Reliability Coefficient of Multiple–Choice and Short Answer Objective Test Items in Basic Technology: Comparative Approach

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Abstract
This study examined the reliability coefficient of multiple-choice and short-answer objective test items in Basic Technology using comparative approach. The study adopted descriptive research design of survey type. 200 students were drawn from the target population in the three senatorial districts of Ondo state using multi-stage sampling technique. 30 multiple-choice objective test items were drawn from the past questions in Junior Secondary School Basic Technology also transformed into short answer objective test items and administered on the same set of selected students. Four research questions were raised and one hypothesis was formulated and tested at 0.05 level of significance. The data collected were subjected to both descriptive and inferential statistics. The results of the analysis revealed that both multiple-choice and short answer objective test had better internal consistency of 0.78 and 0.73 respectively using Cronbach’s Alpha while Spearman Brown split half had good internal consistency in both multiple-choice (0.80) and short answer (0.81) than Cronbach’s Alpha method. It was also revealed that there was significant difference between the performance of students in multiple-choice and short answer objective test format. Despite the fact that multiple-choice objective test is commonly used the short answer test format is still reliable in measuring students understanding of principles and ability in solving technological problems. It was recommended among others that the examination bodies should introduce the use of short-answer format instead of relying on multiple-choice that can only provide recall of fact.

Keywords: Reliability, Psychometrics, Objective Test, Multiple-choice, Short-Answer

Introduction
Psychometrics is the field of study concerned with the theory and technique of psychological measurement, which includes the measurement of knowledge, abilities, and personality traits. Psychometrics primarily concerned with the study of differences between individuals. It involves two major research tasks, namely:

i. the construction of instrument and procedures for measurement; and
ii. the development and refinement of theoretical approaches to measurement.
The psychometric properties of outcome measures include: reliability, validity and responsiveness. In psychometrics, reliability is the overall consistency of a measure. A measure is said to have reliability if it produces the same similar results under consistent conditions.

Reliability of a test is the degree of consistency or stability which the test exhibits, in other words, it is also concerned with how far a particular test result represents the testees in the attribute being measured and how reproductive such test results are repeated on different occasions or when retested with an identical test (Nworgu, 1992). Reliability is all about the consistency, stability, dependability and predictability of any research instrument or test which can be estimated using Test-retest, Split-Half, Parallel/Equivalent, Kuder-Richardson 20-21 and Cronbach Alpha. Coefficient of reliability of a test could be expressed as a coefficient under any of these three conditions:

i. **Stability**: this is attained by correlating a set of measurement with a retest at some later point in time e.g. Test-retest reliability that determines how much error in a test score is due to problem with test administration.

ii. **Equivalence**: can be estimated by correlating two or more sets of measurements presumed to measure the same universe of items e.g. Equivalent/Parallel that determines how comparable two different versions of the same measure are.

iii. **Internal consistency of Homogeneity**: it can be estimated by determining the extent to which measurement on a single form is inter-correlated e.g. Split-Half method, Kuder-Richardson (20-21) and Cronbach’s Alpha.

Testing contributes to theory in developing the science of measurement itself, sometimes called psychometric(s) by studying how different groups of people respond to tests of different types and to determine the difficulty, discriminating, validity and reliability of the test items (Gilbert, 1974).

For student to transit from the three years of Junior Secondary School to Senior Secondary School, he/she must register for the Junior School Certificate Examination (JSCE) conducted by the state Ministry of Education or National Examination Council (NECO) for candidates in the Federal schools, Arm Forces Secondary Schools and other Federal establishment operating secondary school. Private schools also take part in the state or NECO Junior School Certificate Examination (JSCE) provided that they are permitted by their Ministry of Education. A candidate is expected to sit for a minimum of ten subjects and a maximum of thirteen in which Basic Technology is one of the subjects to offer by the students.

**Spearman Brown Split-Half Reliability**

The split-half reliability is based on two halves that are considered as equivalent or parallel (Kerlinger & Howard, 2000). Phelan and Wren (2005) explained that split-half reliability is another subtype of internal consistency reliability. The process of obtaining split-half reliability commenced by `splitting in half“ all items of a test that are intended to probe the same area of knowledge in order to form two `sets” of items (even and odd numbers). The entire test is administered to a group of individuals, the total score for each `set” is counted, and finally the split-half reliability is obtained by determining the correlation between the two total `set” scores. The method requires only one form of a test, there is no time lag involved, and the same physical and mental influence will be operating on the subjects as they take two halves (Aray, Jacobs, Razayieh & Sorensen, 2006). The reliability coefficient is obtained by correlating the two halves using Pearson Product Moment Correlation procedure. Spearman
Brown invented a formula for correlating the coefficient obtained from the Pearson Product Moment Correlation procedure to full length of test. If our test starts with easier items and progress to more difficult ones, then the method will not be effective in producing equal halves. The more the items in any question the higher the reliability, the fewer the items the lower the reliability (kerlinger & Howard, 2000). Using the Spearman Brown correlation is not always advisable if the two halves of test are unequal. For instance, when the two halves of a test have unequal variances, Cronbach’s Alpha can be used. When the two halves of test are equal, the Spearman Brown Coefficient and the Alpha give the same results (Robert & Dennis, 2009).

\[
2 \times r^{\frac{1}{2}} \\
\frac{r}{1 + r^{\frac{1}{2}}} 
\]

Where \( r \) stand for reliability coefficient, \( r^{\frac{1}{2}} \) stand for reliability coefficient of the spill-half

**Cronbach Coefficient Alpha Reliability**

The Cronbach’s Alpha provides a coefficient of internal-item correlation. What it does is to calculate the average of all possible split-half reliability coefficients. Coefficients Alpha has wider application than the Kuder-Richardson 20 (K-R20) formula. The KR20 formula is not appropriate for evaluating internal consistency in some cases. For example, on an ‘attitude questionnaire, you might be presented with a statement such as ‘I believe extramarital sexual intercourse is immoral’. You must indicate whether you strongly disagree, disagree, are neutral, agree or strongly disagree. None of these choices is incorrect and none is correct (Robert & Dennis, 2009). The K-R20 formula requires that you find the proportion of people who got each item ‘correct’. When items are scored dichotomously, it yields the same result as K-R20. (Aray, Jacobs, Razavieh & Sorensen, 2006). With Cronbach’s Alpha creation researchers were able to assess the internal consistency reliability of the instrument that had different scoring and respond scales (Kerlinger etal, 2000). The formula for coefficient alpha is

\[
r = \frac{N}{N - 1} \left[ \frac{S^2 - \Sigma S_i^2}{S^2} \right]
\]

Where \( r \) stand for the estimated correlation, \( N \) is for the number of items on the test, \( S_i^2 \) is for the variance of individual items (i), and \( S^2 \) is for the variance of the total test score. If the variance for the two halves of test is unequal, coefficient alpha can confirm that a test has substantial reliability; however, it cannot tell you that a test is unreliable (Robert & Dennis, 2009).

In taking decision Cohen, Manion & Morrison, (2011) pointed out the following alpha coefficient guidelines called rule of thumb

- \( > 0.90 \) very highly reliable
- \( 0.80-0.90 \) highly reliable
- \( 0.70-0.79 \) reliable
- \( 0.60-0.69 \) marginally minimally reliable
- \( < 0.60 \) unacceptably low reliability
Multiple-choice Test Format
Multiple-choice is a form of assessment in which respondents are asked to select the best possible answer (or answers) out of the choice from a list. Multiple choice items consist of a stem and a set of options. The stem is the beginning part of the item that present the item as a problem to be solved, a question asked of the respondent, or an incomplete statement to be completed, as well as any other relevant information. The options are the possible answers that the examinees can choose from, the correct answer called the key and the incorrect answer called the distracters. Only one answer can be keyed as correct (Wikipedia, 2015). Multiple-choice items are less ambiguous than short-answer items, thereby providing a more focused assessment of students’ knowledge. Multiple-choice items are superior to true or false items in several ways because of its wide coverage of the content of subject matter. Multiple-choice test is an efficient and effective way to assess a wide range of knowledge, skills, attitudes and abilities (Haladyna, 1999). Multiple-choice items are best used for checking whether students have learned facts and routine procedures that have one clearly correct answer (Fairtest, 2007).

Short Answer Test Format
Short answer questions are appropriate in measuring a student understanding of principles. Short answer questions go beyond simple recall or recognition, they require students to consider various factors and to arrive at solutions whether they deal with mathematical or other situations (Ben & Esperanza, 2001). The short answer question requires students to supply the appropriate words numbers, or symbols to answer a question or complete a statement. Questions on a short answer test cue the student as to what to search for but require him or her to actively retrieve that information from memory. Multiple-choice questions on the other hand reduce the degree of memory search required by providing the student with the correct answer as in the alternate choice offered in the test item (Philippe, 1982).

Science and Technology
Science and technology provide people with knowledge and tools to understand and address many challenges. Students must be provided with opportunities to access, understand, and evaluate current information and tools related to science and technology if they are to be ready to live in a 21st century global society. The study of science and technology includes both processes and bodies of knowledge. Scientific processes are the ways scientist investigate and communicate about the natural world (Marine Department of Education Regulation 131, 2007). Technical and Vocational Education is an aspect of technological education that provides students with the required knowledge and entrepreneurship skills to survive in the society.

Oni (2006) pointed out that Technical and Vocational Education (TVE) involves instructions which are generally given to those who need to be employed in commerce and industries or in any type of enterprise which involved the use of tools and other machinery for carrying out their service. The operation and services of such industry could include production and distribution of goods or any other technical related works. Technical and Vocational Education is used as a comprehensive term referring to those aspects of the educational process involving in addition to general education, the study of technology and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life. Technical and Vocational Education as an aspect of Basic Technology is further understood to be:

a) an integral part of general education
b) a means of preparing for occupational fields and for effective participation in the world of work.

c) an aspect of lifelong learning and a preparation for responsible citizenship.

d) an instrument for promoting environmentally sound sustainable development.

e) a method of alleviating property.

(Federal Republic of Nigeria, 2004)

Concept of Basic Technology

Introductory technology was changed to Basic Technology as a result of Basic Education Curriculum that was restructured for primary and junior secondary school in line with the Universal Basic Education (UBE) Programme by the Nigerian Educational Research and Development Council (NERDC). Introductory Technology is a pre-vocational subject offered at junior section of post primary education (Uwaifo, 2011). The main purposes of pre-vocational education and hence that of introductory technology include: requisition of basic technical skills, exposing students to career awareness by exploring understanding of the increasing complexity of technology.

Ivowi (1995) cited in Uwaifo (2011) states the objectives of introductory technology as follows:

- to provide students with technology literacy required for everyday living
- to provide pre-vocational orientation for future development of employable skills and training in technology
- to stimulate creativity.

Nneji, Okon, Nwachukwu, David and Ogbuanya (2013) defined technology as open knowledge or ideas, skills and procedures for making, doing or using things in specifiable and repeatable ways. Nowadays, it is technology that creates work to enable every person to have occupational calling and identify. In Nigeria, technology is raising the standards of living for all. Basic technology was organized around the following themes. You and Technology; Safety; Materials and Processing; Drawing Practice; Tools and Machine; Applied Electricity and Electronics; Energy and Power Maintenance; and Building (Nneji etal, 2013).

Technology is the application of knowledge to the practical aims of human life or to changing and manipulating the human environment. Technology includes the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive. Whereas science is concerned with how and why things happens, technology focuses on making thing happens (Webster, 2013).

Purpose of the Study

The study focuses on the comparison of multiple-choice and short answer objective test in Basic Technology, and to compare the coefficient of internal consistency of the two objective formats by adopting Spearman Brown split-half and Cronbach’s Alpha reliability method. In an attempt to compare the effectiveness of multiple-choice items and short answer items, four research questions were raised while one hypothesis was formulated and tested at 0.05 level of significance.

Research Questions

1. Is there any disparity in the reliability coefficient of multiple-choice full test items and short answer full test items using Cronbach’s Alpha method of estimate?
2. Is there any disparity in the reliability coefficient of multiple-choice split half test items and short answer split half test items using Spearman Brown method of estimate?

3. Is there any disparity in the reliability coefficient of multiple choice full test items using Cronbach’s Alpha method of estimate and multiple choice split half test items using Spearman Brown method of estimate?

4. Is there any disparity in the reliability coefficient of short answer full test items using Cronbach’s Alpha method of estimate and short answer split half test items using Spearman Brown method of estimate?

Research Hypothesis:
There is no significant difference between the performance of students in multiple-choice and short answer objective test in junior secondary school basic technology.

Methodology
The study adopted descriptive research design of survey type. The population for the study consisted of the entire Junior Secondary School (JSS) students in Ondo State, while the target population consisted of the JSS three (JSSIII) students that are preparing for their Junior Secondary Certificate Examination in the state. The sample for the study consisted of 200 students drawn from the public Junior Secondary Schools using multistage sampling technique. In the first stage, the state was categorised into three senatorial district, Ondo Centre, Ondo North and Ondo South using stratified random sampling technique. Each senatorial district consists of six local governments to make a total of 18 local governments in the state. In stage two, two local governments were selected from each senatorial district to make a total of 6 local governments for the study using simple random technique. In stage three, one school was selected from each local government using simple random technique to make a total of six schools for the study. In stage four, proportional stratified random sampling was adopted to select the 200 students for the study due to the existing number of arms and students in each school.

Students were tested on the Junior Secondary School Basic Technology syllabus. The researcher prepared 30 items on basic technology drawn from the 2012, 2013 and 2014 junior secondary school NECO past questions. Items were drawn from the past question based on the syllabus of JSSIII and sampled all the various aspect of basic technology. The 30 test items of multiple-choice were transformed into short answer objective test items without options. The major difference between the two set formats is that the short-answer format does not have any options; there is a space provided at the front of each item where the examinees write the answer by themselves. The multiple choice test formats has five (5) options where the examinees have to pick the correct key or answer.

The 30 test items in basic technology were administered on the 200 students selected for the study. The short answer format was first administered on the selected students for 45 minute under the supervision of basic technology teachers in each school selected for the study. Toward the end of the third week of administering the multiple-choice objective test items format, the short answer format was also administered on the same set of students under the same condition in which the first format was administered and supervised by the basic technology teachers in each school. On each of the format, an instruction was given on how to complete and shade the answer. For the short-answer format the examinees were asked to provide the answer on the space provided in each item and circle the correct answer in each item under the multiple-choice test.
The recommended method here would be to sum all the scores for the old-numbered items to create one total, and then to sum all of the scores for the even-numbered items for the other total. In other case above, two half sum scores were obtained. These scores are correlated using Pearson Product Moment Correlation which produced the correlation of the half-length values. In order to obtain the full-length reliability of the test based on half-length values the Spearman-Brown prophecy formula was introduced.

**Research question one**

**Table 1**

<table>
<thead>
<tr>
<th>Format</th>
<th>Rhn</th>
<th>Percentage</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple choice</td>
<td>0.78</td>
<td>78%</td>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>(Full test items)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Answer</td>
<td>0.73</td>
<td>73%</td>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>(Full test items)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From table one the result obtained using Cronbach’s Alpha method of estimate for multiple-choice test items and short answer test items shows that the multiple-choice format has reliability coefficient of 0.78 (78%) in comparing with the short answer format of 0.73 (73%). This shows that there is slight disparity between the reliability coefficient of multiple choice format and short answer format. The two formats are reliable considering the rule of thumb suggested by Cohen et al, in 2011 that any reliability coefficient from 0.70 and above is reliable.

**Research Question Two**

**Table 2**

<table>
<thead>
<tr>
<th>Format</th>
<th>Rhn</th>
<th>Percentage</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple choice</td>
<td>0.80</td>
<td>80%</td>
<td>Spearman Brown</td>
</tr>
<tr>
<td>(Split half items)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Answer</td>
<td>0.81</td>
<td>81%</td>
<td>Spearman Brown</td>
</tr>
<tr>
<td>(Split half items)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From table two, the result obtained using Spearman Brown method of estimate for multiple choice and short answer split half test shows that the multiple choice format has reliability coefficient of 0.80 (80%) comparing with the short answer format of 0.81 (81%). This shows 1% disparity between the multiple-choice and short answer format. The two formats are highly reliable in basic technology using Spearman Brown method of estimate.
Research Question three

Table 3
Summary of the Reliability Coefficient of Full Test and Split half Multiple-choice Test Format

<table>
<thead>
<tr>
<th>Format</th>
<th>Rhn</th>
<th>Percentage</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple choice (Full test items)</td>
<td>0.78</td>
<td>78%</td>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>Multiple choice (split half test items)</td>
<td>0.80</td>
<td>80%</td>
<td>Spearman Brown</td>
</tr>
</tbody>
</table>

From Table three, the result obtained using Cronbach’s Alpha and Spearman Brown for multiple choice full test items and multiple choice split-half test items respectively shows that multiple choice full test items had reliability coefficient of 0.78 (78%) which is reliable in comparing with the multiple choice split half test items of 0.80 (80%) which is highly reliable. This shows that there is slight disparity (2%) between multiple-choice full test items and multiple-choice split-half test items. The multiple-choice split-half items is highly reliable than the multiple choice full test items in basic technology.

Research Question Four
Table 4: Summary of the Reliability Coefficient of Full Test and Split Half Short Answer Format.

<table>
<thead>
<tr>
<th>Format</th>
<th>Rhn</th>
<th>Percentage</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short answer (full test items)</td>
<td>0.73</td>
<td>73%</td>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>Short Answer (split half test items)</td>
<td>0.81</td>
<td>81%</td>
<td>Spearman Brown</td>
</tr>
</tbody>
</table>

From table four, the result obtained using Cronbach’s Alpha and Spearman Brown for short answer full test items and short answer split half test items. It was revealed that short answer full test items has reliability coefficient of 0.73 (73%) in comparing with the short answer split half test items with reliability coefficient of 0.81 (81%). The short answer split half test items is highly reliable than the short answer full test items in basic technology.

Hypothesis
Table 5: t-test on Students’ Performance in Multiple Choice and Short Answer Objective Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Df</th>
<th>t-cal.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short answer objective test</td>
<td>200</td>
<td>35.10</td>
<td>4.77</td>
<td></td>
<td></td>
<td>199</td>
</tr>
<tr>
<td>Multiple choice objective test</td>
<td>200</td>
<td>37.42</td>
<td>4.78</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P< 0.05

Table five shows that there was significant difference between the performance of students in multiple choice and short answer objective test in Junior Secondary School Basic Technology (t = 4.810, p < 0.05). The null hypothesis was rejected.

Discussion of Findings

The study revealed that both the multiple-choice and short answer full test items using Cronbach’s Alpha showed 0.05 (5%) disparity between the two with reliability coefficient of 0.78 for multiple-choice and 0.73 for short answer format. The study is in conformity with the second reliability coefficient value of 0.70-0.80 guidelines of Cohen et al. (2011) in taking decision which shows that the reliability of the two formats is high enough in taking decision on the internal consistency of the test items in basic technology. Kerlinger and Howard (2000) also agreed that reliability coefficient of 0.60 – 0.85 are acceptable in taking decision if the study is an independent study. The study also revealed the reliability coefficient of multiple-choice and that of short answer using Spearman Brown split half method with coefficient value of 0.80 and 0.81 respectively which in agreement with the finding of Cohen et al. (2011) with acceptable value of 0.80 – 0.90 highly reliable for any good research instrument.

The study also revealed the reliability coefficient value of 0.80 and 0.81 for multiple-choice and short answer respectively using Spearman Brown which is higher than that of Cronbach’s Alpha method for both short answer and multiple-choice objective formats with reliability coefficient of 0.73 and 0.78 respectively. The reliability coefficient of the two formats using Spearman Brown and Cronbach’s Alpha is in agreement with the guidelines suggested by Cohen et al. (2011) and Kerlinger & Howard (2000).

It was revealed that there was a significant difference between the performance of students in multiple-choice and short answer objective test. The multiple-choice with a mean value of 37.42 when compared with that of 35.10 for short answer objective test. The implication is that the students score in multiple-choice is higher than that of short answer objective test. The findings of Bleske-Rechek, Zeng & Webb (2007) revealed that students’ performance in short answer correlate strongly with students’ performance in multiple choice which is not in conformity with the finding of this study.

Conclusion

Multiple-choice objective format has high reliability coefficient than short answer objective test format when compare the value obtained from the two formats using Cronbach’s Alpha.
The multiple-choice and short answer objective test items nearly have the same reliability coefficient using Spearman Brown prophecy formula and the two are highly reliable in estimating the reliability coefficient of Basic Technology objective test items. The coefficient reliability value using Spearman Brown split half method in both multiple choice and short answer is higher than that the value obtained using Cronbach’s Alpha method, the implication of this is that Spearman Brown split half is reliable in estimating the reliability coefficient of any research instrument like any other methods since the variance for the two halves of test are equal. The students of basic technology performed better in multiple-choice format than the short answer format, this shows that multiple-choice items are less ambiguous than short answer test format.

**Recommendations**

The following recommendations were made to guide this study

1. The researchers, educators and examination bodies should introduce the use of short answer objective format in evaluating students understanding of the principles and ability in solving technological problems in basic technology instead of relying majorly on the use of multiple-choice test format that can assess a wide range of knowledge and recall of fact without considering the students understanding the principles of basic technology and technical skills needed to survive in the society by graduates of Junior Secondary Schools in Basic Technology.

2. The use of Spearman Brown prophecy formula should be encouraged if the researcher is relatively sure that the two halves are equal, but if there is any doubt about the homogeneity of the halves, Spearman Brown should not be used since it will over estimate the full length reliability of the test items.

**References**


