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Students' Errors in Solving Proportionality Problems in Secondary School Mathematics

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Abstract. This study investigated the errors committed by students in solving problems on proportion in secondary school mathematics. The design of the study was descriptive. The study was conducted in Bamenda central in the North West region, Cameroon. Ten schools were randomly selected by stratified sampling technique for the study, three male schools, four female schools and three co- educational schools. Data was collected by administering a test on proportion to Form four students. The scripts were marked and errors identified and classified. Chi square was used in analysing the data and testing of the hypotheses. The results revealed that students commit errors in semantic, calculation and substitution. Other errors include confusing proportionality sign to equality sign, incomplete solution, wrong procedure, wrong use of units, wrong answers. It also revealed that girls committed more errors than boys with 64.9% of the total errors and boys 35,1% of the total errors, wrong answer is mostly committed by boys with 29.5% of the total errors committed by boys. Wrong procedure is the error committed mostly by girls with 36.8% of the total errors committed by girls. Based on the findings of the study, therefore, it was recommended among others that teachers should use varying examples in their teaching for more clarification of concepts.

Key words: Students' errors, Ratio, Proportionality, Secondary mathematics.

INTRODUCTION

Mathematics is fundamental in the understanding of other subjects as it stimulates logical reasoning. In this era of globilisation and technological advancement the application of Mathematics is even more relevant due to its connections in the science courses. The vision of advancement in technology can only be realized through improving Mathematics

competency (Arsaythamby, Hariharan & Wan, 2015).The trend in Mathematical competency is decreasing geometrically due to errors committed in solving problems. Students' errors are inherent in Mathematics and the identification of these errors is an integral entity in the learning and teaching of Mathematics. According to Nilza et al (2020) one way to improve students' mathematical abilities, particularly with regards to proportionality problems is by analyzing errors from previous students. Students' process errors in Mathematics stem from so many causes ranging from misconceptions to inability to apply the appropriate steps correctly. Perhaps, lack of proper and adequate preparation could lead to committing errors when solving Mathematical problems. It is imperative to consider the errors in ratio and problems giving the significance of this topic to the understanding of other mathematical topics. Error analysis can help the students form learning experiences which will improve their understanding of mathematics (Rushton, 2018). Studies have indicated that both students and teachers face difficulties comprehending numbers some of which include wrong conceptions about numbers or differentiating numbers. Pala et al. (2019) discovered that most students make concept errors when solving mathematical problems. Bohmann et al. (2017) observed that students who were not exposed to multiplication and division operations in elementary school could result to students making errors later in life. Hughes et al. (2020) opined that Students' misconceptions in understanding questions may also affect errors made by students when solving problems. A study on error analysis done by Ruzlan, Rosalinda and Arsaythamby (2013) in Malaysia revealed that remote lower secondary school students lacked conceptual understanding of fractions. Confusion, insufficient time, anxiety, forgetting the procedures, carelessness, and difficulty of questions were among some of the reasons advanced for errors made. According to Jitendra (2019), there can be concept errors if students cannot express the ratio. Based on findings from previous studies, we can infer that there are basically four types of errors, that is, errors of concept, value, problem-solving and carelessness. Nilza et al (2020) surmised that the errors commited by the students can show a reflection of the teacher and students for the future. The errors may or may not be the same for both males and females. Gender gap could be another factor considered to be influencing the error trends in the study of ratio and proportion. Pala et al. (2019) also observe that in a particular problem the number of female students who had careless errors was more in that particular problem and but there no female student did test-taking errors. Nilza et al (2020) in their study observed in one of the problems the female students were more accurate than the male students. Gender always plays an important role in adolescents' lives, but some environments foreground gender and magnify its influence, while others put gender further in the background and diminish its influence. This process can occur through peers' or teachers' actions, use of certain instruction methods, or a school's organizational characteristics, such as gender segregation of extracurricular activities. It is in the interest of this study to identify which gender commits more errors and the types of errors committed by secondary school students in Cameroon.

STATEMENT OF THE PROBLEM

In the teaching and learning of Mathematics many errors are committed in the process which often results to students developing a phobia for Mathematics and then to lack of interest and poor performance in the subject and other related subjects. Many studies have been done on students' process errors. Although some interventions have been made towards limiting

students process errors in algebra in general, the errors are still persistent in the area of ratio and proportion. It has been generally observed that students shun proportionality problems whenever they have an alternative. This is so because students find it difficult to solve proportionality problems.

Hence what then are the specific skills that students lack as regards the type of errors committed in solving problems involving proportionality? Do these errors have differential effects due to gender? In order to answer the above questions, the researcher therefore, decided to carry out a study on the students' errors in solving problems involving proportion in Mathematics.

Purpose of the study

This study investigated the kinds of process errors committed by students in solving proportionality problems. Also it attempts to investigate the possible influence of gender differences on the process error committed.

Research Questions

1. What are the types of errors students commit in solving problems involving proportion at secondary school level?
2. Do boys commit more errors than girls?

Hypotheses

Ho1: There is no significant difference between the mean error of male and female students in solving proportional problems

Method

The research design for this study was descriptive. The study was conducted in Bamenda central in the North West region, Cameroon. The population of this study was comprised of five thousand form four students from fifty seven (57) secondary schools (boys, girls and co-educational). The form four students were chosen because they have covered most of the concepts in proportion. A stratified sampling technique was employed to select ten (10) secondary schools out of fifty seven (57) schools. One class of form four was selected from each of the ten schools. Data collection was done using test items consisting of five essay questions covering all the main aspects of proportion based on the syllabus. Each of the questions was aimed at identifying one or more of the following possible errors – semantic error, definition error, tabulation error, arithmetic error and change of subject error. The reliability of the instrument was found to be 0.85 using scorer reliability .The data was analyzed using chi square.

Results

In all, 278 scripts were collected and marked .out of the 300 proposed scripts, out of the 278 scripts. 137 were girls.

Research question 1.

What are the types of errors students commit in solving problems involving proportion at secondary school level?

The errors committed by students in solving problems involving proportion are presented in table1.

Types of errors.

1) Wrong interpretation {semantic error}.
2) Wrong calculation.
3) Wrong substitution.
4) Confusing proportionality sign to equality sign.
5) Failure to follow instruction.
6) Incomplete solution.
7) Wrong procedures.
8) Wrong use of unit.
9) Wrong use of mathematics signs.
10) Wrong answers

A look of some of the student's scripts would help in classifying the errors. A student solution is as follows.

Josephine $=470.00F\ in\ 5\ days$

$=1{,}426.5F\ in\ 15\ days$

$?\ in\ 15\ days$

$$\frac{15}{5}\times\frac{470}{1}=1{,}410.00F$$

Bih $= 1{,}426.5F\ in\ 15\ days$

? in 5 days

$$=\frac{5}{15}x\frac{1{,}426.5F}{1}=\frac{1{,}426.5}{3}$$

$$=478.833$$

Bih earned more than Josephine.

The above reveals wrong procedure as well as wrong answer. For example. 3rd and 4th lines reveal wrong procedure. How does? lead to $\frac{15}{5}\times\frac{470}{1}$, that gives $1{,}410.00F$?.This shows that the student does not know how to solve the proportionality problem.

In another script we have.

$$t\alpha\frac{1}{d}$$

dt=k.

$$t\alpha\ \ k \times \frac{1}{d} = t\frac{k}{d}$$

When $d = -5; t = 2$

$$60 = t \times 5$$

$$60 = 5t = t = \frac{66}{5} = t = 12$$

The student knows exactly what is required in solving variation. His problem lies in interchanging proportionality rule to equality rule and also in the wrong use of mathematical sign. He fails to substitute -5 while simplifying. In the 5th line, he failed to substitute the value of -2 given, though he wrote 2 and not -2 and there is no place where he solved for k. He interchanged $t\ for\ k$, also he failed to complete the given problem, though he got correctly, the value for k which he wrote as t.

Research question 2:

Do boys commit errors than girls?

Table 2

Errors committed by boys and girls

S/N	Types of errors	Frequency		Percentage	
		Boys	Girls	Boys	girls
1	Wrong interpretation (semantic).	60	54	18.5	9.0
2	Wrong calculation.	12	49	3.7	8.2
3	Wrong substitution.	21	30	6.5	5.0
4	Confusing proportionality.	24	45	7.4	7.5
5	Failure to follow instruction.	3	12	1.0	2.0
6	Incomplete solution.	18	27	5.5	4.5
7	Wrong procedure	58	221	17.8	36.8
8	Wrong use of unit.	18	12	5.5	2.0
9	Wrong use of mathematical sign.	15	27	4.6	4.5
10	Wrong answer.	96	123	29.5	20.5
Total		325	600	100	100
Percentage		35.1%		64.9%	

From the table, girls commit more errors than boys with 64.9% of the total errors and boys 35,1% of the total errors, wrong answer is errors committed mostly by boys with 29.5% of the total errors committed by boys. Wrong procedure is the error committed mostly by girls with 36.8% of the total errors committed by girls.

Hypothesis 1

The errors committed by form four students in solving problems in proportion is independent of gender

Table 3. Observed and expected frequency of errors committed by form four boys and girls in solving problems on proportion.

S/NO	Types of errors	Boys		Girlsl		Total
		Observed	Expected	Observed	Expected	
1	Wrong interpretation	60	40.1	54	73.9	114
2	(semantic).	12	21.4	49	39.6	61
3	Wrong calculation.	21	17.9	30	33.1	51
4	Wrong substitution.	24	24.2	45	44.8	69
5	Confusing proportionality	3	5.3	12	9.7	15
6	sign.	18	15.8	27	29.2	45
7	Failure to follow instruction.	58	98	221	181	279
8	Incomplete solution.	18	10.5	12	19.5	30
9	Wrong procedure	15	14.8	27	27	42
10	Wrong use of unit.	96	76.9	123	142.1	219
	Wrong use of mathematical sign.					
	Wrong answer.					
Total		345		600		925

Degree of freedom = 9

Alpha level=0.05

Tabulated value of $x^2 = 16.9$

Calculated value of x^2 = 65.1

Since calculated value is greater than the tabulated value, we conclude that there is significant difference between the errors committed by boys and girls in solving proportionality problems.

Discussion

The results of the findings showed that students commit such errors as wrong interpretation of questions, wrong calculation, wrong substitution, confusing proportionality sign with equality sign, failure to follow instruction, incomplete solution, wrong procedure, incorrect use of units, wrong use of signs and wrong answer. These findings are supported by those of Bohmann et al. (2017) who observed that students who were not exposed to multiplication and division operations in elementary school could experience errors later in life. It was discovered from the findings that the error with the highest frequency is wrong procedure. The findings are in line with those of Ruzlan, Rosalinda and Arsaythamby (2013) in Malaysia which revealed that remote lower secondary school students lacked conceptual understanding of fractions and confusion, insufficient time, anxiety, forgetting the procedures, carelessness, and difficulty of questions were among some of the reasons advanced for errors made. Also girls committed more errors than boys indicating that the errors committed by students in solving proportionality problems are dependent on gender. In considering the research questions, the errors committed by students are errors in signs, wrong interpretation of questions, wrong calculation, wrong substitution, confusing

proportionality sign with equality sign, failure to follow instruction, incomplete solution, wrong procedure, wrong use of units and wrong answer.

Implications

The main reasons for committing errors were wrong use of signs, wrong interpretation of questions, wrong calculation, wrong substitution, confusing proportionality sign with equality sign, failure to follow instruction, incomplete solution, wrong procedure, wrong use of units and wrong answer. Teachers and students are expected to analyse the errors that are persistently arising. Error analysis has three stages which are recognition, description and explanation.

Recognition

Instructions are very important. This implies that a student must abide by the given instructions so as to earn all the allotted marks, to a particular question. Generally, the causes of these errors might be carelessness, poor teaching and learning, lack of knowledge and poor foundation. Carelessness is one of the major causes of students' errors. They carelessly present their solution and omit some vital steps. Sometimes instead of a particular sign, say minus (-), would write plus (+) and this is carried on to the subsequent steps such a situation alters the whole thing and the final answer is completely different. Teachers sometimes in their instruction could not adequately convey the required information to the students. Teaching aids are most often not used which could help to simplify a concept. Enough worked examples are not used to clarify the ideas.

Students' lack of the knowledge of a particular concept of idea may be as a result of poor teaching and learning. The effects of lack of knowledge greatly affect the students' performance. Incomplete solutions are presented because the students are choked up on the way as a result of lack of knowledge of the concept.

In terms of sex differences, from the findings, it was discovered that girls commit more errors than boys. This could be attributed to the effects which social and environmental factors have on female. These social factors include the family background of the students, the norms of the society, psychological factors; for instance at adolescent age girls normally get interested in making up. They seem to pay more attention to their physical appearances than their studies. This on the other hand influences performance. Girls themselves can be good in mathematics when handled by qualified teachers who will bring the subject home to the level of their understanding.

Description: Here errors committed by the students are elaborated on.

Wrong use of signs: Here some of the students used the signs wrongly. Instead of getting a positive number after dividing a negative number with another negative number, they still get a negative number.

Wrong calculation: This is a case where the students could not correctly carry out a mathematical operation. The operations are addition (+), subtraction(-), multiplication(×) and division(÷).

Wrong procedure: This is the case where the students could not follow a laid down procedure for solving problems on variation for example. In some cases the students failed

to follow the procedure step by step. A lot of scripts equally showed a mixture of the steps involved. Some of the students were able to state the correct formula for solving problems on variation but could not interpret it.

Failure to follow instructions: Here some of the students failed to show clear workings as were instructed. There was a case where the student used one method to solve three out of the five questions.

Incomplete solutions: This is the case where the student could not complete the solution to a given problem. Some started solving the problem but stopped at a place, they could not continue so could not arrive at an answer.

Confusing proportionality with equality: This is the case where the students could not differentiate between an equality sign and a proportionality sign. Some of them got the signs correctly.

Explanation: Here the detailed analysis of the errors, their possible causes and what the students are supposed to do are dealt with. In the use of signs, the students are supposed to follow the rules which are: (-)×(-)=+; (-) ×(+)=-;(-)÷(-)=+;(+)÷(-)=-. Some students failed to observe this rule. This affected their solution and led to the students having incorrect answers.

Conclusion

The errors observed by the researcher in the students' scripts are: wrong interpretation of question, wrong calculation, wrong substitution, confusing proportionality sign with equality sign, failure to follow instruction, incomplete solution, wrong procedure, wrong use of unit, wrong use of sign and wrong answer. The description and interpretation of the identified errors led the researcher to observe that the possible causes of the errors are carelessness on the part of the students, poor teaching and learning, lack of knowledge and poor foundation earlier laid in the junior classes.

Recommendations

It was discovered from the students' solution that some of the students still find difficulties to divide using large numbers. The teachers could try as much as possible to lay emphasis on the method of division with large numbers or two or three digit numbers.

Many students in solving proportionality problems use the same method for all the problems. The teacher should clarify these methods that are the methods to be used for missing value problems and that of comparison problems.

The study revealed that students encounter some difficulties in the use of correct units. Some students work problems in kilometre and finally record their answer in hours. The teachers should emphasise on the correct use of such units. It was also found out that the students encounter difficulties in the use of signs. The teachers should emphasise and clarify the rules of signs.

Students' scripts also showed that some of them still find it difficult to substitute into the formula which they have clearly written. Proper substitution and proper simplification leading to the completion of the problem should be stressed. A teacher needs to use varying examples in his teaching for more clarification of ideas.

In order to correct the problem of girls committing more errors than boys, the mathematics teacher, the school authority, the Parents Teacher Association (P.T.A.), and the government have parts to play. The mathematics teacher should encourage and inculcate the spirit of competition between boys and girls in the class in co-educational schools. Inter-school mathematics quiz competition should be organized and encouraged between male and female schools. Both the teacher and school authority should use positive reinforcement like giving of prices to the best female students of mathematics. Government on the other hand can award scholarships to the best female students of mathematics and provide job opportunities to them. Teachers should use activity oriented methods such as modelling in the classroom. By the term modelling we mean organising a sort of shopping centre in the classroom, where some students will act as buyers and some as sellers. These activities, on the other hand might help them to understand the concept of proportion better.

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