DEVELOPMENT AND VALIDATION OF PERFORMANCE-BASED INSTRUMENT FOR ASSESSING STUDENTS' PRACTICAL SKILLS IN MACHINE WOODWORK AT SCIENCE AND TECHNICAL COLLEGE LEVEL IN NIGERIA

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Abstract
This study was designed to develop and validate Machine Woodwork Skill Assessment Instrument (MWSAI) for assessing students' practical skills in machine woodwork at science and technical college level. Four research questions were set to guide the study. The study adopted the instrumentation design and was carried out in Adamawa State. The population for the study is 23 respondents. The practical skills draft copy of the instrument was developed and subjected to face, content and construct validation. The NBTE approved curriculum for NTC (machine woodwoek Modules) was reviewed and a task specification table designed from it. After conducting task analysis, 10 tasks were identified and expanded further to give 96 corresponding skills. A 5 – point scale with rating values of 5-very high, 4-high, 3-moderately high, 2-low, and 1-very low was incorporated into the instrument.The instrument was subjected to reliability test and results obtained from task-by-task reliability coefficient range from 0.74 to 0.99 through Cronbach Alpha. Based on the results of the validation; 10 tasks with corresponding 96 practical skills were found valid and reliable hence formed the developed instrument. The developed practical skills assessment instrument was used in assessing 15 NTC III students during machine woodwork practical from the sampled technical college in the study area which revealed high degree of agreement of concordance among the raters. Based on the findings of the study, the following recommendations were proffered: efforts should be made to adopt and enforce the use of MWSAI for assessing students' practical skills in Nigerian technical colleges, and teachers should be encouraged to study and acquaint themselves with the use of the new instrument.

Keywords: Development, Validation, Reliability, Machine woodwork, Practical Skills

Introduction
Assessment instrument is use to elicit information from student that inform the teacher, examiner, school administrators about student's achievement of educational objectives. It is a well-standardized measuring instrument, appropriate to a given assessment (Creswell, 2012). Assessment instruments can be developed in form of tests, interviews, observations, projects, questionnaires, inventory among others. Process assessment of students is usually through observation and rating, best in case of assessing the quality of performance. It requires the assessor observing the learner on the job and then rating the procedural performance. According to Okoro (2002) this approach, subjective and prone to abuse by the evaluators and even the students, a rating scale therefore helps the assessor to discriminate between groups of students.

A very important criterion for objective and reliable assessment suggested by both Okwelle (2011) and Okwori, Adamu and Odo (2013) is to construct and use a well-designed and validated assessment tool. This tool will ensure that the actual performance of the learners

is assessed rather than their personality or attitudes as may be perceived by assessors. Without physical observation, teachers will be generating and working with unreliable data which will mislead both the students and their parents. This situation is can adversely affect the students' true performance records. This agrees with the position of Okwori, Adamu and Odo (2013) that process assessment is subject to a number of different types of error, a well-constructed rating scale, accompanied by explicit instructions of what qualities to look for, usually results in higher reliability than product assessment made without the merits of such a scale.

The students will perform practical skills using tools and necessary equipment while the raters (teachers) will assess their performance based on the instrument developed. A valid and reliable instrument for assessing the skills of students in machine woodwork tasks is therefore of importance. However, related literature available to the researcher has revealed no studies that dealt specifically on the development and validation of instrument for assessing 'machine woodwork' component of woodwork trade operations in science and technical colleges. The absence of such an important instrument for teaching and learning of machine woodwork at science and technical college level coupled with the poor performance of students in National Technical Certificate (NTC) examination (Inti & Fatokun, 2006; National Business and Technical Examinations Board NABTEB, 2016), has prompted the researchers to carry out the study.

Woodwork has areas of specialization and these include carpentry, joinery, cabinet making and wood machining. Federal Republic of Nigeria (2013) identified areas of woodwork as follows: Upholstery, Carpentry and Joinery, wood machines and furniture making. There are four Science and Technical Colleges in Adamawa State, while the State has three and Federal has one Science and Technical College respectively. These science and technical colleges run various trade courses including woodwork, Metalwork practice, Block laying and Concreting, Electrical Installation and Maintenance Work, painting and Decorating among others. Machine woodwork is a component of the NTC woodwork syllabus. Students admitted into these trade courses spend three years in school for the award of NTC on completion of the course, holders of this certificate are refered to as craftsmen.

Product rating according to Ahmed (2017) has limitations such as students getting assistance outside to produce products presented for assessment. Safety and correct use of tools/equipment by students cannot be assessed through the product based assessment instrument. Time spent in constructing a product or number of mistakes made in the process are not considered in the current assessment instrument used by both NABTEB and class teachers. These limitations perhaps have prevented skill development of students experienced in the world of work today. The practical skill test items whose psychometric properties (validity and reliability) will be determined through ability groups of students can surmount these limitations. The instrument will enable the teacher to assess directly the process performance of the students on the task through to the end-product. According to Ahmed (2017) process assessment involves observation and grading of the learners in the entire task skills or step-by-step as students perform the given tasks. Product assessment in Okwelle and Okeke (2012) is ineffective in revealing actual amount of skills possessed by students. Bwala (2016) further buttressed that the best way to assess skills in Science and Technical College should be based on step-by-step of the performing tasks. Shobowale, Odo and Okwori (2011) emphasized that, with process rating assessment, certain attributes of the learners such as the ability to complete task at a given time, safety practices, the skills/competencies and

procedures in the use and care of tools and equipment could be systematically observed objectively and comprehensively assessed.

Statement of the Problem

The product rating method used by the teachers and examination bodies in measuring performance of the students is inadequate. The current practice has made it impossible for the full achievement of the objectives of woodwork trade in science and technical colleges**.** The current assessment practice does not ensure that the students of woodwork trade are taught the proper way of carrying out tasks in machine woodwork. Ombugus (2013) buttressed that the assessments practiced by the teachers and final examination by NABTEB have produced graduates of various technical trades including machine woodwork who are unemployable in the field. According to Okwelle and Okoye (2012) the popular method of assessing students' practical skills in technical and vocational education programmes in Nigerian science and technical colleges is based on mere looking at the students' end products by the examiners with little or no attention to the processes involved in carrying out the practical work. Marks are then awarded to the students on the account of the teacher or examiners' personal judgment which is often bias and misleading.

Woodwork teachers including NABTEB as a board use a marking scheme checklist to assess students' performance in practical components of examinations. This scheme merely highlights the major skills to be rated but lacks vivid specification of skills involved in the process of carrying out the given task. Test used for assessing students should not only be valid but also reliable. Reliability of a measuring instrument according to Fairchild (2008) is the ability of the instrument to measure consistently the phenomenon it is designed to measure. The inference of this appalling trend is that the scores and grades assigned to students in practical works by the examiners may not reflect the true performances of the students. This is because procedural steps to arrive at the completed project are not properly assessed.

The study is therefore prompted on the derisory nature of the present method of evaluation which is product-based, there is an urgent need to improve or overhaul the standard and method of assessment in machine woodwork component by using valid and reliable assessment instruments which will consider the processes of practical activities leading to the completion of the final practical products. The assessments of practical skills practiced by the woodwork teachers and final examination by NABTEB have produced graduates of machine woodwork that are unemployable in the field. This explains why many of the graduates are into other unskilled jobs like commercial motorcyclist, motor-parks workers others even thuggry, kidnaping among others or remain unemployed. This study therefore was designed to develop a standardize instrument for assessing students' practical skills in machine woodwork at science and technical college level.

Purpose of the Study

The purpose of this study is to develop and validate an instrument for assessing students' practical skills in machine woodworking at science and technical college level. Specifically, the study was to:

(i) identify the practical task items considered appropriate for inclusion in Machine Woodwork Skill Assessment Instrument (MWSAI) for assessing students' practical skills in science and technical colleges,

(ii) identify the practical skill items considered appropriate for inclusion in MWSAI for

assessing students' practical skills in science and technical colleges,

(iii) determine the validity of the developed instrument for assessing machine woodwork students' practical skills in science and technical colleges,

(iv) establish the reliability of the developed instrument for assessing machine woodwork students' practical skills in science and technical colleges.

Methodology

Instrumentation design was adopted for the study and was carried out in Adamawa State. The population for the study was 23 respondents comprising 14 woodwork professionals under National Directorate of Employment skill acquisition list, five tertiary institutions lecturers within the study area and four woodwork trade teachers teaching in the four Science and Technical Colleges. Purposive sampling technique was employed to select Government Science and Technical College, Yola for the trial test and the entire population was used as sample size since it is manageable. The MWSAI was developed using the following strategy build up based on the suggestion of UNESCO (2002) and Okwelle and Okoye (2012).

Stringent review of the related literature such as NBTE curriculum

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Isolation of objectives of assessment from the curriculum

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Derive basic tasks statements from the objective

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Development of table of specifications

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Select a rating scale

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Generation of practical skill items

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Face and content validation of the draft items

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Revise the validated draft test items to produce the instrument

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Trial testing of tests to determine validity and reliability

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Final selection of process skill items and assembly

A 96 practical skills draft copy of the instrument was developed and utilized for the study. The instrument was subjected to face, content and construct validation. The NBTE approved curriculum for NTC (Machine Woodwork Modules) was reviewed and a task specification table designed from it. After conducting task analysis, ten tasks were identified, and expanded further to give 96 practical skill items. A 5 – point likert scale with rating values of 5-very high (VH), 4-high (H), 3-moderately high (MH), 2-low (L), and 1-very low (VL) was used for the instrument. The respondents rated the practical skills level of appropriateness for inclusion in the MWSAI. To select practical tasks, factorial analysis of the instrument items were determined which Gall, Gall and Borg (2007) considered to play a major role in the development of various types of assessment instruments used in education. The procedures involved; (1) identifying two psychomotor module areas in the NTC curriculum, (2) building a table of specification based on Simpson's (1972) taxonomy of psychomotor objectives. This followed a process of task analysis (3) generating practical skill items which closely fit the table of specification. The skill items were

subjected to factor analysis benching 0.50 as factor loading at 5% over lapping variance. Therefore, any practical skill with factor loading of 0.50 and above was included in the MWSAI while skill items with factor loading less than 0.50 were not included in the final copy of MWSAI. Three teachers of woodwork were used as assessors for observing and assessing the students as they execute given tasks with corresponding skills of the developed instrument during the field trial. Cohen, Manion and Marrison (2011) recommended that a coefficient ranging from 0.51 to 1.00 indicate high degree of agreement between two or more assessors. The method of data analysis includes mean and standard deviation, factorial analysis, Simpson's (1972) taxonomy of psychomotor objectives, Cronbach Alpha coefficient and Kendall coefficient of concordance.

Results

Research Question One: What are the practical task items considered appropriate for inclusion in Machine Woodwork Skill Assessment Instrument (MWSAI) for assessing students' practical skills in science and technical colleges?

Table 1: Practical Task Items Considered Appropriate for Inclusion in Machine WoodworkSkill Assessment Instrument (MWSAI)

Psychomotor modules	Practical Tasks	$\bar{X}$	σ	Remark
Machine Woodwork I	Operation of a Circular Rip Saw	4.89	0.48	Agreed
	Set up Circular Rip Saw to carry out	4.60	0.75	Agreed
	Operation of a Dimension Bench Saw	4.38	0.96	Agreed
	Operation of a Drill Press Machine	4.70	0.65	Agreed
	Operating Combination Planning Machines	4.59	0.92	Agreed
	Operating Thicknesser	4.84	0.54	Agreed
Machine Woodwork II	Operating the Mortising Machine	4.86	0.39	Agreed
	Operating Surface Planer	4.86	0.43	Agreed
	Operation of a Band Saw	4.79	0.54	Agreed
	Operation of a Wood Lathe	4.73	0.80	Agreed

Results in Table 1 shows the practical tasks considered appropriate for inclusion in the Machine Woodwork Skill Assessment Instrument (MWSAI) for assessing students' practical skills in science and technical colleges. The result showed that all the tasks were agreed to be appropriate for inclusion in the assessment instrument. The standard deviation of averagely below 1.00 for all responses of respondents indicates that the responses were closely unanimous. Based on the data presented and the subsequent analysis, it can therefore, be concluded that the practical tasks obtained through content analysis of the NBTE curriculum were consistently accepted by the respondents.

Research Question Two: What are the practical skill items considered appropriate for inclusion in MWSAI for assessing students' practical skills in science and technical colleges?

Table 2: Practical Skills Items considered Appropriate for Inclusion in Machine Woodwork Skill Assessment Instrument (MWSAI)

Practical Tasks	Corresponding Skills	Factor loading	Remark
Operation of a Circular Rip Saw	Select the machine tools	0.81	Appropriate
	Sharpen the planes on the handle	0.58	Appropriate
	Sharpen the chisels/riving knife to be used	0.62	Appropriate
	Sharpen saw blades to requirements	0.74	Appropriate
	Place the machine cutter in position	0.76	Appropriate
	Grip the cutter by tightening	0.80	Appropriate
	Label sawing area on the machine using canting fence	0.75	Appropriate
	Adjust the machine canting fence	0.78	Appropriate
	Place the work piece while cutting along sawing area	0.74	Appropriate
	Loosen the screws to dismount the machine cutter	0.81	Appropriate
Set up Circular Rip Saw to carry out Grooving	Use the central lever to set the table to the desired cutting depth	0.77	Appropriate
	Adjust the pivoting scale to angle the blade for beveled cuts	0.79	Appropriate
	Position/activate the saw blade by pulling the trigger on the rear handle	0.61	Appropriate
	Push the work piece along the sawing	0.69	Appropriate
	Release the trigger to stop the blade after	0.72	Appropriate
	Fix the riving knife	0.76	Appropriate
	Cut work pieces for grooving	0.81	Appropriate
Operation of a Dimension Bench Saw	Construct jigs/fixtures for intricate jobs	0.83	Appropriate
	Fix the jigs/fixtures for intricate jobs	0.80	Appropriate
	Set up the saw blade	0.86	Appropriate
	Cross cut the work piece to length	0.86	Appropriate
	Place another work piece on the bench while leveling	0.87	Appropriate
	Align another work piece for mitring	0.69	Appropriate
	Cut the wood in a mitring shape	0.84	Appropriate
	Adjust a the work piece for ripping	0.88	Appropriate
	Ripe off the work piece	0.61	Appropriate
	Carry out compound angular cutting	0.66	Appropriate
	Clean parts with modern sanders	0.55	Appropriate

Operation of a Drill Press Machine	Mark out the position of the hole to be drilled	0.99	Appropriate
	Fasten the bit in the chuck	0.97	Appropriate
	Place the work piece on the table height	0.99	Appropriate
	Place a scrap piece underneath to avoid	0.94	Appropriate
	Adjust the depth gauge to regulate the depth of the hole	0.98	Appropriate
	Hold steady the work piece on the table while starting the machine	0.99	Appropriate
	Feed the rotating bit into the work with the feed lever	1.00	Appropriate
Operating Combination Planning Machines	Sharpen cutters using either patent device or wooden straight edge	0.74	Appropriate
	Set cutters using either patent device or wooden straight edge	0.62	Appropriate
	Place the cutters firmly	0.78	Appropriate
	Cut route sheets for the production of	0.76	Appropriate
	Fix route sheets for the production	0.60	Appropriate
	Set - out the rods	0.63	Appropriate
	Sharpen the planning blade	0.79	Appropriate
	Set the planning saw blade on the machine	0.81	Appropriate
	Gauge the length of the planning blades	0.64	Appropriate
	Place the planning blade	0.72	Appropriate
	Plane the work piece	0.74	Appropriate
Operating Thicknesser	Measure the thickness of wood to be	0.77	Appropriate
	Set the machine to appropriate dimensions	0.73	Appropriate
	Place the face side against the fence of the	0.76	Appropriate
	Start the machine while maintaining maximum working speed	0.72	Appropriate
	Push the bridge guard to close up the exposed gap of the cutting slot	0.79	Appropriate
	Feed the wood into the rotating cutter while planning the face	0.79	Appropriate
	Insert the face edge mark	0.81	Appropriate
	Set the scale on the machine as well as width to the given dimension	0.59	Appropriate
	Plane the wood piece to required thickness	0.60	Appropriate
Operating the Mortising Machine	Install cutters firmly	0.50	Appropriate
	Set up the hollow area for mortising	0.84	Appropriate
	Draw directional arrows to fence to be	0.81	Appropriate
	Adjust the fence before placing the work	0.75	Appropriate
	Square the chisel to the fence	0.82	Appropriate

	Gauge the positions of the joints across both sides/ edges then mark	0.82	Appropriate
	Set out the external faces of the joint members when they are to be seen	0.85	Appropriate
	Marking the shapes of mortise and tenon while tracing the shape of the gauged	0.62	Appropriate
	Chisel to the waste sides of the lines	0.67	Appropriate
Operating Surface Planer	Plane the face side as required	0.79	Appropriate
	Test lengthways for straightness with a	0.73	Appropriate
	Test across both ends for flatness with the	0.81	Appropriate
	Test diagonally for winding/twist with	0.81	Appropriate
	Fit the rule with the work piece while putting on the face side mark	0.58	Appropriate
	Plan the face edge of the wood piece and testing with a try-square	0.80	Appropriate
	Set the marking gauge to the proper width and guide all round wound	0.78	Appropriate
	Set the gauge to the thickness and gauging all round while planning to the	0.81	Appropriate
Operation of a Band Saw	Measure the work piece to be cut	0.77	Appropriate
	Mark/set out the work piece	0.63	Appropriate
	Sett the top blade guide to clear the work	0.73	Appropriate
	Turn on the switch while holding the work	0.74	Appropriate
	Feed the work piece slowly into the	0.78	Appropriate
	Cut near the marked line	0.74	Appropriate
	Guide the work piece to keep the blade	0.76	Appropriate
Operation of a Wood Lathe	Start the machine	0.95	Appropriate
	Choose the lathe operation	0.99	Appropriate
	Select the turning tools	0.90	Appropriate
	Set the wood lathe components	0.98	Appropriate
	Square the stock for initiation of work on the machine	0.99	Appropriate
	Cut the stock to the desired length	0.94	Appropriate
	Mark the centre of each end of the stock while positioning it between the lathe	0.98	Appropriate
	Position of the tool and making allowance to have the work piece rotate	0.99	Appropriate
	Spin freely the work piece while avoiding hitting the tool rest	0.97	Appropriate
	Choose the chisel to be used	0.96	Appropriate
	Switch-on the lathe at lowest speed level	0.99	Appropriate

	Move the cutting edge parallel to the rotation of the work piece, making light	1.00	Appropriate
	Push the tool into the work piece, in passes while looking for stress cracks in	0.98	Appropriate
	Identify stress cracks as machine is stopped at intervals	0.97	Appropriate
	Increase the lathe speed to smooth the finished round work piece	0.96	Appropriate
	Hold cutting tool while moving along the wok piece's length	1.00	Appropriate
	Sand the work piece	0.99	Appropriate

Table 2 shows results of practical skill items considered appropriate for inclusion in the MWSAI for assessing students' practical skills in science and technical colleges. All the 96 Machine Woodwork practical skill items had factor loading ranging from 0.50 to 1.00 and so were fit for inclusion in MWSAI for assessing students' practical skills in science and technical colleges.

Research Question Three: What is the validity of the developed instrument for assessing machine woodwork students' practical skills in science and technical colleges?

The instrument was subjected to face, content and construct validation through factor analysis which certify the tasks and corresponding skills valid. Three experts from the Department of Technology and Vocational Education and two in the Department of Measurement and Evaluation from Nigerian Universities, as well as two technical teachers teaching woodwork at the science and technical colleges validated the instrument. The experts reviewed, reworded and re-structured the instrument and made satisfactory comments about the entire tasks and corresponding skills. For the content validity, table of specifications was constructed based on the Simpson's (1972) model of psychomotor domain. This revealed that out of the 96 practical skills, 8.33% comprising 8 practical skill items were assessing the Perception Level; 9.38% comprising 9 practical skill items were assessing the Set Level; 28.13% comprising 27 practical skill items were assessing the Guided Response Level; 26.04% comprising 25 practical skill items were assessing the Mechanism Level; 17.71% comprising 17 practical skill items were assessing the Complex Overt Response Level and 10.42% comprising 10 practical skill items were assessing the Adaptation Level. The Origination Level of Simpson's Model was not involved in the study because it adjusted as being beyond the scope of this study. For the construct validity, factor analysis was employed with 0.50 beanchmark of factor loading.

Research Question Four: What is the reliability of the developed instrument for assessing machine woodwork students' practical skills in science and technical colleges?

Table 3: Reliability Coefficient of Task-by-Task of the Developed Instrument for Assessing Machine Woodwork Students' Practical Skills in Science and Technical Colleges

S/N	Operational Tasks	Number of Skills	Reliability Coefficient
1	Operation of a Circular Rip Saw	10	0.74
2	Set up Circular Rip Saw to carry out	7	0.97

	Grooving		
3	Operation of a Dimension Bench Saw	11	0.88
4	Operation of a Drill Press Machine	7	0.95
5	Operating Combination Planning Machine	11	0.92
6	Operating Thicknesser	9	0.99
7	Operating the Mortising Machine	9	0.98
8	Operating Surface Planer	8	0.99
9	Operation of a Band Saw	7	0.97
10	Operation of a Wood Lathe	17	0.88
	Overall Reliability Coefficient		**0.93**

Table 3 reveals that none of the tasks and corresponding skills in the instrument has reliability coefficients of less than 0.70. This shows that the entire tasks can be included in the instrument. In order to establish the inter-rater reliability in the instrument, a trial testing was conducted using 15 NTC III students of Machine Woodwork and three teachers (assessors). Data obtained from the trial testing was analysed using Kendall's Coefficient of Concordance, Tau (W) to find out if there is significant relationship between the three rater's scorings in the developed instrument for assessment. The degree of agreement of concordance among the raters on the instrument scorings were then computed. The inter rater reliability of the 3 raters were found to be 0.71, 0.78 and 0.82 for raters A and B; B and C; A and C respectively.

Discussion

The fact that a student can present a quality product does not constitute a positive proof that process practical skills are obtained. It is expected that if the assessment instrument used by the woodwork teachers and examining bodies had included process skills and the students are successful as claimed through their results, they will be able to demonstrate acquired manipulative skills in relevant woodwork projects. This situation necessitated the study. The study findings agreed with all the 10 practical tasks as being appropriate for inclusion in the instrument. The construct validity through factor analysis also yielded high loading of above 0.5. This finding agrees with the observation by Ombugus (2013) that the higher the absence of low loading skill items, the more important and suitable the instrument items. All the 96 practical skill items were said to be valid through content validity using table of specifications constructed based on the Simpson's (1972) model.

The study also revealed that task-by-task reliability coefficient range from 0.74 to 0.99, while the overall reliability of the instrument is 0.93 which indicates that the assessment instrument was highly reliable and is in agreement with Fairchild (2008) who stated that acceptable reliability of tests used in education should be above 0.50. The inter rater reliability of the 3 raters were found to be 0.71, 0.78 and 0.82 for raters A and B; B and C; A and C respectively. These values were in agreement with the recommendation by Cohen, *et al.,* (2011) that a coefficient ranging from 0.51 to 1.00 indicate high degree of agreement between 2 or more examiners.

Conclusion

The incompetency of the graduates as observed by the researchers through preliminary studies could be attributed to the wrong scores and conclusions about students' performance obtained from invalid and unreliable instruments. Based on the findings, the study concludes that application of the instrument in student assessment process will improve student practical competencies and performance. A good number of studies have been carried out on the development and validation

of instruments in different technical trades but none particularly, so far on machine woodwork that is valid and reliable. Thus, the gap in machine woodwork valid and reliable practical assessment instrument has been filled with the development and validation of MWSAI. The developed instrument will help the teachers to adjust their teaching and assessment procedures with a more realistic method, such that grades and marks awarded to students will be a true reflection of the students' ability.

Recommendations

Based on the findings of the study, the following recommendations were proffered:

(i) The Ministry of Education should adopt and enforce the use of MWSAI for assessing students' practical skills in Nigerian technical colleges.

(ii) Technical colleges teachers of woodwork trade should be encouraged to study and acquaint themselves with the use of the new assessment instrument.

(iii) Stakeholders (ministries and institutions) should endeavour to develop platforms (conferences, workshops) where the use of this new assessment instrument can be encouraged.

(iv) Examination bodies such as NABTEB, WAEC and NECO should be encouraged to use this instrument during their assessments.

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