REMEDIATION OF COMMON PROCESS ERRORS IN GEOMETRY AMONG SENIOR SECONDARY SCHOOL STUDENTS IN AWKA EDUCATION ZONE, ANAMBRA STATE, NIGERIA

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Abstract
Remediation of common process errors committed by senior secondary three (SS3) students in geometry was investigated. Four research questions and three null hypotheses tested at .05 alpha level guided the study. A mixed design involving the descriptive survey, instrumentation and quasiexperimental designs was used. A sample of 297 and 144 SS3 students for initial identification and final treatment with developed package respectively participated in the study. The sample was drawn from a population of 6,265 SS3 students from coeducational secondary schools in Awka Education Zone, Anambra State using multistage sampling procedure. The Mathematics Diagnostic Test (MDT) and Mathematics Remediation Package (MRP) were used as instrument for data collection and instructional tools respectively which were validated by three experts. The reliability of MDT was determined using inter-rater method. The scores obtained from five independent raters were analysed using Kendalls coefficient of concordance (W) which yielded reliability index of .88. The MDT was used to identify the common process errors committed by students before and after the treatment with MRP. Data obtained were analysed using frequency, percentage, Mann Whitney U test and Wilcoxon signed rank test. The findings revealed among others that five (5) common process errors identified were factual (42.7%), accuracy (23%), diagrammatic (15%), blunder (10.9%) and algorithm (8.4%); the use of MRP was effective in reducing the errors committed by the students and the developed remediation package was gender friendly. Based on the findings, it was recommended that Mathematics teachers should use MDT to identify students' common process errors in Geometry and MRP to reduce the incidence of common process errors in the subject for improved performance in internal and external examinations.

Keywords: Remediation, Common process errors, Geometry, Gender

Introduction

Mathematics is the science of numbers, quantities and space; either as abstract concept (pure mathematics) or as applied to other disciplines (applied mathematics) (Hornby in Okeke &Okigbo, 2021). It is also the foundation for science, technology and engineering (STE). The functional role of Mathematics in STE is so diverse that no aspect of science technology, engineering and business enterprise escapes its application. This justified the reason the Federal Republic of Nigeria (FRN, 2014) in the National Policy on Education made Mathematics a compulsory school subject at primary and secondary school levels of education. According to Okeke and Okigbo (2021), Mathematics is divided into arithmetic, algebra, geometry and analysis.

Geometry, according to Ezeanyi (2021) is a branch of mathematics that deals with the study of different shapes or figures and their properties. It is made up plane and solid shapes including their properties. Plane shape is a geometrical object with length and width/breadth or base and height/altitude only. It is

popularly known as 2-dimentional shape such as square, rectangle, triangle, trapezium, circle and kite. Solid shapes also called 3-dimensional shapes according to Sanders (2019) are a geometry object with length, breadth and height or base area and height. Examples of such objects include cone, frustrum, pyramid, cylinder, cube, prism and sphere. Geometry as part of senior secondary school mathematics curriculum in Nigeria plays an important role in the world of science, technology and engineering. According to Etsu and Ahmad (2018), it provides a rich source of visualization for understanding other mathematical concepts such arithmetic, algebra and statistics. Geometry provides a complete appreciation of the world we live in thus, it appears naturally in the structure of the solar system, geometrical formation, rocks and crystals, plants and flowers and even in animals (Ezeanyi, 2021). Ezeanyi added that geometry is used to develop students' spatial awareness, instruction, visualizations and to solve practical problems.

The important role of geometry notwithstanding, the West African Examinations Council (WAEC) Chief examiners report (2020) in Mathematics noted that many candidates were generally weak in Mathematics especially in the area of geometry and trigonometry. The Chief examiner faulted inadequate coverage of the syllabuses, poor knowledge of the subject, inability of the candidates to show any firm grasp of the details needed to answer the questions and teacher's inability to properly explain the concept of geometry to the students among other reasons. Also, Okigbo and Ejikeme (2017) had earlier identified geometry as one of the areas in Mathematics, teachers and students find difficult to teach and learn respectively.

Extensive research work at different times revealed the factors responsible for the high failure rate recorded in Nigeria at various Mathematics examinations. Etsu (2016) attributed the students' poor performance to factors such as the notion that Mathematics is an abstract and difficult school subject, inadequate qualified teachers to teach the subject, and lack of mathematics laboratory and instructional aids. Specifically, factors that are responsible for students' difficulty in geometry according to Ekwueme (2013) and Ella (2019) include students' inability to prove basic theorems, lack of background knowledge, poor reasoning skill in geometry, geometric learning comprehension, lack of visualizing abilities, teachers' methods of teaching and gender among others.

Generally, various factors have been attributed to be responsible for the poor performance of students in Mathematics which clustered into student-related, teacher-related and systemic factors. Some of the student-related factors include misconceptions, errors committed in the tests and examinations and cognitive ability of the students. The present research involved designing a remediation package based on the errors committed by senior secondary three (SS3) students in geometry through the use of problem-solving skills and testing the efficacy of such package designed in reducing or removing the errors.

Error is a wrong process carried out by students in problem solving which leads to a wrong solution after one has been taught the right process (Inekwe, 2014). Inekwe also viewed mistake as an over sight that may lead to an error in problem solving which is not due to one's lack of knowledge of the correct algorithm. Hence, Melie (2016) stated that error is mistake or incorrect response made by a student to a given stimuli in form of oral or written test. According to Okigbo and Ezeanyi (2021), errors in Mathematics can be factual, procedural or conceptual and may occur for a number of reasons.

Therefore, the basic technique of error analysis involves going through students' test and examination scripts, homework or assignment books and making frequency counts of the errors committed. Postlethwaite (2019) however opined that the most frequent errors committed could be obtained and possible causes of errors also obtained using questionnaire completed by teachers and students about the programme, tests or teaching approach.

A great deal of studies had been conducted in errors that students commit in various school subjects. Example of such studies includes those in Biology (Lawal, 2015) Mathematics (Isa, 2018) and Chemistry (Ajibola, 2018; Melie, 2016). Students' errors in these works were classified according to their type and nature. Ajibola identified six error types as factual, algorithmic diagrammatic, wrong equation, inferential, blunders or carelessness errors. However, Isa identified four error type in Mathematics namely operation, error of computation, algorithm error and random error. The WAEC Chief Examiners' report (2020) also highlighted some students errors in Mathematics paper II such as wrong formula, wrong unit, writing as wrong number, mishandling signs, wrong diagrams, poor computation and poor approximation among others. Many studies on error analysis (Inekwe, 2014; Isa. 2018; Lawal, 2015) concentrated on identifying the errors and their possible causes on the subjects studied. These researchers only identified and classified the errors with a view to improving students' academic achievement without providing a remediation package using problem solving skill to correct the identified errors. This gap in knowledge would be filled by the present study.

A remediation package was designed based on the identified error types and possible reasons that prompted students to commit such errors. According to Shaibu (2017), remediation package takes different designs and approaches. It could be made in a form of training in the method of correcting the identified challenges using a designed programme to be handled by a professional on the chosen method. Shaibu (2017) added that remediation could takes the form of guidance and counselling on the identified areas where errors are prominent. As a means of remediation, Ezeanyi (2021) opined that an instructional material could be designed containing lecture notes and exercises to be delivered to students with identified challenges using a teaching method such as problem-solving method which would be suitable to the cognitive level of erring students and nature of errors committed by the students.

Remediation package which involved problem solving skills was employed for correcting errors committed by senior secondary three (SS3) students in geometry. According to Ezeanyi (2021), problem solving is a student-centred instructional method which exposes the students to new ideas and concepts. In using this method, the students work actively and independently on problems that the teacher presented on problems that the teacher presented to them, they turn from passive listeners to active listener, free learner and problem solvers. Problem solving is also a process of overcoming difficulties that appear to interfere with the attainment of a goal (common process errors in geometry). According to Shaibu (2017), errors committed were first identified in the diagrammatic segment of errors analysis studies and the remediation process follows. Teaching with a remediation package designed based on identified errors committed by students is also the approach employed in the present research.

The efficacy of the remediation package on male and female students was also tested because the issue of gender influence on students' performance in Mathematics is not yet concluded in research. Gender in science is the classification of the role of male and female in science technology, engineering and

mathematics (STEM). Kolawole (2017) reported a significant gender difference in favour of boys, as boys achieved significantly higher than girls in Mathematics. However, Voyer and Voyer (2014) found that female students perform better than males in Mathematics. Yet, Okigbo and Ezeanyi (2021) revealed that both male and female students committed nearly the same frequency of common process errors in Mathematics with the males being slightly more than females. Therefore, the issue of gender related differences in Mathematics is still inconclusive and needs further investigation.

Purpose of the study

The purpose of the study was to determine the frequencies of common process errors committed by senior secondary three (SS3) students in geometry in Awka Education Zone of Anambra State, Nigeria. Specifically, it determined the;

1. Frequencies of common process error type committed by SS3 students in geometry
2. Frequencies of the common process error types committed by SS3 male and female students in geometry.
3. Effect of a remediation package in reducing the frequency of the common process errors types committed by of SS3 students in geometry
4. Frequencies of the common process error types committed by SS3 male and female students taught geometry using the remediation package

Research questions

Four research questions were posed to guide the study. They include;

1. What are the frequencies of common process error type committed by SS3 students in geometry?
2. What are the frequencies of the common process error types committed by SS3 male and female students in geometry?
3. What are the frequencies of common process errors committed by SS3 students in geometry before and after the administration of the remediation package?
4. What is the difference between the frequencies of the common process error types committed by SS3 male and female students taught geometry using the remediation package?

Hypotheses

Three hypotheses were formulated and tested at .05 alpha level.

1. There is no significant difference in the frequencies of the common process error types committed by male and female SS3 students in geometry
2. The frequencies of common process errors committed by SS3 students in geometry before and after the administration of a remediation package is not significant.
3. There is no significant difference in the frequencies of the common process errors committed by SS3 male and female students taught geometry using the remediation package.

Methods

The research adopted a mixed design method involving the descriptive survey, instrumentation and quasi-experimental designs. This involves identifying the errors committed by senior secondary three (SS3) students, designing a package (instrument) for correcting the errors using problem-solving method and testing the efficacy of the designed package using sampled SS3 students. The study was conducted in Awka Education Zone, Anambra State, Nigeria which is made up of five local government areas (LGAs) namely; Awka South, Awka North, Anaocha, Njikoka and Dunukofia.

Population and sample

The population comprised 6,265 SS3 students from Awka Education zone, Anambra State, Nigeria. The sample comprised 297 and 144 SS3 students for initial identification and final treatment with developed package respectively. The sample of 297 was drawn from eight out of 61 public secondary schools in Awka Education zone using multistage sampling procedure involving purposive, stratified and simple random sampling (balloting) techniques while the sample size of 144 was purposively drawn from four schools that committed the most frequent errors in geometry.

Instrument for data collection

Two instruments namely; Mathematics Diagnostic Test (MDT) and Mathematics Remediation Package (MRP) were used for data collection. The MDT was used to identify the common process error types committed by SS3 students while the MRP was used for intervention after identifying the errors. The MDT consisted of 20 essay questions in geometry adapted and modified from WAEC past questions for 10 years (2011 -2020). The MRP was an instructional material containing lesson notes, hands-on activities (involving problem-solving skills) developed by the researchers on geometry for treatment (teaching the four out of eight schools that committed more errors in geometry). It was prepared to address and correct the identified errors.

The MDT and MRP were validated by three experts in science education and measurement and evaluation from Nnamdi Azikiwe University, Awka and WAEC Chief examiner in Mathematics attached to Anambra State with more than 25 years cognate experience in teaching and marking of Senior School Certificate Examination (SSCE) questions. Their inputs were used to produce the final copies of the two instruments. The reliability of MDT was determined using inter-rater method by administering MDT to 20 SS3 students from school outside the study area but with similar characteristics and environment. Their scripts were graded by five independent raters and the scores obtained were analysed using Kendalls coefficient of concordance (Kendalls W). This yielded a reliability index of .88.

Method of data collection

The Mathematics Diagnostic Test (MDT) was used to identify the common process errors committed by students before and after the treatments and the scores were recorded as pre-test and post test scores respectively. The five (5) common process error types (factual, algorithm, diagrammatic, blunder and accuracy errors) were identified from each of the items in the MDT. The frequencies of these errors were also recorded. This was followed by teaching 144 SS3 students from four coeducational school

that committed the most frequent errors using MRP (Mathematics Remediation Package). At the end of the teaching, MDT was reshuffled and used as post test to determine the efficacy of MRP in correcting the errors committed by SS3 students in geometry.

Method of data analysis

The data collected were analysed using frequency counts and percentages to answer the research questions while Mann Whitney U test and Wilcoxon signed rank test were used to test the null hypotheses at .05 alpha levels. In taking decision, if the probability value (P-value) is less than or equal to significant value of .05 ($P \leq .05$), the null hypothesis was rejected but if otherwise ($P > .05$), the null hypothesis was accepted.

Results

Table 1: Frequency distribution of common process error types committed by SS3 students in geometry

S/N	Error type	n	Frequency	Percentage (%)
1	Factual	127	6805	42.7
2	Algorithm	25	1332	8.4
3	Diagrammatic	45	2396	15.0
4	Blunder	32	1731	10.9
5	Accuracy	68	3670	23.0
	Total	297	15934	100

Table 2: Frequencies of common process error types committed by SS3 male and female students in geometry

S/N	Error type	Total Frequency	Male (n=151) Percentage	Frequency	Female (n=146) Percentage	Diff	%
1	Factual	6805	3613	53.1	3192	46.9	6.2
2	Algorithm	1332	876	65.8	456	34.2	31.6
3	Diagrammatic	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
	Grand total	15934	8028	50.4	7906	49.6	.08

Table 3: Frequency of common process error types committed by SS3 students in geometry before and after remediation (n= 144)

S/N	Error type	Before remediation Frequency	Percentage	After remediation Frequency	Percentage	% Reduction
1	Factual	4169	80.5	1010	19.5	61.0

2	Algorithmic	901	79.0	240	21.0	58.0
3	Diagrammatic	1361	81.2	315	18.8	62.4
4	Blunder	1131	79.8	287	20.2	59.6
5	Accuracy	2023	82.5	429	17.5	65.0
	Total	9585	80.8	2281	19.2	61.6

Table 4: The frequency of common process error types committed by SS3 male and female students in geometry before and after remediation

S/N	Error type	Male				Female				%
		Before		After		Before		After		Error
		Freq	%	Freq	%	Freq	%	Freq	%	diff
1	Factual	2022	48.5	529	12.7	2147	51.5	481	11.5	1.2
2	Algorithmic	341	37.9	68	7.5	560	62.1	172	19.1	-11.6
3	Diagrammatic	691	50.8	194	14.3	670	49.2	121	8.9	5.4
4	Blunder	717	63.4	144	12.7	414	36.6	143	12.6	0.1
5	Accuracy	653	32.3	204	10.1	1370	67.7	225	11.1	-1.0

Table 5: The independent samples Mann Whitney U test of significant difference in the frequencies of common process errors committed by male and female students in geometry

Gender	n	Mean ranking	U	Sig	Decision
Male	151	147.31			
			11277.50	.731	Accept $H_0$1
Female	146	150.74			

Table 6: Summary of Wilcoxon signed rank test of frequencies of common process errors committed by SS3 students in geometry before and after remediation

Remediation	n	W	Sig	Decision
Before	144			
		501.27	.000	Reject $H_0$2
After	144			

Table 7: The independent sample Mann Whitney U test of significant difference between the frequencies of common process errors committed by SS3 male and female students after remediation

Gender	n	Mean ranking	U	Sig	Decision
Male	74	69.38			
			2812.00	.355	Reject $H_0$3
Female	70	75.80			

Discussion

The findings of this study from Table 1 showed that the total frequency of common process errors committed by the students in geometry is 15934. The identified common process errors were classified into factual, algorithmic, diagrammatic, blunder and accuracy error types based on the classification of WAEC Chief Examiners report (2020). From Table 1, the factual errors had the highest frequency count while the algorithmic error had the least frequency. The factual error having the highest frequency is in line with the views of Ekwueme and Ali (2012) and Inekwe (2014) who studied the common errors and academic achievement in senior secondary certificate examination in Mathematics and found that students committed more of structural error which has to do with conceptual knowledge of the basic concepts in Mathematics. The finding (Table 2) further showed that males slightly commit more errors than females in geometry apart from diagrammatic errors where males committed relatively less errors than females. This finding disagrees with that of Ekwueme and Ali (2012) who reported that girls committed more process errors in Mathematics than their male counterparts in Enugu State. The difference could be because the present study concentrated specifically in area of geometry not Mathematics in general. However, the difference in the frequency of errors committed by male and female students (Table 5) was not significant. Thus, there was no significant difference in the mean frequency of common process errors committed by SS3 male and female students in geometry in Awka Education Zone of Anambra State, Nigeria. The Frequencies of the common process errors guided the researchers in designing a remediation package used for intervention with the hope of reducing those process errors types. The outcome of the intervention revealed a reduction of errors committed by the students (Table 3). The finding from the results also indicated that there was a significant difference in the frequencies of common process errors committed by the participants before and after the intervention strategy. The reduction in the common process errors committed was as a result of students' exposure to remediation package using problem solving strategy. This showed that the treatment package was effective in correcting most of the errors committed by students in geometry and was able to address the use of incorrect problem - solving skills and strategies that led to common process errors in response to items in Mathematics examinations. The treatment was also very effective for both sexes (Tables 4 & 5). The finding is in agreement with that of Moore (2019) and Oyedele (2016) whose findings showed that diagnostic prescriptive instruction significantly and positively influences Mathematics achievement.

Conclusion

The study has concluded that common process errors are integral part of mathematics instruction and remediation package developed by the researchers is effective in reducing the incidence of these errors in geometry irrespective of students' gender.

Recommendations

Based on the findings from results, the study recommends as follows;

1. Mathematics teachers should always engage the students in the classroom with diagnostic tests like Mathematics Diagnostic Tests (MDT) so as to identify their common process errors in Mathematics.
2. Mathematics remediation package (MRP) should be used by Mathematics teachers to reduce the incidence of common process errors in mathematics.
3. Mathematics textbook authors and other textbook developers should use the instruments like MDT and MRP developed in this study as a guide in reviewing their Mathematics textbooks.

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