Influence of Mathematical Language on Achievement in Mathematics by Secondary School Students in Kenya

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Abstract

Language is a system of communication, which is either spoken or encoded in written or signed form; its fluency aids an individual in logical thinking. The unique linguistic structure of mathematics makes the learning of mathematics similar to learning of a foreign language. Thus the level of understanding of mathematical language affects the level of communication of mathematical ideas. Recent trends in Kenya show that the achievement in mathematics among secondary school students in Kenya is below average. This effectively calls for identification of factors that can enhance the understanding of mathematical concepts for higher achievement. This study was aimed at determining how the mathematical language influences achievement in the subject by secondary school students in Kenya. A survey was carried out on a sample of 661 secondary school students and 71 secondary school mathematics teachers using structured questionnaires and three sets of mathematics tests. The results show that achievement in mathematics is highly related to students’ understanding of mathematical language. Students make mistakes when solving mathematics problems due to lack of understanding of mathematical language. Thus mathematical language plays a major role in the understanding and achievement in mathematics.

Keywords: Achievement, Influence, Mathematical language, Structures, Symbols, Terms

Mathematical Language

One of the definitions of mathematics is that it is as a language, it is a body of
knowledge, denoted and enacted in terms of a standardized language. Well developed language fluency can be an aid to logical thinking. Mathematical language is a system of communication with its own set of symbols, convections or special words. Mathematics concepts are present by mathematical structures. Hence mathematical language information is solicited in three divisions that is, mathematical terms such as product, reflection, angle, determinant, etc; symbols such as $\mu$, $\leq$, $\pi$, $\neq$, $\sqrt{\cdot}$, $+$, $5$, $\sum$ etc; and mathematical structures such as $A = \pi r^2, x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \int_{b}^{a} f(x)dx, (1 + x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} + \cdots$ etc.

Achievement in mathematics has been poor and students have considerable difficulties with mathematical skills and concepts. Misconceptions in mathematics may be attributed to inability to communicate using the appropriate terms, symbols, and structures. Although, language plays a significant role in learning and in success in mathematics, teachers still downplay its importance in helping learners acquire the prerequisite mathematical language skills.

Njeru and Orodho (2003) observed that performance in mathematics in the year 2001 and 2002 in Kenyan secondary schools was below average. The Ministry of Education Science and Technology (2004) indicated that mathematics was the worst performed subject in the 2003 Kenya Certificate of Secondary Examination with a mean score of 19.3%. In addition, research in the mathematical language as a method of teaching has been minimal, hence the inadequate information indicating the extent to which this factor affects achievement in the subject. In this study, achievement was constitutively defined as succeeding in understanding a mathematical concept.

**Methods**

An *ex post facto* research design was employed in this study. The correlation methodology was adopted; the dependent variable of the study was Students’ Achievement in mathematics while the independent variable was understanding of mathematical language (terms, symbols & structures). A total of 18 secondary schools in Kenya and a sample of 661 (352 boys & 309 girls) students and 71 teachers (39 males & 32 females) participated in the study. In each school, one lesson was observed and the most recent end term examination paper and its results were used.

The instruments used to provide the needed data were;

**Observation Schedule (OS)** which provided information on mathematical terms, symbols and structures that were presented in the lesson by the teacher and the level of explanation, and also identified any that was ignored or left out in relation to the content given. Observations were also recorded on whether the learners were concerned with mathematical terms, symbols or structures presented in the lesson or whether the teachers asked questions that required learners to give their meaning.
Influence of Mathematical Language

**Mathematics Teachers’ Questionnaire (MTQ)** solicited information on the extent of inclusion of definition of mathematical terms, symbols and structures in lessons as well as opinion on students understanding of the same.

**Students’ Questionnaire (SQ)** provided information from students on inclusion of mathematical language in lessons as well as their understanding of mathematical language.

**Mathematics Tests (MT)** provided information on students understanding of mathematical terms by explaining 40 selected terms. The terms were from a wide variety of topics in secondary school mathematics syllabus. In the second set of test, students explained 24 commonly used mathematical symbols by indicating what they represent or what they stand for. In the third test, 20 common structures in secondary school mathematics provided information on student’s understanding of mathematical structures by explaining both of their surface and deep structures.

**Most Recent end Term Examination Paper and Marks** provided data on mathematics achievement and extend to which questions are set on mathematical language.

**Results and Discussions**

**Class Size, Lesson Attendance by Teachers and their Qualification**

The recommended number of students per class by the Government is 40. However data shows that 81.7% of the schools have more than forty students per class. A large number of students in a class would affect the teachers’ output in providing for individual difference. In large classes students find it hard to concentrate and do not ask questions (Habeshaw, Gibbs & Habeshaw, 1992). A crowded class does not provide a good atmosphere for teaching and learning of mathematics. The results also showed that 0.2% of the classes missed a mathematics teacher for over a year, 0.2% for a term and 82.2% for part of the term. This implies a loss of time for learning and covering the syllabus within the stipulated time. Secondary school mathematics teachers are expected to be professionals by training. The obtained data shows that 98.7% of secondary school mathematics teachers trained professional teachers, therefore their output is expected to be high. Mastery of the subject is an absolute necessity for effective teaching (Sidhu, 1995).

**Achievement in Mathematics and understanding of mathematical language**

The results obtained show achievement in mathematics’ had a modal score of 30% and a mean score of 33.4%; the scores are skewed to the right as shown in Figure 1. This implies poor achievements in mathematics.
The scores for mathematical language are also skewed towards the right as shown in the Figure 2. The modal scored was 11.4% while the mean score was 9.9% with the highest score of 29.4%. This is an indication that the understanding in mathematical language is also poor as is achievement in the subject.

The combined scores in mathematical achievement and understanding are given in Figure 3, which indicates that understanding in mathematical language is poor compared to that of achievement in mathematics. Since mathematical language is the means by which mathematical concepts are presented and acquired, it implies that improvement in this language would improve achievement in the subject. According to Grouws and Cebulla (2000) sufficient time should be allocate for mathematics instructions so as to give teachers enough time to handle concepts.
The results show that both the understanding of mathematical language and achievement in mathematics among secondary school students are below average. The fact that the mean score for mathematical language is less than that of achievement in mathematics implies that students’ understanding of mathematical language is poorer relative to achievement in the subject. This implies that pupils learn mathematics using a language that they do not understand. These observations concur with that of Curcio (1990) who observed that learning mathematics requires development of a mathematical language in which abstraction of mathematical concepts can be made. The concept of understanding is basic to cognition and it facilitates the ability to make decisions, reasonable judgment and comprehension of mathematical concepts (Benjafield, 1997).

Correlation of Achievement in Mathematics and Understanding of Mathematical Language
Data shows that achievement in mathematics is highly correlated to students’ understanding of mathematical language \( (r = .206, \ P < .01) \). Thus mathematical language contributes as a communication media towards achievement in the mathematics. According to Tudor (1996) the structure of a language reflects its functional and communication use. Gecau (2001) indicated that any communication should be able to make sense and must take into account organization, structure and institutional interrelationships. Mathematical concepts are accommodated and assimilated through a series of experiences, which can be achieved through mathematical languages.

Poor mean scores of 4.2, 6.0 and 6.6 were achieved respectively for mathematical terms, symbols and structures. According to Creswell (1994) interpretation of a language is pairing of expression with their meaning. Some structures are complex and their meaning depends on the meaning of the symbols involved together with the rules of combining them. A correlation analysis of the mathematical language components shows that mathematics achievement is significantly correlated \( (p<1\%) \) to understanding of mathematical language for each component (terms, symbols and structures). This is an indication that all aspects of mathematical language are significant to achievement in mathematics.

It was observed that when solving mathematical problems, students engage in mathematical structures more than where they are required to explain mathematical terms or symbols. Out of 18 observed lessons, the teachers never got concerned with the definition of mathematical terms in of the lesson. In one case, a teacher was teaching about ‘simultaneous equation’ but the teacher started with solving simultaneous equations by elimination. In this case, mathematical terms involved are equations, simultaneous and eliminations, which should have been defined by the teacher before proceeding to solve problems.

Wood (1998) observed that children might fail to solve a problem just because they do not understand what is being said to them, while Costello (1991) asserts that there is a subtle linguistic aspect of mathematics, which create difficulties. The real difficulty is in appreciating the meaning conveyed by different preposition and their connectiveness. The construction of meaning rather than the question of rigor are the
central problem facing mathematical language. Meaning of the component words as well as the information coded structurally helps learners derive and convey meaning of the mathematical terms (Pimm, 1987).

Conclusions
From the results, students’ understanding of mathematical language and achievement in mathematics in Secondary school is poor. Achievement in mathematics in highly related to students understanding of mathematical language. Mistakes students make when solving mathematics problems is partly due to student’s lack of understanding of mathematical language. Achievement in mathematics could be improved by including definitions of mathematical language in lessons, set questions that would require definitions of mathematical terms, symbols or structures and award marks for definitions. In the last decade, the work of educational planners has moved from increasing school enrolment to improving quality (Groppello, 2003).

Recommendations
Mathematics syllabus should emphasizes mathematical language as part of the content to be learned, hence reorganization of mathematics textbooks to include mathematical language as part of the content to be taught, mathematics teacher education to emphasize definition of mathematical language when presenting content to learners, national examinations could include questions that may require definitions in mathematical language, and in-service or workshop to mathematics teachers on importance and inclusion of mathematical language in teaching mathematics could be provided.

References