Mathematical Language Skills of Prospective Teachers of Science Education

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ABSTRACT: This study investigated mathematical language skills of prospective teachers of science education. Effective teaching and learning of science educationcan only be actualized with correct use of the mathematical language content which consist mathematical rules, concepts, symbols and terms. The sample of the study is made up of 21 prospective teachers drawn from Department of Science Education, A.B.U Zaria (C.O.E Minna campus). Among other factors, the paper stressed that the poor performance of students in Science education is due to difficulties encounter in mathematical language. It also exposes some of these semantic and syntactic difficulties under Algebra, Geometry and Number & Numeration. Results indicated that 76% of participants were not able to use the mathematical language adequately and usually not able to explain the concepts using symbols and structures. It recommended among others that: teachers of science educationat the ordinary level eschew their over relaxed attitude, caused by the assumption that English language is no pre-requisite for mathematics learning. Finally, in order to improve their mathematical language competence, the School management should encourage teachers of science education to preserve the integrity of teaching profession and linguistic competence through periodic workshops on proper reading of mathematics and non-mathematics literatures.

Keywords: Mathematics Language, Prospective Teachers, Semantic Error, Syntactic Error, Mathematics Performance.

I. INTRODUCTION

Mathematics is the central intellectual discipline of science education. It is taught as a core course to all students at the primary and secondary school levels in order to give a solid basis for scientific development and prepare them for the next level of education (1).

In spite of the importance and entry requirement of Science subjects, Nigerian students' performance at secondary school level had been poor and their achievement has been relatively low over the years (2, 3, & 4).

Several factors have been attributed to the low performance in secondary school Science subjects among which includes: poor methods of instruction, lack of instructional materials and understanding of mathematical language (5). Various attempts have been made towards improving the poor performance in mathematics without remarkable success (1).

Mathematics is a universal language that ensures mutual communication between individuals through concepts, terms, symbols and grammar (6). Mathematical language is a system of communication with its own set of symbols, convections or special words. Hence solicited in three parts, that is mathematical terms such as sum, difference, product, matrices, angle, etc.; symbols such as μ, $\geq$, , $\neq$, $\sqrt{}$, 5, $\sum$, etc. and mathematical structures such as $A = \pi r^2$, $\int_b^a f(x)dx$, $x = \frac{\sum fx}{\sum f}$, $I = \frac{PRT}{100}$ ... etc.

According to (6), students of Science education can only establish an effective communication when they are able to speak in

Mathematics. As most of the terms, symbols and concepts of mathematics are in existent or rarely seen in everyday life, students are often unfamiliar to mathematical language. If the teacher fails to use accurate symbols, concepts and terms when teaching to students the content of a lesson, students may perceive it in a different way or even attribute an incorrect meaning (7). Misusing the language of the mathematical field will entail a poor communication between the student and the teacher, leading students, in the longer term to conceptual errors for not being able to properly structure concepts in their minds. This is why mathematics lessons require its technical language to be used in accordance with mathematical knowledge. The findings on mathematical language reveals that students have much problems in using mathematical language accurately when conveying mathematical knowledge (5). Researches revealed that students can generally use symbols but without knowing their meaning (7).Literatures stresses that teachers play a very significant role in the development of mathematical language (8, 9 & 7). According to (10) students would not be able to use mathematical language without assistance. (7) also argues that students can learn the rules of mathematical language through teachers' explanations.

Achievement in Science subjects both in external and internal examinations at primary and secondary levels has been poor and learners have considerable difficulties with mathematical language skills and concepts. It was reported by National Teachers' Institute [11] that the students' answer scripts at all levels of mathematics reveals at least eight types of errors. These include:

1. Syntactic error: it is an error in the relationship between a symbol and other symbols in a mathematics expression. Some examples include: i. $3^2 = 6$,
ii. $8+3(x-4)= 11+x-4$ iii. $a+ a+ a=a^3$

2. Semantic error; it is an error as a result of not taking into consideration what a symbol stands for or represent in a mathematical expression. While what a symbol stands for or represents is known as referent.

3. Cultural Inhibition Errors: Sometimes are earlier experience of a child prevents that child from responding correctly to another situation.

Example: A child was taught by a social studies teacher in primary one using vernacular (Hausa). The teacher explained half as rabi i.e. part of a "whole". In later years, this student was given a set of diagrams to identify half. The student identified the shaded area of fig. below as half.

Half
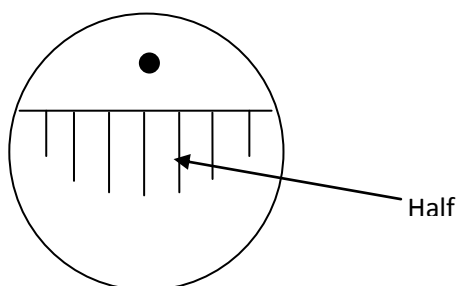
This student got a wrong answer.

4. Premature Approximation Error: This occurs where a student approximates a value obtained in a part of a problem and uses the approximated value in working subsequent part of the problem.

Example: Two points P(50°N, 40°W) and Q(50°N, 10°W) are situated on the same latitude on the surface of the earth. If radius of the earth is 6400km and π = 3.142, calculate:
(i)   The radius of the parallel of latitude 50°N
(ii)   The distance PQ along the circle of latitude.
Correct answer to one decimal place
In working: the student gets the value of r as 6400 cos30 = 5542.4 or 5542km.he use the approximated

r = 5542 in setting are $PQ = \frac{30}{360} \times 2 \times 3.142 \times 5542$

This gives a wrong answer as 2502.2 to one decimal place where as if correct r = 5542.4 were used there are PQ = 2902.4 to one decimal place.

5. Mechanistic Understanding Error: it is an error of no conviction of a mathematical concept due to individual belief. For example, consider the following conversation between the Teacher (T) and Student (S)

Teacher (T): What is the meaning of $x^2 - y^2$?
Student (S): $x^2 - y^2 = (x + y)(x - y)$ i.e. their sum into their difference.
Teacher (T): why is $x^2 - y^2 = (x + y)(x - y)$?

Student (S): He said that it is difference of two squares and that's how you did it or in our text book. That means the student has no conviction of the concept. Such student cannot transfer knowledge for example when asked to simplify$851^2 - 4^2$, the student proceeded to use long multiplication thereby exposing him/her to a likely error in big multiplication.

6.   Pragmatic Error: is as a result of bias or personal emphasis or wrong connotation given to the symbol by individual student.

Example: A student was asked a+a, in working, the answer a+a=2 which is wrong. This student pragmatically takes a+a to mean 1a+1a and then the coefficients 1+1 to gets 2 and misses the "a". Another example, a teacher always present a straight line as y=mx+c in another time the teacher given V=at +u, the student could not recognize it as straight line.

7.   Understanding error: is an error as result of misinterpretation of word problem.

Example: There are three times as many student(s) are teacher (t) in the school. Write a mathematical relation of t and s. Try the problem and compare your result with other students. If 50 students attempted the question. Majority of them answered as 3s = t, other responded i. 3st   ii. t= 3+s iii.st= 3. Other six students got the correct answer as s= 3t

8.   Misreading error: it is an error committed as result of wrong copying of question.

Example; simplify a-4 multiply a^9

Student in copying this question the negative power -4 was copied as 4

Misconceptions in subject mathematics may be attributed to inability to communicate using the appropriate terms, symbols and structures. Thus, mathematical language plays a significant role in mathematics learning of every learner and success in it. So mathematics teachers still down play its importance in assisting students acquire the prerequisite of mathematical language skill (7).

While teaching in Bida Educational Zone, the researchers found out that most students failed to grasp maths skills and concepts. Students have problems in using mathematical language accurately when conveying mathematical knowledge, and generally use symbols but without knowing their meaning. The reason for that failure could have been that the terms and symbols which they encountered were unfamiliar, confusing and sometimes contradictory. The research then became interested in finding out the truth about this conjecture, focusing on the concepts of geometry such as sets, ray, angle or polygon and formulas such as the Pythagorean Theorem and other geometrical forms. In this respect, this study is expected to add a contribution to the field. Considering that teachers of mathematics stand an important role in developing those skills. This reveals the knowledge by math prospective teachers in field of language in geometry concepts, set theory and other areas of mathematics. Furthermore, the study purposed to highlight some semantic, syntactic and instructional errors which affect definitions, proper perception and mathematical reasoning adversely as reported by National Teachers' Institute [11].

A syntactic error is an error in the relationship between a symbol and other symbols. Semantic error is an error as a result of not taking into account what a symbol stands for or represents in an expression. However, some semantic difficulties which affect teaching and learning of mathematics will be highlighted on Number and Numeration, Algebra and Geometry.

Semantic and Syntactic Errors in Number and Numeration

In a study by (9) most mathematics teachers and students represent a signed number like -4 as "Minus 4", whereas 4 are not being subtracted from any number. A "-4' (negative 4) is a single number maintaining a position on the number line of the set of integers just as "positive 4" does. Furthermore, -4+5 is read as "Minus 4 plus 5". Naturally speaking, the expression is not proper since you can't subtract 4 things where nothing exists. Hence, the negative sign is always regarded as an operation (subtraction) as in case of 5-4. In the classroom situation such mathematical construction like -4+5, -3+2 are less preferred to their equivalents: 5-4, 2-3. Hence this is a syntactic problem. It is emphasized that mathematics teachers should avoid such expression but the teachers should clear the concepts showing the equivalent construction for better understanding. Also, in subtraction if the negative number is greater than the positive number the normal addition should be done but the answer will take a negative sign, i.e. take the small number away from the big number, but the answer will have a negative sign since the bigger number has a negative sign. Note that positive numbers are to the right of zero and negative numbers are too left of zero.

"Zero" – is referred to as non-negative and non-positive integer but defined by some mathematics teachers as nothing. Also, 8005 is pronounced by many as 8 zero zero 5. The symbol zero (0) is mixed up with letter O (alphabet). "$\frac{2}{3}$"is read as 2 over 5 instead of 5 divide 2. Transfer 1 to the tens column many say carry 1 and write down 3

as in 4+9=13, all these are linguistic problems that affect teaching and learning in mathematics. Semantic and syntactic problems could block students' opportunities of good achievements in mathematics. Yet another area of difficulty reported by (6) is the interpretation of characteristics and the mantissa under logarithm. For example some regard $\bar{1}.2561$ as -1.2561. This is incorrect (semantic &syntactic errors). Here characteristic is -1, mantissa is 0.2561. The numerical expression $\bar{1}.2561$ involves an expression equivalent to -1+0.2561 or 0.2561-1. Here-1.2561 is equivalent to -0.7439.The negative sign above 1 is localized as1 only. Mathematics teachers should spend time to explain the basic concept for proper future mathematical building. The relationship existing between characteristics and mantissa in a logarithm is still vague to many students learning mathematics even though they excited in the manipulation of the logarithmic table as expressed by (6).

Semantic and Syntactic Errors in Algebra
Algebra is a major area within mathematics which first arose out of the need to do calculation in trading and to understand the relationship between numbers (6). According to (7), there is incorrect communication to students by some mathematics teachers as in "if $\varkappa$=4" some say when $\varkappa$=4 because "when" refers to time. Logically speaking there is never a time when $\varkappa$ will be equal to 4. Furthermore, removing and applying the brackets "teachers/students commonly say "open and close" the brackets". Another linguistic problem (syntactic error) during mathematics instruction in algebra. For example the vogue in mathematics teaching is to refer to 'x=9 as x is equals to 9" rather than "x equals 9 or x is equal to 9". This is real linguistic problem that surround majority of mathematics teachers and students alike. These grammatical problems affect meaning

of concepts and construction of mathematical ideas adversely.

The phrase "cross multiply" $\frac{a}{b} = \frac{c}{d}$ to obtain ad=bc is often said incorrectly instead of "multiplying both sides by the LCM of the denominators" to obtain ad=bc. Hence, teachers of mathematics are strongly advised to avoid such technical phrase like "cross multiply", which leads to erroneous application, especially at the primary school levels. Also one of the linguistic problems (syntactic) affects majority of mathematics teachers both the experienced and inexperienced ones is in expression such as $\varkappa$+4=10. To solve for "$\varkappa$" they will say crossing equality sign, the sign of plus 4 will change to negative 4. Instead of subtracting 4 from both sides. The same syntactic error, if given: x-4= 10. Teachers should spend time to lay the Basic foundation for simple expression for building a solid foundation in such expressions. These linguistic problems adversely affect the meaning of concepts and constructions of mathematical ideals, for the fact that most mathematical ideas and concepts have no equivalence in local language.

Semantic and Syntactic Errors in Geometry
Geometry is a vital branch of mathematics that deals with study of different shapes. It forms the building blocks of engineering and technical graphics. It has been observed that students have not been demonstrating strong conceptual knowledge of the course (12).
Semantic and syntactic conceptual difficulties are experienced by students in terms of geometric terms such as "subtended", "subtended at the centre", and on the remaining part of the circumference especially when poor diagrams are drawn with inadequate dimensions. To eliminate these difficulties, teachers of mathematics must use three letters instead of two are used to represent the arc and also careful use of coloured chalk to show similarities and differences in the figures drawn. For examples
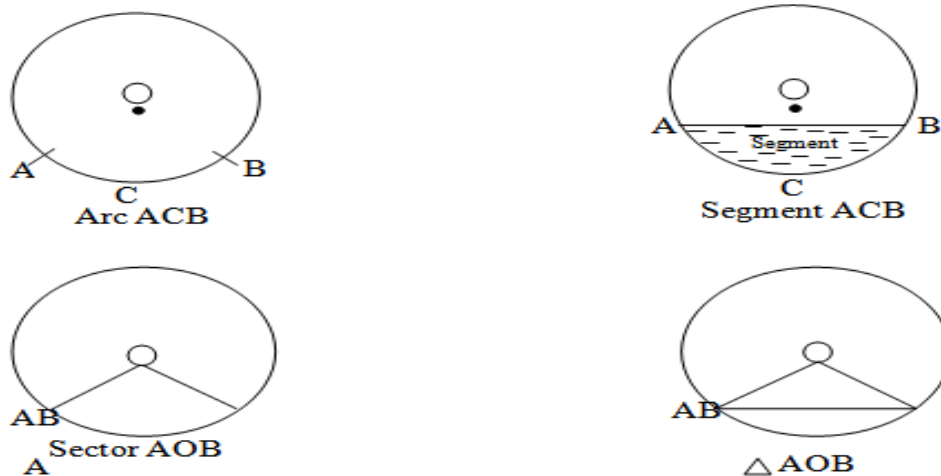
An arc is a part of the circle
A segment is an area of the circle bounded by an arc and a chord.
A sector is an area of the circle bounded by an arc and two radii
Showing all these in a single circle causes an aberration as submitted by (Inekwe, 2019).

Furthermore, there are some terminologies and concepts that are usually associated with geometric proof which are assumed by many teachers as being understand by students. Such concepts and terms as theorem, postulate, corollary, axioms, inductive proof, proposition and premise are hardly explained to the students. All these rises to semantic and syntactic conceptual difficulties and thus declaring it a "non - touch" or "no-go" area of secondary school curriculum. The teachers must be patience and careful explain these difficulties before going ahead in actual proof for a smoother majority of students as stressed by (10, 7 & 6).

Another unclear definition ought to generate semantic difficulties. For example a plane is wrongly defined as "a flat surface" rather than "A 2-dimentional surface without thickness". A straight line to some is "the shortest distance between two points" rather than a set of points which continues in opposite directions indefinitely, ( ), ( ), a line segment is a set of points with two end points while a ray is a set of points with one fixed point ( ). Due to some teachers of mathematics incorrect definitions of straight line, line segment and ray, there are arising misconceptions in their meanings. "Angle" to some is the space between two lines rather than "a measurement of rotation between two rays". A triangle is incorrectly defined as "a figure bounded by 3 lines" instead of "a plane figure bounded by 3 line segments". It was observed that some prospective teachers shy away from definition of "locus". "Locus is a set of points traced when a variable point obeys a certain rule, e.g. "circle is the locus of points equidistant from one fixed point called the centre". (5) revealed in their findings that Nigerian students are faced with problems of syntax, semantics and vocabulary among others due to the existing difference in mother tongue. For the fact that mother tongue, semantic, syntactic and vocabulary problems have the following effect in the teaching and learning of mathematics:

- Hinders the rate and ease of concept formation
- Dents the teaching and aesthetic of mathematics
- Leads to wrong application of mathematics principles
- Downgrades the mathematics teacher in presence of students
- A teacher with grammatical difficulty will teach errors.

Thus, teachers play an important role in developing those skills, it is important to identify math prospective teachers-who are the teachers of the future-own skills in using the field language of certain areas of Number and Numeration, Algebra and Geometry. This study reveals the knowledge by math prospective teachers of the field language in a number of mathematics concepts.

II. METHODOLOGY

This study is based on descriptive analysis, which is a qualitative research methodology. (13) has defined qualitative research methodology as a research based on process allowing showing perceptions and events in their natural environment in a realistic and holistic way.

The study adopted a qualitative research methodology to elucidate the research problem as it is a methodology used in order to obtain detailed explanations from natural environments.

Research participants are 21 prospective teachers of Science Education studying Bsc.Ed (Mathematics Education) drawn from 300level and 400level Ahmadu Bello University, Zaria (C.O.E Minna Campus). The Degree students have been teaching in their secondary schoolsbefore being admitted in Degree programme and also have undergone teaching practice. Research participants were asked a total of fourteen (14) questions which require them to use correct conceptual knowledge and mathematical terminology related to such concepts.

III. ANALYSIS OF RESULT

Table 1: Explanation type frequency by explanation accuracy and symbol

S/N	Questions	Correct (P)	Incorrect (F)
1.	Ray	(7) 33%	(14) 67%
2.	Angle	(2) 10%	(19) 90%
3.	Set	(4) 19%	(17) 81%
4.	Cone	(5) 24%	16 76%
5.	Line segment	(5) 24%	(16) 76%
6.	Straight line	(3) 14%	(18) 86%
7.	Trapezoid	(9) 42%	(12) 58%
8.	Arc & Segment	(6) 29%	(15) 71%
9.	Pythagorean Theorem	(7) 33%	(14) 67%
10.	Parallel lines	(2) 10&	(19) 90%
11.	Locus	(8) 38%	(13) 62%
12.	Directed numbers	(2) 10%	(19) 90%
13.	Chord	(4) 19%	(17) 81%
14.	Fraction	(6) 29%	(15) 71%

Grand total pass   70 (23.8%)
Grand total failure   224 (76.2%)

IV. DISCUSSION

The study expected from prospective teachers to explain some mathematical concepts by using symbols as well as orally explaining formulas provided with their rules resorting to mathematical terminology. The study intended to determine the sufficiency by prospective teachers of using the mathematical language and the way they made use of it. 76% failure among these prospective teachers who were already teaching before they came for further course in mathematics education. This has demonstrated that prospective teachers did not have sufficiency of using the language of mathematics. These results confirmed several studies made by (10, 5, and 7).

The results got from the discussion with the prospective teachers were quite interesting. They said they had difficulties in explaining some mathematical symbols and had problems when teaching with aid of diagrams especially those of geometric figures. They indicated that students who see the symbol for a rectangle think that it is the actual object of study and then start to measure it with a ruler and a protractor. Prospective teachers pointed out that even the "equals" sign (=) is usually misunderstood and abused. For example, when solving linear equations and alike.

Finally, it was found that most teachers just use terms, words and symbols without giving thorough explanations and clear examples. (10) and (5) also argue that there is an element of redundancy in teachers and text materials which makes it impossible for students to perceive every symbol, terms and structures. This needs to be explored further.

V. CONCLUSION

This study has investigated mathematical language skills of prospective teachers of Science education. The study has exposed some semantic and syntactic problems in some concepts in mathematics which cause misconceptions in the teaching and learning of Science subjects. It has also sensitized prospective teachers on appropriate strategies to take to overcome students' difficulties.

From the findings of the study there is evidence that most students fail to interpret or understand mathematical language due to the way by which they are taught to read, pronounce and

use them. Meticulous attention to mathematical language is required of mathematics teachers especially those teaching in primary and secondary schools to avoid communicating their confusions to the younger minds.

VI. RECOMMENDATIONS

Education and learning processes should not only focus on operational knowledge, but also the use of explanatory symbolic and oral language and prospective teachers' skills should be developed accordingly. If concepts are learned and taught adequately enough, success in Science subjects will be likewise improved. Based on this, the following recommendations were made:

1. Science subject teachers at ordinary level should eschew their over-relaxed attitude, caused by the assumption that English Language is no pre-requisite for Mathematics learning.
2. School management should encourage teachers of science education to preserve the integrity of teaching profession and linguistic competence through periodic workshops on proper reading of mathematics and non-mathematics literatures.
3. There is need for the prospect teachers of Science subjects to participate in mathematics and language of mathematics workshops, seminars as well as conferences.
4. Teachers should become role models to their students in using mathematical language correctly and efficiently.
5. Teachers should also know about mathematics and convey knowledge in a way that students can comprehend the concepts accurately and properly.

REFERENCES

[1]. Gambari, A.I, Falode, C, &Adegbenro, D. (2014). Effectiveness of computer animation and geometrical instruction model on mathematics achievement and retention among junior secondary school students. European Journal of Science and Mathematics Education 2(2) 114-125.
[2]. West African Examination Council (WAEC, 2011). West African senior secondary school certificate examination. May/June Chief Examiner report.
[3]. National Exanimation Council (NECO, 2012). Senior secondary school certificate examination.May/June Chief Examiner report.
[4]. Gimba,R.W. (2013): Effects of computer package on achievement, retention and interest in settheory among secondary school students in Niger State. Unpublished Ph.D. ThesisUniversity of Nigeria. Nsukka.
[5]. Ahmad M. &Auwal H. (2018). Effect of mathematical language on mathematics performanceamong senior secondary school students in Niger State. Kano Journal of Educational Psychology B.U.Kano. 1(1) 133-125
[6]. Inekwe, O.I. (2019). Mathemaphobia: The differential derivative. 43rd Inaugural Lecture at MichealOkpara University of Agriculture, Umudike.
[7]. Nejla, G. (2018): Mathematical language skills of mathematics prospect teachers. Universal Journalof Educational Research 6(4) 661-671.
[8]. Zachariah, K.M. (2012): Influence of mathematical language on achievement in mathematics bysecondary school students in Kenya. International Journal of Education and Information Studies 2(1) 1-7.
[9]. Ahmad, M. (2017): Mathematical language and functional curriculum.Proceeding of Sept 2017MAN Annual National Conference.
[10]. Silvanos, C. (2012): How does the use of mathematical symbol influence understanding of mathematical concepts by secondary school students? International Journal Soc. Science & Education 3(1) 35-45.
[11]. National Teachers' Institute (N.T.I, 2007). Nigeria certificate in education course book on mathematics cycle III.
[12]. Ahmad, M. &Etsu, M. (2019): Impact of collaborative learning strategy on academic performance in geometry among senior secondary school students in Niger State. Niger Journal of Technology Education 6(1) 97-106.
[13]. Sambo, A. A. (2008). Research method in education. Ibadan Stirling-horden Publishers (Nigeria)