Instrument for Assessing Students' Carpentry Skills in Technical Colleges in Nigeria

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Abstract

The study developed and validated Carpentry Skills Assessment Instrument (CSAI) for technical college students based on Simpson's theory of skill development using instrumentation research. The study was carried out in Kwara, Kogi, Nasarawa and Niger states of Nigeria. The study was delimited to three out of 26 technical colleges and also 15 out of 420 students. The instrument was subjected to face, content validation and factorial validity. Face validation was carried out by three experts from the Department of Industrial and Technology Education, Federal University of Technology, Minna. The content validation was carried out by the 36 carpentry teachers using a table of specifications which was constructed based on Simpson's 1972 model of psychomotor domain where 106 items were retained. The 106 validated items were subjected to factorial analysis where five items were discarded. A pilot study produced reliability coefficient of 0.87 using Cronbach Alpha statistics. The developed Carpentry Skill Assessment Instrument was trial tested in assessing 15 students of carpentry in three technical colleges. Nine teachers of carpentry and joinery (research assistants) were involved as raters, (three in each school). The raters observed and assessed students while carrying out a Carpentry Work Sample Practical Test (CWSPT) during the trial testing. Mean, Standard Deviation, Factorial Analysis and Spearman correlation technique (r_s) were used to answer the research questions. The results revealed that 14 tasks clusters with 101 corresponding skill items and 13 practical skills were found valid and relevant for inclusion in the Carpentry Skill Assessment Instrument. The Carpentry Skill Assessment Instrument produced internal consistencies that ranged from 0.55 to 0.68 and an overall reliability of 0.64. Based on these results, it was recommended that the external examination bodies (NABTEB, NECO and WAEC) should integrate CSAI items in their examination of carpentry students, and that seminars and workshops for teachers on how to make use of the developed Carpentry Skills Assessment Instrument be organized by examining bodies.

Key words: Instrument, Validity, Reliability, Assessment, and Carpentry Skills

Introduction

Carpentry students in Technical Colleges (TC) are required to demonstrate skillfulness in the use of tools, materials and machines to carry out practical tasks as

a result of training received. TC students are given skill training at the National Technical Certificate (NTC) level that qualifies them as Craftsmen. Skill is an ability or expertise to perform a specific task (Department of Education, Science and Training, 2006). Ogwo and Oranu (2006) described skilled actions in terms of sight, sound, or other impressions sent to the mind which in turn directs the muscle. Later, through practice and repetition, the actions become automatic or habitual. This depicts skill development in carpentry as a process rather than product of training.

Carpentry is a construction trade that involves the use of tools and materials such as wood, nails, screws, iron mongery and numerous chemicals in constructing buildings, formworks, hoardings, boat making, ship building, Vehicle body building and civil engineering, to mention but a few. To determine whether students have acquired skills and or competencies necessary for employment and progress in an occupation, some assessment of performance is necessary. Performance tests are often used to measure skills. In performance test, both the process and product are measured. Process assessment is concerned with the procedure adopted by students in carrying out performance test; while product assessment involves assessing the outcome.

Assessment is the process of manipulating and processing the results obtained from measurement to take relevant decision about what is being measured. Meaningful assessment can only be achieved with the use of a valid and reliable instrument. Consequently, assessing students' skills require the use of a measurement instrument. When a person is assessing something, the person is engaged in the determination of the worth and value of what is being assessed (Anikweze, 2005). This means that assessment of Carpentry skills acquired by (TC) students is an effort to place a true value on goodness, effectiveness or ineffectiveness of learning experiences, teaching activities and their expected outcomes.

It is widely accepted that in developing assessment instruments, issues of validity and reliability must be given adequate attention. In developing the Carpentry Skills Assessment Instrument (CSAI) needed attention was given to the determination of its validity and reliability. Anikweze (2005), Ohuche and Akeju (1988) and Okoro (2000) described three important properties of good measuring instruments: First, the instrument must be valid; secondly, the instrument must be reliable; thirdly, the instrument must be usable (it must possess the characteristics that allow it to be used by many users).

Validity of an instrument infers that the performance attributes being measured are relevant to the skill dispositions to be judged. Reliability, a major requirement of an assessment instrument, is the ability of an instrument to measure correctly what it is designed to measure. Radhakrishna (2007) stated that it is a must to develop a valid and reliable instrument in order to reduce measurement errors.

Assessing either the process or the product alone could jeopardize the whole process of skill assessment. However, current practice by carpentry teachers of assessing the finished product alone indicates lack of valid and reliable instrument that could be used to assess the processes of carrying out carpentry work by technical college students. Teachers in most cases base their assessment on completed practical tasks (Ugunduluwa, 2008).

Statement of the problem

Assessments of the objectives of practical lessons require the use of a valid and reliable assessment instrument. Lack of valid and reliable instrument for assessing the carpentry skills acquired by technical college students' during practical work has continued to jeopardize the achievement of the objectives of carpentry in Technical, Vocational Education and Training (TVET). The implications of using invalid and unreliable instruments for assessing students performances is that no meaningful and reliable inferences can be made from such assessment.

Therefore, in order to improve the assessment of practical activities in carpentry work at the technical college level, there is need for valid and reliable instrument. Hence the problem of the study was what valid and reliable instrument could be used for assessing technical college students' practical skills in carpentry at NTC level.

Purpose of the Study

This study produced an instrument for assessing competencies of Technical College students in carpentry. Specifically, the study:

i. determined the relevant operational tasks required for inclusion in the carpentry skills assessment instrument
ii. determined the relevant practical competencies required for inclusion in the carpentry skills assessment instrument
iii. developed the Carpentry Skills Assessment Instrument (CSAI)
iv. determined the validity of the CSAI, and
v. determined the reliability of the CSAI.

Research Questions

The following questions guided the study:

1. What are the relevant operational tasks required for inclusion in the carpentry skills assessment instrument?
2. What are the relevant practical skills required for inclusion in the carpentry skills assessment instrument?
3. How valid is the carpentry skills assessment instrument?
4. How reliable is the carpentry skills assessment instrument?

Ho: There will be no significant difference among three independent raters in their scoring of students' performances using Carpentry Skills Assessment Instrument (CSAI).

Procedure and Method

A Carpentry Skill Assessment Instrument (CSAI) was developed for technical college students based on Simpson's theory of skill development using instrumentation research. The study was carried out in Kwara, Kogi, Nasarawa and Niger states of Nigeria. The study was delimited to process measurement of the basic skills in design, planning and constructing, erecting and finishing stages of carpentry work at NTC level, with major emphasis on the use of hand and machine tools, safety practices and maintenance of tools. No specific reference was made to types of projects because of the varied nature of practical projects in carpentry. The study was also delimited to three out of 26 technical colleges and also 15 out of 420 students because of cost of administering the Carpentry Work Sample Practical Test (CWSPT). The study was also delimited to the final year technical college students because they have completed the CCJ 13 & CCJ 14 carpentry modules included in the NBTE syllabus. The study did not cover the model of tools, equipment or machines used for carrying out carpentry tasks because changing technologies affects the manufacture of tools/machines. These might have constrained the study.

The CSAI was constructed based on the following steps:

- Isolation of objectives of assessment from the curriculum.
- Development of table of specifications based on Simpson's 1966 psychomotor model.
- Generation of carpentry tasks and practical skills to be assessed in students.
- Development of a Carpentry Work Sample Practical Test (CWSPT).
- Initial content validation of the draft tests (Items and Work Sample). 14 task clusters, 106 task operations, 13 skills that should be observed in students when performing practical work and five-point rating scale were validated.
- Developed a rating scale used for collecting data on the skills possessed by students during the test. The rating scale was a researcher designed five-point response category descriptive rating scale with each of the categories of the rating scale indicating a criterion or performance level for each weighted score.
- Factorial analysis on three components of the raters' scores retained 106 operations and discarded five. The instrument was pilot tested on 10 randomly selected TC III students of Government Technical College, Malali, Kaduna and produced internal consistency values that range from 0.65 to 0.85 for the 14 clusters and a reliability coefficient value of 0.87 for the entire instrument using Cronbach-Alpha statistics.
- Tryout of tests on a sample of about 15 TC III students to determine validity and reliability. A total of nine research assistants (three in each of the schools used), were used to collect data for the research during a trial test.
- Final assembly of the CSAI was done.

Data Analysis

To answer research questions one and two, the mean ($\bar{x}$) was computed for every item. Items that produce a mean score of 3.0 or higher were accepted while items with scores below 3.0 were rejected and consequently not included in CSAI. To answer research question three, the data collected were subjected to factorial analysis on three components; where two of the three components are in agreement and produced a factor loading of 0.50 and above, the item was considered valid and included in the instrument. The assessment data obtained using CSAI during the trial test were correlated using Spearman Rank Correlation r_s to determine the reliability of the CSAI and provide answer to research question four. The values of the r_s were subjected to ANOVA to test the correlation in the rating of students' performance for significance at five percent level of probability using Statistical Package for Social Sciences (SPSS version 22.0) and determined the agreement among raters on each of the items.

Results

Research Question one: What are the relevant operational tasks required for inclusion in the carpentry skill assessment instrument?

Table 1: Mean of Carpentry Teachers on the Relevance of Operational Tasks Required for Inclusion in the Carpentry Skills Assessment Instrument.

S/N	Operational Tasks	No of Skill Items	N	Mean	SD	Remarks
1	Interpret drawing/Instructions and plan work	7	36	3.27	0.85	Relevant
2	Measuring and Laying out timber	11	36	3.27	0.83	Relevant
3	Testing for squareness	3	36	3.46	0.74	Relevant
4	Sawing timber to size	9	36	3.22	0.82	Relevant
5	Shaping timber	10	36	3.24	0.84	Relevant
6	Dressing or planning timber	11	36	3.21	0.81	Relevant
7	Boring and drilling	8	36	3.21	0.84	Relevant
8	Clamping and cramping	5	36	3.32	0.94	Relevant
9	Constructing and Erecting	5	36	3.36	0.97	Relevant
10	Finishing	15	36	3.30	0.86	Relevant
11	Maintenance of tools/equipment	7	36	3.39	0.85	Relevant
12	Nailing and screwing	4	36	3.60	0.73	Relevant
13	Setting up and using portable electric tools	3	36	3.29	0.96	Relevant
14	Adopting safe working practices	8	36	3.45	0.84	Relevant

N = Number of validates (carpentry teachers); SD = Standard Deviation.
Source: Field work

The results shows that all the 14 tasks had mean values ranging from 3.21 to 3.60 and are more than the 3.0 value for acceptance. Evidently the respondents agreed that all the 14 tasks are relevant for inclusion in to the carpentry skills assessment instrument. The standard deviation values for the 14 tasks ranged between 0.73 to 0.97 and were less than 1.96, 95% confidence limit which implied that the responses of the respondents are close to one another and to the mean. This added some values to the reliability of the mean.

Research Question two: What are the relevant practical skills required for inclusion in the carpentry skill assessment instrument?

Table 2: Mean of Carpentry Teachers on the Practical Skills that should be assessed in students during practical work

S/N	Practical Skills	N	Mean	SD	Remarks
1	Selecting appropriate tools	36	3.36	0.99	Relevant
2	Promptness in starting a given task	36	3.30	0.62	Relevant
3	Correct use/manipulation of tools	36	3.50	1.10	Relevant
4	Care of tools during and after work	36	3.44	0.93	Relevant
5	Composure when carrying out tasks	36	3.52	0.87	Relevant
6	Body movement/skillfulness in carrying out task	36	3.47	0.73	Relevant
7	Ability to complete task within a given time	36	3.80	0.82	Relevant
8	Demonstrate safe work habit during work	36	3.50	0.81	Relevant
9	Economy in the use of materials/supplies	36	3.44	0.99	Relevant
10	Enthusiasm/hard work in performing a given task	36	3.47	0.84	Relevant
11	Correct layout of shapes and sizes	36	3.52	0.87	Relevant
12	Systematic approach to task execution	36	3.55	0.86	Relevant
13	Correct handling of materials	36	3.61	0.96	Relevant

N= Number of validates; SD = Standard Deviation.
Source: Field work

Data showed the 13 items had mean values ranging from 3.30 to 3.80 which are more than the cut-off value of 3.00. The respondents agreed that all the 13 skills are relevant for inclusion in the CSAI for assessing students' skills during carpentry practical activities. The standard deviation values for the 13 skills ranged from 0.62 to 1.10 and are less than 1.96 at 95% confidence limit which implied that the responses of the respondents are close to one another and to the mean.

Research Question three: How valid is the carpentry skill assessment instrument for assessing students' practical skills?

Table 3: Summary of Factorial Analysis conducted on Operational Tasks

S/N	Operational Tasks	No of Items Tested	No of Items Valid	Factor Loading at 0.50
1	Interpreting drawing/Instructions and planning work	7	7	0.71
2	Measuring and laying out timber	11	10	0.64
3	Testing	3	3	0.88
4	Sawing timber to size	9	8	0.61
5	Shaping timber	10	9	0.62
6	Dressing or planning timber	11	11	0.62
7	Boring and drilling	8	7	0.67
8	Clamping and cramping	5	5	0.75
9	Constructing and Erecting	5	5	0.77
10	Finishing	15	15	0.65
11	Maintaining tools and equipment	7	7	0.67
12	Nailing and screwing	4	4	0.67
13	Costing of joinery items (to be included in theory)	3	3	0.79
14	Adopting safe working practices	8	8	0.68
	Total	**106**	**101**	**0.70**

Source: Field work.

The 14 tasks had factor loadings that ranged from 0.61 to 0.88 and were above the factor loading of 0.50 at 10% over lapping variance with three components. All the 14 tasks were relevant for inclusion in the CSAI. However, from the 106 Items, five in tasks 2, 4, 5, 7 and 9 were discarded because they have factor loading below 0.50. The items discarded were items 17, Marking out curves using dividers and trammels; 28- Chopping out mortise with a mortise chisel; 33- Planing timber surface with the smoothing plane; 54- Scraping with a wood scraper and 63- Boring timber with a hand drill. In general, 14 tasks, 101 items and 13 skills are valid enough and were included in the CSAI. This finding agreed with Bakare (2014), Giachino and Gallington (1977) that if content has no components of non – loading items, it is assumed that the factorial validity of the tasks or content is high.

Research Question four: How reliable is the carpentry skill assessment instrument for assessing students' practical skills?

Table 4: Summary of Reliability Estimates of the Carpentry Skills Assessment Instrument.

S/N	Task Clusters	r_s	Remark
1	Interpreting drawing and planning work	0.66	Reliable
2	Measuring and laying out timber	0.63	Reliable
3	Testing	0.63	Reliable
4	Sawing timber to size	0.68	Reliable
5	Planning timber	0.65	Reliable
6	Shaping Timber	0.66	Reliable
7	Boring and drilling	0.61	Reliable
8	Clamping and cramping	0.63	Reliable
9	Maintaining tools and equipment	0.64	Reliable
10	Driving iron mongeries, dowels, etc. into timber	0.63	Reliable
11	Removing iron mongeries, dowels, etc	0.55	Reliable
12	Installing hardware fixtures	0.68	Reliable
13	Costing of joinery items	0.68	Reliable
14	Adopting Safe working practices	0.64	Reliable
Total estimates for the 14 Clusters		**0.64**	**Reliable**

r_s = Spearman Correlation Coefficient

Source: Field work.

All the 14 carpentry tasks had a high spearman reliability coefficient that ranged from 0.55 to 0.68 while the entire instrument had reliability coefficient of 0.64. The result is in consonance with the recommendation of (Landis & Koch, 1977) that acceptable reliability of a test or agreement of raters on students' tests in education ranged from 0.41 to 1.00. Therefore given the high reliability coefficients or substantial agreement for various tasks in the instrument, the items in CSAI are reliable and can be used for assessing technical college students' practical skills in carpentry at NTC level.

Findings of the Study

1. 14 tasks with 101 corresponding skill items were relevant and included in the CSAI.
2. 13 practical skills that should be assessed in carpentry students were validated.
3. The CSAI was found to be valid for assessing students' practical skills.
4. The reliability coefficient of the 14 clusters ranged from 0.55 to 0.68 while that of the entire instrument was 0.64
5. There was no significant difference among three independent raters in their scoring of students' performance using CSAI.

Discussion of findings

The findings on relevant operational tasks required for inclusion in the instrument for assessing practical activities revealed that 14 tasks items were relevant and included in the carpentry skills assessment instrument. Garba (1993), Okoro (2003),

Olaitan (2003), Bukar (2006), Mohammed (2006) and Ombugus (2013) noted that items that satisfied all psychometric properties with high mean are relevant and worthy for inclusion in an assessing instrument. 14 tasks satisfied all the psychometric properties of a good skill items and therefore worthy for inclusion in the carpentry assessment instrument. Inclusion of relevant skill items in assessment instrument helps in measuring the stated objectives adequately.

Findings also revealed 13 skills that should be assessed in students during practical. Similar findings by Garba (1995) and Yalams (2001) also supported selection of appropriate tools, correct use/manipulation of tools, and care of tools as vital in a competency based assessment guide for technical college instructors and lecturers of carpentry.

Findings on the validity of carpentry skills assessment instrument revealed valid 14 tasks and 101 corresponding skill items. Face validation was the first stage of the CSAI development ascertained by three specialists from the Federal University of Technology, (FUT) Minna.. This is in agreement with Stemler (2004), Mohammed (2006) and Olaitan (2003) Bukar (2006) and Bakare (2014), that to establish face validity or validation, experts are hired to vet, remove, reword and replace any irrelevant item(s) of the instrument with useful ones.

To ascertain the content validity of CSAI, the test items were generated based on table of specifications developed through job/task analysis and suggestions by experts. The findings are in agreement with the finding of Amuka (2002), Ombugus (2013) and Okeme (2011) who established content validity from detailed and comprehensive table of specification and comments of some experts. Garba (1993) and Odu (2000) added that job/task analysis helps in building validity in an instrument.

A second stage of validation was carried out on CSAI using 36 C&J teachers used for the study. 14 tasks and 106 test items were found to be valid for the study. In addition to face and content validation of the CSAI, factorial validity test using factor analysis was conducted, where 14 tasks and 101 operation items were found valid enough for inclusion in the CSAI. Five operation items were not found valid and were discarded. The finding agreed with the findings of Bakare (2014) who employed factor analysis to validate items of cell phone maintenance training modules for national diploma students. Bakare (2014), Bukar (2012) and Balogun and Mustapha (2014) concluded that test items that have high factor loading and satisfy other psychometric properties are important for selection.

Findings on reliability of CSAI revealed that 14 tasks had reliability coefficients from 0.55 to 0.68; the 101 corresponding skill items had reliability coefficient values that ranged from 0.41 to 1.00, while the entire items had reliability coefficient value of 0.64. This means that all the 101 tasks and their items are reliable enough for inclusion in the CSAI. The findings of Ombugus (2013), Odu (2000), Yalams

(2001), Zhang and Lam (2008) who obtained a reliability coefficient values of 0.71, 0.68, 0.86, and w = 0.97 respectively using Cronbach alpha statistics gave credence to the findings of this study.

Conclusion

Simpson's model of skill development has proved usable in producing a framework for the development of a valid instrument for use in TVET. The era of technical college students graduating with little or no required employable skills for work is over. The developed CSAI will reduce measurement errors in students' practical assessment because all the procedures for good development and validation of test instrument were followed to fill the gap created by lack of valid and reliable instrument to assess the teaching and learning of carpentry towards achieving the overall objectives of TVET. The practice by carpentry teachers of assessing students' cognitive achievement and products of their work alone can now be a thing of the past because teachers can now use the developed CSAI to assess the skills possessed by TC students. This will make the assessment of carpentry work comprehensive and the achievement of the objectives of TVET in carpentry realizable. Teachers can now infer to the results of their students to make judgment on processes involving skill development in carpentry.

5.4 Recommendations

1. Examination bodies (NABTEB, NECO and WAEC) should integrate CSAI to examine carpentry students.
2. Teachers of carpentry should be encouraged to make use of the CSAI for assessing students in carpentry.

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