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Gender Difference in the Understanding of Mathematical Terms, Symbols and Structures among Students Exposed to Embedded Mathematics Language Factor Teaching in Secondary School in Nakuru County, Kenya

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Abstract: **The purpose of this study was therefore to determine gender differences in understanding of Mathematical Terms, Symbols and Structures among students exposed to embedding mathematics language factors during instruction in Secondary schools in Nakuru County. The study used Solomon Four Non-Equivalent Control Group design. The target population was 1300 form two students in Nakuru County. A total sample of 180 students and their teachers was drawn from four selected Co-educational Secondary Schools. Purposive and simple random sampling were used to select the schools and the particular streams to be involved in the study. Consulting experts in the School of Education, Laikipia University, determined validity of research instruments. Five different instruments namely Understanding of Mathematical Terms Test (UMTT) whose reliability coefficient was 0.7831, Understanding of Mathematical Symbols Test (UMST) whose reliability coefficient was 0.762, Understanding of Mathematical Structures Test (UMSrT whose reliability coefficient was 0.840, Mathematical Achievement Test (MAT whose reliability coefficient was 0.782 and Mathematics Classroom Observation Schedule (MACOS) whose reliability coefficient was 0.771 were used to collect data. The hypothesis were tested at a significance level of .05. The finding of this study showed that EMLF learning strategy reduced gender disparity in achievement of secondary school mathematics. The findings of this study will benefit mathematics teachers, curriculum developers, policy makers, school inspectors and teachers trainers with a view to improving performance in mathematics achievement and understanding of mathematics in secondary schools.**

Keywords: **Gender, Mathematics Terms, Mathematics Symbol, Mathematics Structures and embedded mathematics.**

I. INTRODUCTION

The meaning to mathematics varies from one school of thought to another. Mathematics is defined as an approach of describing associations among numbers to other measureable units and it is in position of expressing both simple equations and the interactions between particles that are smallest and the farthest objects in the known universe (Microsoft Corporation, 2003). In general Mathematics is widely applied in physical science, engineering, medicine, geography, business and operations in the industries among many other areas (Smith, 2004). Mathematics is also important in our daily activities in numerous ways. It is used as an art, in beauty design, music and painting. Mathematical analysis of many hours has resulted to generation of computers. Plan to fuel-efficient, automobile and aircrafts, weather prediction, control of traffic, and imaging in medical facilities all are a result of mathematical analysis. Mathematics is also used as a tool in Science, English, Technology, Finance, Business, and Industries and in other school subjects to solve problems pertaining to these disciplines. In Kenya, mathematics is offered as one of the core subjects in primary and secondary education curricula (KIE, 2002). At tertiary levels, general mathematics is offered in nearly all programmes where it is not a core subject. This emphasizes the importance attached to the subject in development of science and technology and the demand that every child should study mathematics at school (Cockroft, 1982). Mutunga and Brakell (1992) observed that mathematics occupies a major portion of a school study and it is a constituent of the overall education system. In their view, therefore, the government and other stakeholders expect schools to offer children mathematics education that is worthwhile. This expectation is not realizable when learners continue to perform poorly in the subject at national level (KNEC, 2010).

Despite its importance to individuals and society globally, mathematics is a subject that is poorly performed at national examinations by many secondary school learners worldwide (TIMSS, 2004) and Kenya in particular (KNEC, 2010). At the international scene, learners' score in mathematics at primary and post primary schools has not been better as indicated by TIMSS (2004). TIMSS showed that there were large differences in performances, across countries in the world as indicated by percentages of students' mathematics scores compared to international benchmarks at the fourth grade. Singapore had 38% of its learners reaching the advanced international benchmark (i.e., the standard mean score), followed by just over 20% of the learners in Hong Kong and those from Japan. The highest performing countries at the eighth grade had about one third or more of their learners reaching the advanced international benchmark. In contrast, 19 of the lowest-performing countries had 1% or less of their learners reaching this benchmark.

1. Statement of the Problem

Mathematics national performance at the KCSE examination has been poor, and Nakuru County has been no exception. Furthermore, girls continue to perform more poorly than boys. This poor performance is partially attributed to difficulties in mathematics language factors such as lack of understanding of mathematical symbols, structures and terms and the inability to communicate using appropriate mathematical terms, symbols and structures. Moreover, methods of teaching rely on the traditional teacher centred method in dissemination of mathematical information. These methods are also the blame lack of ability by students in achieving meaningful learning. There is paucity of research that seeks to determine the effects of using mathematics language factors on learners' achievement. It was against this backdrop that the study was intended to investigate the Gender Difference in the Understanding of Mathematical Terms, Symbols and Structures among Students Exposed to Embedded Mathematics Language Factor Teaching in Secondary School in Nakuru County, Kenya

2. Objective of the Study

To examine gender difference in the understanding of mathematical terms, Symbols and Structures among Students Exposed to Embedded Mathematics Language Factor Teaching in Secondary School in Nakuru County, Kenya

Research Hypotheses

In conducting the study the following hypothesis were tested

Ho: There is no statistically significant gender difference in the understanding of mathematical terms, symbols and structures between male and female students exposed to EMLF

Ha: There is a statistically significant gender difference in the understanding of mathematical terms, symbols and structures between male and female students exposed to EMLF

II. LITERATURE REVIEW

1. Understanding Mathematics

Understanding in Mathematics Abstraction: Pesels and Kirshner (2001), view abstraction in mathematics as the process of identifying the essential in one or more mathematical structures by the underlying essential core of a mathematical concept, removing any dependence on real world objects with which it might have been connected, and generalising it so that it has wider applications or matching among other abstract description of equivalent phenomena. They argued that once the essential core has been studied to discover its mathematical properties the result can be applied to any other structure, which has the same essential core. Content must be tied directly to a concept in order for student to assimilate the essential information and skills (Erickson, 2002).

Understanding in Mathematics Structures: Mathematical structures are ways in which mathematical symbols and notations are put together to express a certain concept (Mitchelmore, 2002). The mathematical structures are divided into two major categories namely; surface structure and deep structure. Surface structure: Johnson and Rising (1972) refers to this as the symbolization process of mathematics, which are the symbols used to represent ideas. For example ab, ∫xdx, 47 and (3,7). These are some of the specialized mathematical notations or symbols system, which represent mathematical concepts. Deep structures: These are the actual mathematical concepts represented by the surface structure (Johnson & Rising, 1972). From the examples on surface structure, their deep structure is as follows: ab= a x b, ∫xdx integrate f(x)=xwith respect to x, 47 = 4 x 101 + 7 x 100 and (2,3) – ordered pair locating a point on a plane. Learners of mathematics are faced with the difficulty of grasping the deep structures of mathematics rather than its surface structure (DeCorte, 1990),. Also some structure of mathematical symbols are not all consistent and have to be learned in an adhoc way (i.e. study for a particular purpose) to convey the mathematical deep structures, which they are intended to convey.

Dreyfus (1990) emphasizes that learning of mathematics is understanding structural relationships between concepts and their application. These relationships should be learned together with their symbolisation. Dean (1982) stated that generalisation is the process by which mathematics passes from understanding the structure from the previously learned structure, which can be extended to a finite or infinite number of other structures. According to him, mathematical notation has assimilated symbols from many different alphabets and type faces. It also includes symbols that are specific to mathematics, such as J, α, Δ, Λ. Schwarzerberger (2002) views mathematical notation as central to the power of modern mathematics. Learning of mathematics emphasizes that structured relationship should be learned together with their symbolization. In his view, the mathematical notion used for formulas has its own grammar, not dependent on a specific natural language, but shared internationally by mathematicians regardless of their mother tongues.

Understanding in Mathematical Concepts: Tobin (1996) states that mathematics is a language that is characterised by concepts and facts. Willing (1990), argues that children acquire terms that cover some of mathematics concepts in a curriculum. These concepts change in character as new ways of thinking emerges at secondary school level. If a child does not reach a satisfactory understanding of basic mathematics concepts taught in primary, there is little chance that he/she will achieve any success in the more advanced areas of the subject. Therefore, the primary school teacher shoulders the responsibility of producing children who have well-formed basic concepts. For example, children may abstract a concept of triangles from experience with different shapes and use that to recognise triangle of different shapes, until they need to modify this concept at some stage to consider. Each advanced concept is based in more elementally concept and cannot be grasped without a solid and specific understanding. But some concepts can only become meaningful within a structure such as, a vector or a group element. Therefore students cannot understand what a differential equation means unless they have understood the concept of differentiation (Malloy & Johns, 1998).

For concepts to develop effectively pupils need to perform their physical action until they are able to reason abstractly. The importance of understanding mathematical concept is emphasised by Pirie and Kieren (1994). Thus children must have the real and relevant practical experience if they are to internalize a concept. To make concept fully operational the teacher should present pupils with a great variety of situation as possible which exemplify the concept. Thus concepts are constructed from a series of experiences. Godino and Batanero (1996) assert that mathematics is a hierarchical subject where each of steps cannot be understood unless first the previous steps are mastered. Hence learning in mathematics depends on previously learned basic concepts. Also concept learnt allows classification and processing of incoming information by drawing from past experiences. Any new information inconsistent with an existing concept is rejected outright if it does not make sense, if the new insight is credible and therefore inconsistent with the old existing scheme, then the scheme must be modified to accommodate it (Willing, 1990). Teachers can provide a collection of suitable experiences to help promote in development of the concept. Examples used must involve only those concepts, which learner can already understand. Piaget stages of intellectual development are a useful guide to the teaching in which mathematics should be geared so that the complexity of the subject matter is matched to the conceptual ability of the child. Understanding is important and desirable since it generally promotes retention of the concept. Dreyfus (1990) says students construct knowledge dialectically by progressing through a concept images in whose evolution on overcoming cognitive obstacles.

2. Gender Difference and Understanding of Mathematics

According to dicennor (2000) science and mathematics education leads to careers, which have always been associated with male members of the society. While girls have been dominating subjects like home science and generally home economics, as they are believed to relate to their roles as women in the society. Consequently, gender is a social aspect that describes the activities to be carried out by the boys and girls in community. Although sex and gender are terms that overlap, gender in this case was preferred because of the emphasis on the difference in attainment between girls and boys in secondary school mathematics. It is therefore, important to consider gender in relation to understanding in mathematics in this study because mathematics serves as a basic requirement in many career programmes (O'Connor, 2000). Consequently the current world trend and research emphasis on gender issues following the millennium declaration of September 2000 (United Nations, 2000) which has as its goal, the promotion of gender equity, the empowerment of women and the elimination of gender inequality in basic and secondary education by 2005 and at all levels by 2015.

Over the past three decades, a considerable number of studies seeking to determine a relationship between gender and mathematics understanding have been conducted in various countries. In recent years research efforts (Ericikan, McCreith, & Lapointe, 2005; Johnson, 2000; Leahe & Guo, 2001; Zhang & Manon, 2000) show no significant differences in understanding of mathematics between boys and girls as they start getting acquainted with mathematics. Nonetheless, differences favoring male students begin to emerge with time. Although these studies address gender-related differences, the distinction is usually made by sex (i.e., considering individuals' biological characteristics rather than the sociocultural background that shapes their gender identity). Consequently, literature indicates that the role played by gender in mathematics understanding is multifaceted. (Fennema, Carpenter, Jacobs, Franke & Levi, 1998; Maccoby & Jacklin, 1974, Shibley-Hyde, Fennema & Lamon, 1990) show that many reports of differences in mathematics understating related to gender have been presented over the past decades. Understanding differences have been postulated to be due at least in part, to attitudinal differences regarding mathematics. Fennema & Sherman (1977), using the Fennema-Sherman mathematics attitudes scales, found several gender differences in high school students' attitude. For the students in those high schools in which the males performed significantly better on mathematics achievement tests, Fennema and Sherman (1977) found that males also had higher scores on attitude scales including confidence in understanding mathematics, viewing mathematics as male domain, attitude towards success in mathematics, mother's support, father's support and usefulness of mathematics. Since that initial report, similar gender differences in attitude towards mathematics have been reported for different ages and using different measurement scales (Duffy, Gunther & Walters, 1997; Forgasz, 2006; Meyer & Koehler, 1990; Stipek & Gralinski, 1991). Yet in another study by the use of episode writing, "ability to solve mathematics Problems", "having the correct answers", "accurate and fast solution", "ability to apply daily life situations", "knowing the underlying principle", "understanding the procedure and strategies", "ability to clarify concepts" , "knowing the relationships among concepts" and "ability to explain to others" for both boys and girls were some of the indicators of understanding as perceived by both girls and boys.(Wong, 1993a, 1995b).

III. METHODOLOGY

1. *Research Design ,Target Population*

The research design used in this study was Solomon Four Non-Equivalent Control Group Design. This design used non-equivalent groups (Fraenkel & Wallen, 2000; Mugenda & Mugenda, 2003). This design was considered appropriate because the subjects were already constituted and it was not possible to randomly select them individually. The design involved a random assignment of intact classes of subject to four groups with Two groups being experimental and other Two as controls. The target population constituted of form two students drawn from 13 public co-educational secondary schools in Nakuru County, Kenya. There are approximately 1300 Form Two students in Nakuru County, Kenya (Nakuru County, Kenya Educational statistics, 2012). The co-educational schools were selected because the study was to look into gender differences in performance. Samples were drawn from Form Two mathematics students. These students were involved because the topics "Linear inequalities", "Further measurements" and "Indices and Logarithms" are taught at this level in Kenya's secondary schools curriculum (KIE, 2002). The four topics were chosen because they are rich in symbols and terms.

2. *Sampling and Sampling Size*

The study involved public secondary schools within Nakuru County, Kenya. Purposive sampling and simple random sampling were used so as to select Co-educational secondary schools within the Nakuru County from the sampling frame. Generally, a sample size is determined by the number of variables in the study, type of research design, method of data analysis and the size of accessible population. However, according to Mugenda and Mugenda (1999), at least 30 members per group in the design are required for experimental research. Information from the DEO's office shows that there are 13 co-educational schools in Nakuru County. Simple random sampling was used to select 4 schools from the 13 co-educational schools. The sampling unit was secondary schools and not the individual learners since learners are taught as intact groups. However, the individual learners were units of observation. The four sampled schools were randomly

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assigned to the control and the treatment groups. If a selected school assigned to an experimental group had more than two streams, all the streams were exposed to the treatment but two streams randomly selected for analysis. All mathematics teachers of selected schools participated.

3. Data collection instruments

The research instruments used in this study were Understanding of Mathematical terms test (UMTT), Understanding of Mathematical symbols test (UMST), Understanding of Mathematical Structures test (UMSrT), The Mathematics Observation Schedule (MACOS), Mathematics Achievement test (MAT).

The observation schedule provided information on what goes on in class in relation to embedding of mathematics language factors from the secondary school mathematics teachers and students. The researcher used it to follow the teaching of Embedding Mathematics Language Factors (EMLF) during the lesson. Understanding mathematics test sets I, II and III provided information on learners understanding of mathematical terms, symbols and structures respectively. Mathematics Classroom Observation Schedule (MACOS): The researcher sat in all Form Two classes in the selected schools and using the observation schedule recorded, all the mathematical terms, symbols and structures that were presented in the lesson. The researcher was very keen on the level of explanation and also identification of any mathematical term, symbol and structure that was ignored or left out in relation to the content given. Observation was also carried out on how the learners were interacting with mathematical terms, symbols or structures presented in the lesson and whether teachers asked questions that required learners to discuss and give their meaning. Activities in the mathematics classroom were observed and data captured using the mathematics classroom observation schedule. This was to help the research to monitor the implementation of the instructional module. Mathematical Achievement Test (MAT) : This provided information on scores on the students' Mathematical Achievement as affected by mathematics language factors. This consisted of 20 structured questions. The scores were used as a means of measurement.

4. Data Collection, Processing and Analysis

The researcher followed the following procedure: data collection procedures started from the graduate school, Laikipia University where the researcher obtained an introductory letter to help in seeking permission to carry out study in different areas and institutions. The letter was taken to National Commission for Science, Technology and Innovation in order to obtain a research permit authorising one to visit selected schools in order to carry out the research. After the research permit was obtained (appendix G) letters were prepared and taken by the researcher to the District Education Officer and to the Head Teachers of the selected schools, seeking permission to allow the research to be conducted. The research agreed with teachers in the experimental schools on the appropriate date for training. The mathematics teachers in the two experimental schools (E1 and E2) were trained during the recess for one week (during the April holiday 2015) on use of the mathematical language factor teaching strategy module by the researcher. The duration taken by the researcher to complete the work was 9 weeks. This study provided quantitative data that was used to produce both descriptive and inferential statistics using the SPSS software version 20. Raw data was summarized in the form of tables and descriptively analysed using means, standard deviations and percentages. Hypotheses were tested using the one-way Analysis of Variance (ANOVA) since it tested the significance of difference between more than two means at once. LSD Post-Hoc comparison was used to find out whether the difference occurred on pairs of groups and the direction of the difference.

IV. RESULTS AND DISCUSSIONS

The differences on mathematics achievement and understanding mathematics pretests by gender were also examined during the pretest analysis. The test of differences by gender was determined using the t-test

Table 1: Comparison of the Students' Pre-test Mean Scores on Mathematics Achievement and Understanding Mathematics by Gender

Scale	Group	N	Mean (M)	SD	df	t-value	p-value
1.Mathematics achievement	Male	41	19.93	10.57	80	1.388	.169
	Female	41	23.66	13.60			
2.Understanding mathematics terms	Male	41	23.41	14.11	80	0.445	.657
	Female	41	24.85	15.14			

3.Understanding mathematics symbols	Male	41	28.02	14.77	80	0.429	.669
	Female	41	26.66	14.08			
4.Understanding mathematics structure	Male	41	30.61	13.24	80	0.434	.666
	Female	41	31.98	15.20			
5.Understanding of mathematics (i.e., combined 2,3,4)	Male	41	27.35	8.89	80	0.235	.815
	Female	41	27.83	9.61			

Mathematics achievement pretest mean score (M = 19.93) of male students was not significantly different from that of the females (M = 23.66) at the .05 level (t(80) = 0.1388, p = .169). The two groups were similar on mathematics achievement before the commencement of the programme. Male students understanding of mathematics terms mean score ((M = 23.41) was not significantly different from that of the females (M = 24.85) at the .05 level (t(80) = 0.445, p = .657). This is an indication that the two groups were similar at the point of entry. The difference between the male students' understanding of mathematics symbols mean score (M = 28.02) was not significantly different from that of the females (M =26.66) at the .05 level (t(80) = 0.429, p = .669). This means that the two groups were homogenous before the commencement of the programme. Male students understanding of mathematics structure mean score (M = 30.61) was not significantly different from that of the females (M = 31.98) at the .05 level (t(80) = 0.434, p = .666. This implies that the males and females were comparable at the point of entry. The results in Table 1 further shows that the male students understanding of mathematics combined mean score ((M = 27.35) was not significantly different from that (M = 27.83) of the females at the .05 level (t(80) = 0.235, p = .815). Given that the E1 and C1 had comparable characteristics on the two measures; mathematics achievement and understanding of mathematics, they were considered suitable for the study as the pre-test analysis shows that they were drawn from a similar population.

Table 2: Differences by Gender in Understanding Mathematics Posttest Mean Scores of Students Exposed to ELMF

Scale	Gender	N	Mean (M)	SD	Df	t-value	p-value
1. Mathematics terms	Male	41	47.93	15.64	80	0.231	.818
	Female	41	47.27	9.34			
2. Mathematics symbols	Male	41	51.02	14.82	80	0.464	.644
	Female	41	49.63	12.17			
3. Mathematics structure	Male	41	51.22	15.46	80	0.136	.892
	Female	41	51.66	13.68			
4. Understanding mathematics	Male	41	50.06	14.10	80	0.198	.844
(All combined 1,2 &3)	Female	41	49.52	10.17			

The t-test results in Table 2 show that the mean (M = 47.93) of the male students on understanding mathematics terms was comparable to that of their female counterparts (M = 47.27) since they were not significantly different (t(80)= 0.231). The results also reveal that the means of the males (M = 51.02) on understanding mathematical symbols was similar to that of the females (M = 49.63) as they were not significantly different at the .05 level (t(80) = 0.464, p=.644). The results further show that the mean score (M = 51.22) of the male students on understanding mathematics structure was comparable to that of their female counterparts (M = 51.66) since the difference between the two was not significant at the .05 level (t(80) = 0.136, p=.892). The test results comparing the female students mean score (M=49.52) on the understanding mathematics (i.e. all constrast combined) and that of the males (M=50.06) showed that the difference was not significant (t(80) = 0.198, p= .844). The results suggest that gender does not affect students taught using EMLF strategy.

Further analysis was done on students understanding of mathematics to ascertain whether the results of the t-test were not due to differences at the point of entry. Comparison of posttest mean scores by gender was done using the ANCOVA with the KCPE scores as the covariate. The adjusted mean scores with KCPE as the covariate are in Table 2.

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Table 3: Students Exposed to EMLF Adjusted Understanding Mathematics Posttest Mean Scores with KCPE as the covariate

Scale		Gender	N	Adjusted Mean	Standard Error
1.	Mathematics Terms	Male	41	48.03	2.022
		Female	41	47.17	2.022
2.	Mathematics symbols	Male	41	51.11	2.130
		Female	41	49.54	2.130
3.	Mathematics structure	Male	41	51.29	2.296
		Female	41	51.59	2.296
4.	Understanding mathematics	Male	41	50.14	1.931
	(i.e. combined 1,2 & 3)	Female	41	49.43	1.931

An examination of the results in Table 3 reveal that the adjusted male mean scores on mathematical terms (M = 48.03), mathematical symbols (M = 51.11), mathematical structure (M = 51,29) and understanding mathematics (M = 50.14) were comparable with those of the female mathematical terms (M = 47.17, mathematical symbols M = 49.54, mathematical structure M = 51.59 and understanding mathematics M= 49.43) for each construct. This was confirmed by the results of the ANCOVA test as shown in Table 4

Table 4: Differences between Understanding Mathematics Posttest Mean Scores of Male Students Exposed to ELMF and that of their Female counterparts

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
1. Mathematics Terms	Construct	14.910	1	1 4.910	0.089	.766
	Error	13183.195	79	166.876		
2.Mathematics symbols	Construct	50.092	1	50.092	0.270	.604
	Error	14630.544	79	185.197		
3.Mathematics structure	Construct	1.765	1	1.765	0.008	.928
	Error	16998.719	79	215.174		
4. Understanding of Mathematics (i.e.combined 1,2 &3)	Construct	10.262	1	10.262	0.067	.796
	Error	12024.542	79	152.209		

The results of the ANCOVA test show that difference between mean scores of the male and female students on understanding mathematics terms was not significant at .05 level , (F(1, 79) = 0.089, p= .766). The results also reveal that the mean scores of the males on understanding mathematical symbols was not significantly different from that of the females (F(1, 79) = 0.270, p= .604). The results further show that the means scores of the male students on understanding mathematics structure was comparable to that of their female counterparts since the difference between the two was not significant at .05 level, (F(1, 79) = 0.008, p = .928). The difference by gender of the students on understanding of mathematics (i.e. All constructs combined) was also not significant (F(1, 79) = 0.067, p= .796). This is an indication that gender does not affect the students in the experimental groups on understanding of mathematics when taught using EMLF teaching strategy. This further confirms, difference in the understanding of mathematics terms, symbols and structures for students exposed to EMLF strategy.

V. CONCLUTION

The Hypothesis established whether there was any difference by gender in the learners' understanding mathematical terms, symbols and structures between learners' taught using EMLF language factors strategy and those taught through conventional methods. The result of both the t-test and ANCOVA tests revealed that the means of the male on understanding mathematics was not significantly different from that of the females. This is an indication that gender does not affect the students in the experimental group understanding of mathematics. Therefore, the third hypothesis which states that there is no statistically gender difference in the understanding of mathematical terms, symbols and structures of students exposed to EMLF was accepted. The findings of the study have shown that gender does not affect students' understanding of mathematics taught using EMLF teaching strategy. This shows that EMLF strategy does not discriminate against gender of the learners' hence an effective strategy which can be used irrespective of the nature and type of learners. Thirdly, from the findings of objective three gender does not affect students mathematics performance when students are taught using EMLF teaching strategy. The study concludes that EMLF teaching strategy reduces gender disparities in secondary school mathematics.

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