



AN INVESTIGATION OF STUDENTS' ERRORS IN THE CONSTRUCTION OF STATISTICAL GRAPHS AND CHARTS AND THE MEANS OF REMEDIATING THE ERRORS

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Abstract

This paper employed survey research design to investigate the types of errors students commit in the construction of statistical graphs and charts as well as the remediation strategies. The research was guided by four research questions. The target population was made up of one hundred and twelve (112) NCE 1 students and 22 lecturers from two colleges of education in Kano state. A sample of 80 students and all the 22 lecturers was purposively selected. Two instruments, a Statistics Performance Diagnostic Test (SPDT) and a Statistics Errors Remediation Questionnaire (SERQ), were developed and used by the researchers to collect data. SPDT was an essay test and had a reliability coefficient of 0.73 from the test-re-test method. SERQ contained 12 items and had a reliability coefficient of 0.81 from the Cronbach-alpha method. Frequency counts and percentages were used to analyze data from SPDT while the mean was used to analyze data from SERQ. The findings showed that students mostly commit labeling and title errors in the construction of graphs and charts. It was also discovered that mathematics teachers rated the use of instructional materials, such as graph board and blackboard construction sets in teaching graphs and charts as the best accepted error remediation strategy. It was concluded that NCE students have difficulty and commit errors in the construction of graphs and charts and such errors need to be remediated. Finally, the paper recommended that mathematics teachers should improvise relevant instructional materials like graph board and blackboard construction sets and use them in teaching so as to help students to overcome the identified difficulties and construct error-free statistical graphs and charts for improved performance in statistics.

Keywords: Error, statistics, graphs, charts, mathematics

Introduction

One of the integral parts of human life is decision making. Decisions are usually based on the available information. Statistics provides a veritable tool for making decisions when we are

faced with uncertainties. Brase and Brase (2008) defined statistics as the study of how to collect, organize, analyze and interpret numerical information obtained from data. Statistics can also be defined as the branch of mathematics that deals with the study of the collection, organization, presentation, analysis and interpretation of data for the purpose of drawing valid conclusions and making reliable decisions based on the evidences at hand.

The importance of statistics in our daily life is very vital. Lawal, Yelposu and Nenlat (2015) maintained that a strong foundation in basic statistics is needed if one is to participate in societal, professional and daily life activities. Lawan, et al., further opined that statistics is continually assuming a central role in the curricula of all the levels of education because it is needed in the natural sciences, social sciences and technological activities. For instance, the Nigerian Educational Research and Development Council (2007) has made statistics a theme in the current senior secondary mathematics curriculum while the National Commission for Colleges of Education (2012) included statistics as a core course in Nigeria Certificate in Education (NCE) program.

Statistics is broadly divided into two branches. These are descriptive and inferential statistics. Descriptive statistics involves the methods of organizing, picturing and summarizing data from samples or a population. On the other hand, inferential statistics involves the methods of using information from a sample to draw conclusions concerning the population. This study focused on graphs and charts aspects of descriptive statistics. The importance of graphs and charts in quality control in production and service industries was stressed by Deming in Brase and Brase (2008) noting that the use of statistical chart to organize data from industries can serve as a strategy for monitoring and improving service and production industries.

However, despite the importance of statistics, Lawal, Yelposu and Ajao (2011) stressed that many students encounter difficulties in statistics courses. The researchers further observed that final year students in tertiary institutions face a lot of difficulties in applying what they have learnt in statistics theoretically when they come to write their research projects. In line with this view, the West African Examinations Council (2012) reported that drawing and reading from graphs is one of the weaknesses of students in the West African Senior Secondary Certificate Examination. In an attempt to overcome students' difficulties in mathematics, mathematics educators are recently paying attention to analysis of the misconceptions and errors committed by students while solving problems.

According to George and Charles- Ogan (2015), misconception, in mathematics, is a mistaken idea held by students due to misunderstanding mathematical concepts. In some cases, misconception arises when students formally or informally use incorrect rules or correct ones outside their appropriate domain of application in the hope that those rules will yield the correct solution. Burghes and Samson (as cited in George and Charles-Ogan, 2015) opined that misconceptions of mathematical concepts lead to errors. Error, in mathematics, is a deviation from the accepted and recognized standard of solving mathematical problems. (George and Charles-Ogan, 2015). Whenever an error occurs in doing so, it leads to a partial solution or totally wrong solution of the problem. Because of this, students' errors must not be taken for granted by mathematics teachers. Errors need to be handled properly by diagnosing their types and the reasons for committing them and remediating the errors. George and Charles-Ogan (2015) attributed the causes of errors to the use of poor methods of teaching/inadequate teaching, informal thinking, poor remembrance and inadequate adherence to rubrics, among others. Thus, diagnosing the causes of students' errors is necessary for better learning.

James and Taiwo (2011) defined diagnosis as the process of identifying the difficulties encountered by students in the course of learning mathematics and using the information obtained to develop remedial strategies that will help to overcome the identified difficulties. Apart from improving students' performance, diagnosis helps the teacher to evaluate himself concerning his teaching. Tests, interviews and observations can be used to diagnose students' errors. The results of such tests will indicate where a student needs help. In essence, a teacher using diagnosis is like a medical doctor, who diagnoses an illness in a patient and prescribes a drug for them that will treat the illness. Therefore, in teaching, diagnosis goes with remediation for maximum results.

James and Folorunso (2012) defined remediation as any strategy meant to correct deficiencies in learners either individually or in groups. Several mathematics educators (James & Folorunso, 2012; Yusha'u & Musa, 2012; Attah & Guwam, 2015; and George & Charles-Ogan, 2015) empirically concluded that diagnosis and remediation of students' misconceptions and errors can be used to raise academic performance in areas different from statistics and in different settings/locations. Other researchers reported that the use of mixed ability groups in teaching mathematics as found in collaborative and co-operative learning

strategies helps low ability students to improve academically due to the elaborated explanations they receive from high ability peers (Chan, 2004). Therefore, it is expected that the elaboration of learning materials by able peers can remediate students' errors in solving mathematical problems. Hence, the need to investigate students' errors in statistics concepts and the possible ways of remediating these errors for improved academic performance in mathematics in Kano state.

Statement of the Problem

Students' performance in mathematics has been discouraging over the years. The poor performance affects statistics as a branch of mathematics since students find statistics courses and concepts difficult (WAEC, 2012; Lawal, Yelposu and Nenlat, 2015). If statistics is to play its role in planning and decision-making for entrepreneurship and economic advancement, it must be taught with understanding. In order to promote learning with understanding, teachers are expected to locate, identify and be aware of the areas where learners have difficulties and commit errors while attempting to solve problems in statistics. The information gathered is then used to remediate the errors. However, NTI (2011) observed that most teachers are unable to do this due to their rush to cover the syllabus, which leads to poor performance. The researchers felt that diagnosing and remediating students' errors will, possibly, assist to improve their performance in statistics. Therefore, the problem of the study is to investigate students' errors in the construction of statistical graphs and charts and identify the strategies that could be used to remediate the errors.

Purpose of the Study

The main purpose of the study is to investigate the type of errors students commit in the construction of statistical graphs and charts and come up with remediation strategies. The specific purposes are to:

1. Identify errors that students commit in drawing the bar-chart.
2. Identify students' errors in constructing the pie-chart
3. Diagnose the errors students commit in constructing the histogram
4. Find out the strategies that can be used to remediate students' errors in constructing statistical graphs and charts.

Research Questions

The following research questions were formulated to guide the study:

1. What type of errors do students commit in drawing the bar-chart?
2. What are the errors that students make in constructing the pie-chart?
3. What errors do students commit in constructing the histogram?
4. What strategies could be used by teachers to remediate students' errors in constructing statistical graphs and charts?

Methodology

Descriptive survey design was used for the study. The population of the study was 112 NCE 1 students and 22 mathematics lecturers of Colleges of Education in Kano State. Purposive sampling was used to select 80 of the students who answered at least one question on the construction of graphs and charts and all the 22 lecturers involved in the study. The instruments used were a Statistics Diagnostic Performance Test (SDPT) and a Statistics Error Remediation Questionnaire (SERQ). SDPT was an essay test constructed by the researchers and covered the construction of the bar-chart, the pie-chart and the histogram from a given data. SDPT had a reliability coefficient of 0.73 from the test-retest method. On the other hand, SERQ contained 12 items constructed by the researchers and its reliability was 0.81 using Cronbach-alpha. Each item in SERQ is a statement to which a respondent is expected to indicate his/her level of agreement. The four levels are coded as follows: Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1. A cut-off point of 2.50 indicates agreement and anything below 2.50 indicates disagreement. The two instruments (SDPT and SERQ) were validated by two mathematics educators in the Department of Mathematics, Federal College of Education, Kano and three experienced senior secondary school mathematics teachers in Kano Metropolitan. All the 112 students were taught the construction of graphs and charts. Thereafter, SDPT was administered on them and marked by the researchers. In the process of marking, they noted, identified and recorded the types of errors the students committed using a checklist. SERQ was administered on the lecturers to elicit information on the strategies that could be used by mathematics teachers to remediate students' errors in drawing graphs and charts. Data from SDPT was analyzed using frequency counts and percentages while the mean was used to analyze data from the SERQ.

Results

Data obtained from SDPT was used to answer the first three research questions for this study while data from SERQ was used to answer the last research question. This is presented as follows:

Research question 1: What type of errors do students commit in drawing the bar-chart?

Table 1: Frequency counts and percentages of the types of errors committed by students in drawing a bar-chart

| S/N | Type of Error | Frequency N=80 | Percentage |
|-----|--|-------------------|------------|
| 1 | Scale Error | 29 | 36.25% |
| 2 | Labeling Error | 71 | 88.75% |
| 3 | Length of bars not proportional to the frequency | 30 | 37.50% |
| 4 | Unequal spacing between bars | 29 | 36.25% |
| 5 | Unequal width of bars | 29 | 36.25% |
| 6 | Title error | 70 | 87.50% |
| 7 | Drawing histogram instead of bar chart | 14 | 17.50% |

Table 1 indicates that majority of the students committed labeling error (88.75%) and title error (87.50%). The frequency of the occurrence of other errors (items 1, 3, 4, 5) is approximately 30 (37.50%). However, only 14 students (17.50%) constructed the histogram when asked to draw a bar chart.

Research question 2: What are the errors that students make in constructing the pie-chart?

Table 2: Frequency counts and percentages of the types of errors students make in constructing pie-chart

| S/N | Type of error | Frequency N=67 | Percentage |
|-----|----------------------------|----------------|------------|
| 1 | Error in angle calculation | 19 | 28.53% |
| 2 | Error in angle measurement | 64 | 95.52% |
| 3 | Labeling error | 18 | 26.87% |
| 4 | Title error | 58 | 86.57% |

Table 2 shows that most of the students committed errors in measuring the sectoral angle representing each item in the data (95.52%) followed by title error (86.57%). In terms of labeling error and sectoral angle calculation, only 26.87% and 28.53% respectively committed these errors.

Research Question 3: What errors do students commit in constructing a histogram?

Table 3: Frequency counts and percentages of the types of errors committed by students in constructing histogram

| S/N | Type of Error | Frequency N=50 | Percentage |
|-----|--|-------------------|------------|
| 1 | Scale Error | 15 | 30% |
| 2 | Labeling Error | 40 | 80% |
| 3 | Length of bars not proportional to the frequency | 21 | 42% |
| 4 | Unequal width of bars | 08 | 16% |
| 5 | Title Error | 41 | 82% |
| 6 | Drawing bar chart instead of histogram | 07 | 14% |
| 7 | Use of class interval instead of class boundary | 18 | 36% |

From Table 3, it can be seen that the commonest errors students commit in constructing the histogram are labeling (80%) and title (82%). 21 students (42%) drew bars whose length did not correspond to the frequency of the items they represent. Also, 18 students (36%) used class interval on the horizontal axis of their histogram instead of class boundary to indicate the given variable to be represented.

Research Question 4: What are the strategies that could be used by teachers to remediate students' errors in constructing statistical graphs and charts?

Table 4: Teachers' mean rating of the strategies for remediating students' errors in the construction of statistical graphs and charts

| S/N | Strategy | SA | A | D | SD | M | Decision |
|-----|---|----|----|---|----|------|----------|
| 1 | Use of relevant instructional materials such as graph board and blackboard construction sets in teaching graphs and charts remediates students errors | 17 | 4 | 1 | 0 | 3.73 | Agreed |
| 2 | Use of peer tutoring and problem solving strategies will remediate students' errors in constructing graphs and charts | 9 | 12 | 1 | 0 | 3.36 | Agreed |
| 3 | Use of WAEC Chief Examiner's Report to expose students to errors committed by students in drawing graphs and charts over the years remediates students errors | 5 | 12 | 4 | 1 | 2.95 | Agreed |
| 4 | Drilling students on the rubrics of examination helps students to avoid errors in constructing graphs and charts | 10 | 11 | 1 | 0 | 3.41 | Agreed |
| 5 | Revising pre-requisite topics such as measuring angles, drawing angles and Cartesian coordinates before teaching graphs and charts remediate students errors | 12 | 9 | 1 | 0 | 3.50 | Agreed |
| 6 | Drilling students on the uses and proper handling of mathematical set instruments will remediate their errors in graphs and charts | 10 | 10 | 2 | 0 | 3.36 | Agreed |
| 7 | WAEC and NECO should set questions regularly on drawing and reading graphs and charts to encourage teachers and students to put more effort in learning them | 6 | 11 | 5 | 0 | 3.05 | Agreed |
| 8 | Students should be encouraged to draw graphs and charts using data from practical problems | 11 | 11 | 0 | 0 | 3.50 | Agreed |
| 9 | Exposing students to good study habits will remediate their errors in graphs and charts | 5 | 14 | 3 | 0 | 3.09 | Agreed |
| 10 | Encouraging students to read materials containing graphs and charts is a strategy for remediating students' errors in graphs and charts | 8 | 12 | 2 | 0 | 3.27 | Agreed |
| 11 | Teaching graphs and charts using computers is a strategy for remediating students' errors in graphs and charts | 4 | 9 | 8 | 1 | 2.72 | Agreed |
| 12 | Specialist statisticians be employed to teach statistics is a strategy for remediating students' errors in graphs and charts | 6 | 9 | 6 | 1 | 2.91 | Agreed |

From Table 4, it can be seen that mathematics teachers agreed that all the strategies (1-12) could be employed to remediate students' errors in the construction of statistical graphs and charts.

Discussions of Findings

The study revealed that students commit labeling and title errors mostly when drawing the bar-chart (Table 1). Correct labeling and title are very important, as they readily tell the reader what the data are all about, for easy interpretation and discussion. Complete absence or unclear labeling and title in the bar-chart might be due to a haphazard reading of the question before attempting to work on the data. These errors could also be due to language problems. Also, from Table 1, it can be deduced that students could not differentiate between a bar-chart and a histogram. Although the frequency of this error is not high, yet it is a significant finding, which needs the attention of teachers.

Furthermore, the study showed that students have great difficulty in measuring angles when drawing a pie-chart as they mostly commit errors in that area (Table 2). Another major error they committed is that of title. When the sectoral angle is wrongly measured, the information contained in the data is thus altered. This affects interpretation and decision making. Errors in angle measurement when constructing a pie-chart can be attributed to poor students' foundation and the lukewarm attitude of some to provide a personal mathematical set for their practice. It could also be due to the failure of teachers to use appropriate instructional materials when teaching the pie-chart.

It was also discovered that labeling and title errors were the most frequently committed errors in constructing histogram. These were followed by errors in drawing bars that are not proportional to the frequency of the items being represented and using class intervals to draw the histogram (Table 3). Using class interval can be due to students' inability to differentiate between some important terms associated with a grouped frequency table, such as class boundary, class mark, class limit and class interval. Using bars that are not proportional to the frequency might be due to the fact that some students used the wrong scale in drawing the histogram. All these findings are in line with those of WAEC (2012) that drawing and reading from graphs and charts are difficult areas for students. It also confirmed the results of James and Taiwo (2011) that descriptive statistics is an area in statistics where students have difficulty and commit errors.

Data from Table 4 indicated that all the strategies (1-12) were accepted by mathematics teachers to be employed in teaching statistical graphs and charts to remediate students' errors in that area. The most accepted strategy is the use of instructional materials, such as the graph board and blackboard construction sets in teaching graphs and charts (item 1). Items 5 and 8

were rated as the second best accepted strategies while item 4 was rated as the third best accepted strategy. The least accepted strategy is the use of computers to teach graphs and charts (item 11). This result strongly indicates that graphs and charts can be effectively learnt when teachers use relevant instructional materials to demonstrate the correct procedures. The fact that the use of computers in teaching graphs and charts is rated low among the remediation strategies might not be unconnected with the unavailability of computers in schools and teachers' incompetence in using computers to teach mathematics.

Conclusion

Based on the findings of the study, it could be concluded that students have difficulty in the construction of statistical graphs and charts and commit errors in that area. Identification, locating causes and remediating these errors are duties that should not be neglected by mathematics teachers for improved performance in statistics.

Recommendations

Relevant instructional materials for teaching statistical graphs and charts, such as graph boards and blackboard construction sets, should be provided for schools by ministries of education and colleges of education authorities. Mathematics teachers could also improvise these materials at a low cost where the original ones are not available. Mathematics teachers should also employ problem-solving as well as collaborative teaching strategies in teaching graphs and charts, so that students' misconceptions and errors could be remediated by able peers in the course of group discussions and elaborations. Teachers should ensure adequate mastery of pre-requisite topics by students before introducing the construction of graphs and charts. Such topics like measuring and drawing angles and Cartesian co-ordinates need to be properly understood by students before learning graphs and charts. The WAEC Chief Examiner's Reports should be made available by State Ministries of Education to schools and mathematics teachers should acquaint themselves with the report and use the same to expose their students to the various errors students commit in the construction of graphs and charts. This will make them avoid committing such errors.

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