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Identification of Common Process Errors of Senior Secondary School Students in Mathematics in Anambra State

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Abstract
The study sought to identify the common process errors of senior secondary school students in geometry in Anambra State. Mixed design method was used for study involving a survey, instrumentation and quasi-experimental designs was used. Three research questions and one hypothesis guided the study. Multiple stage sampling procedure was used to draw a sample of 297 from a population of 6265 senior secondary three (SS3) students. The Mathematics Diagnostic Test (MDT) was the instruments for data collection which was validated by three experts. The inter rater method was used to establish the reliability of the instrument which yielded a reliability index of 0.88. The data collected were analyzed using frequency counts, percentages and Mann Whitney U test. Findings of the study showed among others that; five (5) common process errors types in mathematics were committed by SS3 students; factual error was the most committed error type while algorithmic errors was the least committed; male students committed more errors than their female counterparts; there was no significant difference in the frequency of the common process errors committed by SS3 male and female students. Based on the findings, it was recommended among others that mathematics teachers should constantly engage the students in the classroom with diagnostic tests to identify common process errors in mathematics so as to help solve those errors.

Keywords: *Error identification, common process errors, gender*

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I. Introduction

Science education is an essential part of education of all people growing up in a fast changing and increasingly complex technological world. Yakubu (2019) captured this succinctly when he used the analogy that Science and Technology are to modern life what hands are to the body. According to the author, science and technology are used to harness the forces of nature and transform the raw resources with which nature endows man into goods and services for better quality of life. To concretize the policy aim, all secondary school students in Nigeria are expected to offer at least one science subject as a prerequisite for higher learning, while mathematics is a compulsory subject in Nigerian secondary schools.

Mathematics is a subject that deals with the study of numbers, figures and relationship which aid in solving real life problems in our daily activities as an individual, organization or government. According to Iyiola (2020), Mathematics is the foundation of hard core science and technology and it is liable index of the potential for development. It plays a vital role in the development of science and technology. Such importance justifies its inclusion as a compulsory subject in the primary and secondary school levels of education system, especially in Nigeria. Furthermore, in the school system, the idea that mathematics helps in the learning of other subjects, science and art subjects inclusive. The power of every good scientific and research work also depend on mathematics. This implies that mathematics enhances horizontal and vertical transfer of learning.

According to Okigbo and Ezeanyi (2020), mathematics plays important roles in educational advancement but students still lack interest and perform poorly in the subject. There is ample evidence to show all over the world that majority of secondary school students' performance in mathematics have been variously reported by individuals and group of persons to be generally poor. For instance, Bahr (2020), Abdule (2018), Inekwe (2017) and Okigbo & Ejikeme (2017) examined students' performance in secondary school mathematics in Nigeria and reported that performance has been generally poor and sometimes fluctuate over the years. This is not encouraging as the fluctuating performance is an indication of misconceptions by the students and efforts should be geared towards identifying the common process errors that mar students' performance in mathematics with a view to solving these problems.

Researchers at different points have done extensive work to reveal the factors responsible for the high failure rate recorded in the nation at various mathematics examinations, both internal and external. Ezeanyi, (2021) attributed the students' poor performance in mathematics to factors such as the notion that mathematics is an abstract and difficult subject, inadequately qualified teachers to teach the subject as specialists, improper method of teaching mathematics, and lack of mathematics laboratory, insufficient instructional aides and poor use of instructional materials among others.

It is disheartening that research Awofala, (2020) and data from national examination bodies like WAEC for the last five years have shown a fluctuating performance in mathematics probably because majority of secondary school students often dread and show negative attitude towards mathematics. There is therefore the need to conduct further studies in order to diagnose some of the problems and errors committed by the students with a view to finding solution to the identified errors.

Error is a mistake especially one that causes problems or affects result of an activity (Homby, 2019). Inekwe (2017) defined error as a wrong process carried out by students in problem solving which leads to a wrong solution after one has been taught the right process. The author also viewed mistake as an oversight that may lead to an error in problem solving which is not due to one's lack of knowledge of the correct algorithm. Errors in mathematics can be factual, procedural, or conceptual, and may occur for a number of reasons. The 2020 WAEC Chief Examiner's classification of errors committed by students in mathematics with some modifications was adopted for this study. The error classifications used are; Factual error such as using wrong formula, Algorithmic error such as wrong substitution, Diagrammatic error such as wrong diagram, Blunder or Carelessness such as wrong mathematical operations and Accuracy error such as wrong conclusion.

The common process errors committed by secondary school students in mathematics could be identified according to gender because the issue of gender influence on students' performance is not yet a concluded research. According to Ajibola (2018), Gender in science is the classification of the role of male and female in science, technology, engineering and mathematics (STEM). Significant gender difference in favour of boys as reported by researchers like Kolawole (2017) and Ariyo (2016) had also shown that boys achieve higher in mathematics than girls. They have also observed that this has often led to the acute shortage of the number of females that gain access to scientific studies and technological training at the tertiary institutions. Similarly, Shuaibu and Ameh (2021), Voyer and Voyer (2019) also found that female students perform better than their male counterpart in mathematics. The issue of gender-related differences in mathematics is still a controversy and need to be further investigated.

Statement of the Problem

Students' continuous deteriorating achievements in mathematics are glaring and alarming. It is obvious that students register very poor achievements in senior secondary school certificate examinations over the years in mathematics. In Anambra state for example, research and statistical information from examination bodies like WAEC indicated a fluctuating academic performance of candidates that have sat for SSCE. A statistics of entries and results for mathematics in Nigeria; May/June WASSCE indicated an average pass of about 42% for the state. Specifically, WAEC chief examiners report (2020) identified the factors responsible and clustered them into student-related, teacher-related and systemic factors. Some of the students' related factors include misconceptions, errors committed in tests and examination and cognitive ability of students among others. As a result, the researcher deemed it fit to investigate the types and frequency of errors committed by senior secondary school students in mathematics and to classify them according to gender.

Purpose of the Study

The purpose of this study was to identify the common process errors of senior secondary three (SS3) students in mathematics in Anambra State, Nigeria.

Specifically, the study sought to:

1. Identify the common process errors committed by SS3 students in mathematics.
2. Determine the frequency of types of common process errors committed by SS3 students in mathematics.
3. Determine the frequencies of the common process errors committed by SS3 male and female students in mathematics.

Research Questions

The following research questions guided the study.

1. What are the common process errors in mathematics committed by SS3 students in Anambra State?
2. What are the frequencies and percentages of the common process error types in mathematics committed by SS3 students in Anambra State?
3. What are the frequencies of the common process errors committed by SS3 male and female students in mathematics in Anambra State?

Hypothesis

One null hypothesis was tested in this study at 0.05 alpha levels.

1. There is no significant difference in the frequencies of the common process errors committed by male and female SS3 students in geometry.

II. Methodology

This study adopted a mixed design method involving a descriptive survey research design. The population consisted of 6,265 senior secondary three (SS3) mathematics students in Awka Education Zone of Anambra state, Nigeria. The sample for the study was 297 SS3 mathematics students sampled through multi-stage sampling. From the state, stratified and simple random sampling technique was used to select eight schools from the zone. One intact class each was drawn using simple random sampling technique (balloting). A total of 297 SS3 students were obtained from the eight intact classes consisting of 151 male and 146 female students.

Mathematics Diagnostic Test (MDT) was the instrument used to investigate the common process errors in mathematics. The instrument was made of two parts I and II. Part I was used to obtain the personal data of the respondents like school and gender. Part II consisted of 20 essay questions in mathematics adapted and modified from WAEC past questions for different years. These questions were within the mathematics curriculum covered in senior secondary schools.

The instrument was face and content validated by experts and also trial tested. The reliability of MDT items was determined using inter rater method by administering them to 20 SS3 students outside Awka Education zone. Their scripts were graded by five independent raters. Scores obtained were correlated and analyzed using Kendall's coefficient of concordance (W). This yielded reliability coefficient of 0.81 which was considered high enough to be used for the study.

The researcher used the mathematics teachers from the different schools to administer the MDT in order to identify the common process errors committed by the students. The students used pen and paper to show all their workings. After collecting the scripts, the five (5) common process errors (factual, algorithm, diagrammatic, blunder and accuracy errors) were identified in each item in the MDT from each respondent. For example where a student was asked a question that required formula, substitution, diagram, mathematical operations or final answer and could not accomplish any of the tasks, the student was considered to have committed factual, algorithm, diagrammatic, blunder or accuracy error respectively. The frequencies of these errors were determined and grouped according to gender.

The data collected from the MDT were analyzed using descriptive and inferential statistics. The research questions were answered using frequency counts and percentages; while Mann Whitney U test was used for testing the hypothesis at 0.05 level of significance. In taking decision, if the probability value is less than or equal to significant value of 0.05 ($P \leq 0.05$), the null hypothesis was rejected but if otherwise ($P > 0.05$), the null hypothesis was accepted.

III. Results

Table 1: Frequency distribution of the common process errors committed by SS3 students in mathematics

S/No	Common process errors	Frequency	Percentage
1.	Inability to state theorems used in circle geometry	1539	9.7
2.	Inability to apply Pythagoras theorem in solving problems	1214	7.6
3.	Inability to state trigonometrical ratio	1765	11.0
4.	Inability to use the formular of solid shapes	1384	8.6
5.	Inability to contruct angles	331	2.1
6.	Inability to measure lines accurately	109	0.6
7.	Inability to make neat arcs of circles	785	4.9
8.	Wrong use of units in final answer	1428	9.0
9.	Wrong approximations	928	5.7
10.	Carelessness in solving problems	716	5.0
11.	Inability to complete question item	673	4.2
12.	Inability to turn word problems into solvable mathematical relations	425	2.6
13	Wrong mathematical operations	314	2.0
14.	Wrong substitution of values into formular	531	3.3
15.	Wrong simplication of mathematical relations	62	0.4
16.	Wrong drawing and incomplete diagrams	479	3.0
17.	Wrong use of scales for plotting graphs	692	4.3
18.	Inability to locate position of given points on a graph	342	2.1
19.	Wrong extrapolation of values from a graph	903	5.7
20.	Inability to communicate final answers correctly	1314	8.2
	Total:	15934	100

From the result of the MDT administered to the students, the following common process errors were identified and presented on Table 1. The common process errors were identified based on the nature of tasks embedded into the questions designed in the Mathematics Diagnostic Test (MDT). Twenty common process errors were identified from the students' scripts. The identified common process errors were classified into errors-types and descriptive statistics inform of frequency counts and percentages of the classified error-types were used. Errors 1, 2, 3, 4 and 19 were categorized as Factual errors, Algorithmic errors comprised of errors 12, 13, 14 and 15, Diagramatic errors comprised of errors 5, 6, 7, 16 and 17, Blunder comprised of errors 10, 11 and 18 while Accuracy errors comprised of errors 8, 9 and 20.

Table 2: Percentage distribution of the common process error types committed by SS3 students in mathematics

S/N	Error type	Frequency	Percentage
1.	Factual	6805	42.7
2.	Algorithmic	1332	8.4
3.	Diagramatic	2396	15.0
4.	Blunder	1731	10.9
5.	Accuracy	3670	23.0
	Total	15934	100.0

From the result in Table 2, the most frequent error-type committed was factual errors with 6805 (42.7%) followed by accuracy errors with 3670 (23.0%). The third highest percentage error committed was on diagrammatic errors with 2396 (15.0%) followed by blunder with 1731 (10.9%) and finally algorithmic errors with 1332 (8.4%).

Table 3: Percentage distribution of the common process errors committed by SS3 male and female students in geometry

S/N	Error type	Frequency	Male		Female		Percentage Difference
			Frequency	Percentage	Frequency	Percentage	
1	Factual	6805	3613	53.1	3192	46.9	6.2
2	Algorithmic	1332	876	65.8	456	34.2	31.6
3	Diagramatic	2396	860	35.9	1536	64.1	28.2
4	Blunder	1731	807	46.6	924	53.4	6.8
5	Accuracy	3640	1872	51.0	1798	49.0	2.0
Total		15934	8028	50.4	7906	49.6	0.8

The result on Table 3 shows that after the identification of common process errors, male students had higher frequency counts of 3613, 876 and 1872 in factual, algorithmic and accuracy errors respectively than their female counterparts with frequency counts of 3192, 456 and 1798 in the same error types. The female students had higher frequency counts of 1536 and 924 in diagrammatic and blunder respectively than their male counterparts who had frequency counts of 860 and 807 in the same error types. Generally, the male students had a total frequency count of 8028 representing 50.4% of the sample while the female students had a frequency count of 7906 representing 49.6% of the same sample. The percentage difference between them was 0.8%, showing that the male students recorded a slightly higher frequency of common process errors than the female students.

Table 4: Summary of Independent – Samples Mann Whitney U Test of frequencies of common process errors committed by male and female students

Gender	N	Mean ranking	U	Sig.
Male	151	147.31	11277.500	0.731
Female	146	150.74		

The result in Table 4 indicated that the mean rankings for male and female students were 147.31 and 150.74 respectively which yielded a U value of 11277.500 and a p value of 0.731. The p value obtained was greater than the level of significance set at $P \leq 0.05$. The null hypothesis one is therefore accepted. This indicated that there is no significant difference in the frequency of common process errors committed by the male and female students in the MDT.

IV. Discussion Of The Findings

The findings of this study showed that twenty different common process errors were identified to have been committed by senior secondary school students in geometry with different frequencies. The errors were identified based on the tasks given to the students in the diagnostic tests. The total frequency of common process errors committed by the students as identified was 15934. The different common process errors identified is in agreement with the view of Adule (2018), Homby (2019), Inekwe (2017) who stated that the process errors are common in physics mathematics respectively. The finding is also in agreement with the view of Shaibu (2021) that common process errors in mathematics range along a spectrum from those relatively local to the phenomena to those more conceptually derived.

The identified common process errors were classified into factual, algorithm, diagramatic, blunder and accuracy error-types based on the classification of WAEC Chief Examiners report (2020). Frequencies of common process errors types indicated in Table 2 showed factual error has the highest frequency and algorithmic error having the least. The factual errors and algorithmic errors are due to several causes related to the concept that is being learnt, the students' previous knowledge and ability. The factual error being the highest in frequency was in agreement with the findings of Ajibola (2018) but in disagreement with the findings of Ariyo (2016) who identified accuracy error as the highest occurring in learning quadratic equations. The finding also disagrees with finding of Kolawale (2017) who found computational errors highest in whatever form or type and causes some anomaly in the teaching and learning of mathematics which is needed for national development.

More observations of the frequency of common process errors committed by male and female students displayed in Table 3 revealed an interesting result. The result indicated a percentage difference of 0.8%; the male students committing slightly more errors than the female counterparts. The result of the gender related influence on the frequency of common process errors between male and female students indicated a no significant difference as shown on Table 4 on the frequency of errors committed by male and female students. The findings were in agreement with findings by Shaibu (2021) that both sexes become exceptionally the same in the level of common process errors committed in mathematics. Contrary to the present study were the findings by Ariyo (2016) that despite all similarities in mathematics, male students perform significantly higher than female students. This by implication showed that female students committed more errors in mathematics than males in the said examination or test.

V. Conclusion

This study has provided empirical evidence that common process error types committed in mathematics by secondary three students includes factual, algorithmic, diagrammatic, blunder and accuracy errors. Also, the male students committed slightly more frequency of common process errors than the female students in the study.

VI. Recommendations

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

Mathematics teachers should constantly engage the students in the classroom with diagnostic tests with a view to identifying common process errors in mathematics.

Mathematics textbook authors and other textbook developers should adopt the instrument (MDT) developed in this study as a guide in developing future textbooks so as to help reduce some of these errors committed by students.

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