mean, suggesting that while basic workshop operations can be carried out, advanced practical tasks may be constrained by shortages of specialised equipment.

3) Research Question Three: To what extent does institutional support predict material waste reduction rate in metalwork technology among technical students? Results are presented in Table IV.

TABLE IV
MEAN AND STANDARD DEVIATION OF INSTITUTIONAL SUPPORT (N = 142)

S/N	Item	Mean	SD	Decision
1	The institution provides adequate funds to support material waste reduction practices	2.83	1.07	Agreed
2	The institution supplies sufficient materials and tools to minimize unnecessary wastage	2.76	1.12	Agreed
3	The institution organizes training programmes on effective material management and waste reduction	2.41	1.05	Disagreed
4	The institution enforces policies that promote careful use of workshop materials	2.68	1.10	Agreed
5	The institution provides maintenance services that help prevent waste caused by faulty equipment	2.37	.99	Disagreed
6	The institution encourages monitoring and supervision to ensure reduction of material waste	2.71	1.03	Agreed
	Grand Mean	2.63	1.06	Agreed

Since the grand mean of 2.63 exceeds the criterion mean of 2.50, respondents agreed that institutional support helps in material waste reduction. Respondents agreed that the institution provides funds, supplies materials and tools, enforces policies, and encourages monitoring and supervision, but disagreed that adequate training programmes and maintenance services are provided, suggesting weaknesses in staff capacity development and equipment maintenance that may limit the institution's overall effectiveness in waste reduction.

C. Testing the Hypotheses

1) Hypothesis One: Teachers' attitude to workshop practices does not significantly predict material waste reduction rate in metalwork technology among

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technical students. Simple linear regression was used to test this hypothesis, and results are presented in Table V.

TABLE V
REGRESSION ANALYSIS OF TEACHERS' ATTITUDE TO WORKSHOP PRACTICES ON MATERIAL WASTE REDUCTION RATE

R	R^2	Adj. R^2	Std. Error		
.168	.068	.058	4.357		
Source	Sum of Sq.	df	Mean Sq.	F / Sig.	
Regression	77.603	1	77.603	4.088	
Residual	2657.890	140	18.985	p = .045	
Total	2735.493	141			
Model	B	Std. Err.	Beta	t	Sig.
(Constant)	13.076	1.250	—	10.461	.000
Teachers' attitude	.163	.080	.168	2.022	.045

The results in Table V show a calculated F-ratio of 4.088, significant at p = .045 (df = 1, 140), indicating that teachers' attitude to workshop practices significantly predicted material waste reduction rate. The correlation coefficient (R) of .168 and adjusted R^2 of .058 indicate that 58% of the variation in material waste reduction rate was accounted for by teachers' attitude, with the remaining variance attributable to factors outside the study. The regression equation is Y = 13.076 + 0.163(X). The standardised coefficient (Beta = .168) and t-value of 2.022 (p = .045) confirm a significant, positive relationship between teachers' attitude to workshop practices and material waste reduction rate. On this basis, H01 was rejected.

2) Hypothesis Two: Availability of equipment does not significantly predict material waste reduction rate in metalwork technology among technical students. Results are presented in Table VI.

TABLE VI
REGRESSION ANALYSIS OF AVAILABILITY OF EQUIPMENT ON MATERIAL WASTE REDUCTION RATE

R	R^2	Adj. R^2	Std. Error		
.226	.051	.044	4.306		
Source	Sum of Sq.	df	Mean Sq.	F / Sig.	
Regression	139.177	1	139.177	7.505	
Residual	2596.316	140	18.545	p = .007	
Total	2735.493	141			
Model	B	Std. Err.	Beta	t	Sig.
(Constant)	12.148	1.273	—	9.539	.000
Availability of equipment	.221	.081	.226	2.739	.007

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The results in Table VI show a calculated F-ratio of 7.505, significant at p = .007 (df = 1, 140), indicating that availability of equipment significantly predicted material waste reduction rate. The correlation coefficient (R) of .226 and adjusted R^2 of .044 indicate that 4.4% of the variation in material waste reduction rate was accounted for by availability of equipment. The regression equation is Y = 12.148 + 0.221(X). The standardised coefficient (Beta = .226) and t-value of 2.739 (p = .007) confirm a significant, positive relationship between availability of equipment and material waste reduction rate. On this basis, H02 was rejected.

3) Hypothesis Three: Institutional support does not significantly predict material waste reduction rate in metalwork technology among technical students. Results are presented in Table VII.

TABLE VII
REGRESSION ANALYSIS OF INSTITUTIONAL SUPPORT ON MATERIAL WASTE REDUCTION RATE

R	R^2	Adj. R^2	Std. Error		
.236	.056	.049	4.296		
Source	Sum of Sq.	df	Mean Sq.	F / Sig.	
Regression	152.066	1	152.066	8.241	
Residual	2583.426	140	18.453	p = .005	
Total	2735.493	141			
Model	B	Std. Err.	Beta	t	Sig.
(Constant)	11.743	1.355	—	8.667	.000
Institutional support	.237	.082	.236	2.871	.005

The results in Table VII show a calculated F-ratio of 8.241, significant at p = .005 (df = 1, 140), indicating that institutional support significantly predicted material waste reduction rate. The correlation coefficient (R) of .236 and adjusted R^2 of .049 indicate that 4.9% of the variation in material waste reduction rate was accounted for by institutional support. The regression equation is Y = 11.743 + 0.237(X). The standardised coefficient (Beta = .236) and t-value of 2.871 (p = .005) confirm a significant, positive relationship between institutional support and material waste reduction rate, the strongest of the three predictors examined. On this basis, H03 was rejected.

D. Summary of Findings

i) Teachers' attitude to workshop practices significantly predicted material waste reduction rate in metalwork technology among technical students, with a positive teacher disposition associated with improved waste reduction.

ii) Availability of equipment significantly predicted material waste reduction rate, with better-equipped workshops associated with less material wastage.

iii) Institutional support significantly predicted material waste reduction rate, and exerted the strongest influence of the three institutional variables examined, with adequately funded and well-supervised institutions associated with greater waste reduction.

V. DISCUSSION OF FINDINGS

A. Teachers' Attitude to Workshop Practices and Material Waste Reduction Rate

The finding that teachers' attitude to workshop practices significantly predicted material waste reduction rate is consistent with [41], who noted that a positive teacher attitude acts as a catalyst for skill acquisition and efficient material utilisation, whereas a negative or indifferent attitude can lead to negligence, errors, and substantial waste generation during metalwork activities. Positive teacher attitudes

are associated with reduced wastage as learners become more careful, attentive to detail, and committed to achieving high standards in their work, while negative attitudes, such as a lack of interest or fear of injury, can lead students to mishandle materials or tools, resulting in increased scrap, rework, or damage to equipment. This finding also aligns with [13], who observed that motivation and incentives influence teachers' attitudes toward teaching and workshop practices: when teachers receive adequate remuneration, recognition, and opportunities for professional development, they demonstrate greater commitment to their work, whereas poor working conditions and inadequate institutional support may lead to frustration and negative attitudes toward practical teaching, with safety conditions in the workshop further affecting teachers' willingness to fully engage students in hands-on learning.

B. Availability of Equipment and Material Waste Reduction Rate

The finding that availability of equipment significantly predicted material waste reduction rate agrees with [17], who noted that schools receiving government-funded equipment upgrades recorded markedly lower waste production in student projects due to better workmanship and reduced material spoilage, underscoring that equipment availability is a strategic determinant of learning quality and resource efficiency rather than merely a logistical concern. The availability of tools and equipment is fundamental to hands-on subjects like metalwork: when schools lack essential tools, students are often forced to improvise, share excessively, or omit critical steps in the production process, all of which contribute to higher rates of material wastage. This is consistent with [16], who found that adequate provision and availability of workshop equipment are essential for effective skill acquisition, and that well-maintained, modern equipment reduces human error and improves precision, while schools operating with obsolete or worn-out tools struggle to achieve clean cuts, proper welds, or accurate measurements, leading to errors that result in discarded or unusable products.

C. Institutional Support and Material Waste Reduction Rate

The finding that institutional support significantly, and most strongly, predicted material waste reduction rate is consistent with [20], who noted that institutional support plays a crucial role in determining efficiency and productivity in vocational education, particularly through the provision of infrastructural facilities, qualified personnel, administrative backing, and policies that encourage skill development, proper workshop practices, and accountability. Metalwork activities inherently involve the risk of material waste due to measurement errors, incorrect machining procedures, and a lack of proper planning or supervision, but when schools provide adequate institutional support through structured curricula, modern tools, and regular supervision, the rate of such waste can be drastically reduced. This aligns with [19], who noted that institutional factors such as prompt tool maintenance, availability of consumables, and adherence to standardised workshop procedures help to instil discipline and reduce trial-and-error operations that often lead to material wastage, and with [21], who found that schools that track and report material-usage patterns create an environment of accountability that compels students to approach metalwork tasks more conscientiously. The lack of institutional support, by contrast, contributes to increased waste through inconsistent supervision, obsolete equipment, and demotivated instructors, a situation common in underfunded technical colleges where students are forced to improvise due to a lack of access to proper machines or updated technical guidance.

VI. CONCLUSION

Based on the findings of this study, it is concluded that institutional variables significantly predict material waste reduction rate in metalwork technology among technical students in Calabar Education Zone of Cross River State, Nigeria. Specifically, positive attitudes exhibited by teachers toward workshop practices enhance material waste reduction rate among ST-2 students in the study area; adequate availability of functional equipment improves students' ability to reduce material wastage

during practical activities; and institutional support, reflected in funding, policy enforcement, and supervision, most strongly predicts waste reduction rate among the three variables examined. These findings affirm, within a constructivist framework, that the institutional conditions surrounding practical instruction, namely instructor disposition, material resources, and administrative backing, meaningfully shape how efficiently technical students manage metal materials during training.

VII. RECOMMENDATIONS

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

i) Technical colleges should organise regular professional development, motivational, and recognition programmes for metalwork teachers to sustain positive attitudes toward workshop supervision and waste-conscious instruction.

ii) Government and school authorities should prioritise the procurement, upgrading, and regular maintenance of metalwork equipment, particularly welding, cutting, and shaping machines, to reduce trial-and-error wastage during practical activities.

iii) School administrations should strengthen institutional support systems, including adequate funding, staff-training programmes, and equipment-maintenance services, to reinforce waste-reduction practices in metalwork workshops.

iv) Technical colleges should institute and enforce clear material-control policies, with regular monitoring and supervision of workshop practices, to hold both teachers and students accountable for material usage.

v) Curriculum planners and technical-education boards should incorporate waste-reduction and sustainability principles explicitly into metalwork training modules, complementing the institutional interventions above.

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