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EFFECTIVENESS OF A LANGUAGE BASED PROGRAM IN SCHOOL MATHEMATICS ON STUDENTS UNDERSTANDING OF STATISTICS

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ABSTRACT. Mathematical knowledge and understanding is important not only for scientific progress and development but also for its day-to-day application in social sciences and arts, government, business and management studies and household chores. But the general performance in school mathematics in Kenya has been poor over the years. There is evidence that students have problems in understanding and interrelating the symbols and special language structure as used in mathematics. Nevertheless in a recent study, a program called Socialized Mathematical Language (SML) module was designed to enhance student's learning outcomes in school mathematics. The study was carried out in a real classroom setting that involved comparisons between the treatment and control groups. A Solomon Four Group quasi-experimental design was employed to involve four high schools in Bungoma District. A total of 156 form two students enrolled in four intact classes from the selected schools were exposed to the same content in statistics for a period of two weeks. Three dependent measures namely the Mathematics Achievement Test (MAT), the Mathematics Skill Test (MST) and the Mathematics Classroom Environment Questionnaire (MCEQ) were used to assess the effectiveness of the program on students' academic achievement in understanding of statistics, their skill performance and perceptions of the classroom environment during statistics lessons. The results affirm statistically significant learning gains in favour of the treatment groups. The study concludes that the use of SML program has a major implication for school mathematics instruction in the area of statistics.

KEYWORDS. Students Understanding, Statistic Education, Mathematical knowledge.

INTRODUCTION

Mathematics plays a central role in scientific progress and development. Its fundamental role lies in its everyday application in most social sciences, government and business transactions, physical sciences and engineering, biological sciences and medicine, military and aerodynamic advancements and household chores. This has made the subject compulsory in the school curriculum in Kenya (Mutunga and Breakel, 1992; Republic of Kenya, 1999). This is because students are expected to apply the knowledge of mathematics in both familiar and unfamiliar situations. However, the literature indicates that a considerable number of students have inadequate understanding of mathematics and mathematical concepts and skills

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(Kenya National Examinations Council (KNEC), 2000; Ministry of Education, Science and Technology (MOEST), 2001). In effect the topic on statistics has constantly been difficult to learn by students or teach by teachers. However, this should not be the case considering the central role of statistics in the mathematics curriculum at all levels (Kenya Institute of Education (KIE), 2002; Wasike, 2003). According to the Kenyan education system, the teaching and learning of statistics involves concepts and skills dealing with data collection, organization, analysis, representation and interpretation. This is not only useful but applicable in planning, decision making and research by companies, government departments and scientists (KIE, 2002).

The language policy in Kenya stipulates that English language is the medium of instruction at the secondary school level (Bogonko, 1992; MOEST, 2001). But, mathematics as is conceived everywhere in the world has a subject language with internationally accepted terminologies and symbol system that has condensed meaning (Costello, 1991; Durkin and Shire, 1995). These symbols and terminologies are not familiar and sometimes contradict meanings in ordinary English especially in the area of statistics. The literature is replete with studies indicating that language interferes with mathematics learning especially when English is used as a medium of instruction to second language users (Thijs and Van Den Berg, 1995; Durkin and Shire, 1995; Gramley and Patzold, 1996; Wasike, 2003). This provides evidence to suggest language problems where students have to understand and interrelate the symbols and special language structure as used in mathematics and especially statistics. There is need therefore to incorporate language models in mathematics instruction.

The language-based program is one such model that has recently been lauded for its capability to simply and explain the symbols and special language structures in mathematics (Wasike, 2003). This program describes the meaning of technical terms in mathematics in comparison to their meaning in English. Such a program may be used in a mathematics instructional setting to provide an environment for student understanding of mathematical symbolism and language structure. In other words, it enables the student to understand concepts and skills not only in mathematics but also make comparison with the ordinary meaning from the English language (Costello, 1991; Durkin and Shire, 1995; KNEC, 2000; Wasike, 2003). Therefore the study reported in this paper was set up to develop a language based program in school mathematics and investigate its effectiveness on students understanding of mathematics and their perception of the learning environment.

THE PROBLEM

The general performance in mathematics among secondary school students in Kenya has been poor for many years (KNEC, 2000). There is evidence that many of the serious problems facing secondary school mathematics instruction today should not be attributed to deficiencies in the curriculum, teaching or assessment but spring from language considerations rather than

the inherent difficulties of the subject (MOEST, 2001; KNEC, 2000; Wasike, 2003). There is need however to improve student understanding of mathematics as this is core to Kenyan quest for industrialization. As such a language based program was developed and its effect on student understanding of mathematical concepts and skills in statistics and their perception of their learning environment studied. This paper is an attempt to contribute in regard.

THE PURPOSE OF THE STUDY

The purpose of the study was to investigate the effect of a language based program on form two students understanding of the topic statistics in mathematics and also assess their perception of the mathematics classroom environment.

METHODS

The Sample

A total of 156 secondary school students from four secondary schools in Bungoma District of Western Province in Kenya served as the subjects of the study. These students were randomly selected from intact classrooms because school authorities do not normally allow classes to be split for research purposes once they are constituted. The subjects were randomly selected from four intact classrooms in four schools. All the groups were comparative enough in terms of number and resources. Moreover, the pretest analysis showed no significant difference on all the dependent measures (Wasike, 2003).

Research Design

The Solomon- Four group quasi – experimental design was employed for this study. The design is rigorous and robust enough in eliminating variations that might arise because of experiences and contaminate the validity of the study (Koul, 1992; Kothari, 2003). The design involves a random assignment of subjects to four groups with two groups being the treatment group and the others being the control group. One treatment and one control were administered the pretest. The experimental groups were exposed to the program – the experimental treatment while the control groups denied. The four groups were all post tested after the exposure to the content of statistics.

Instruments

Three dependent measures namely the Mathematics Achievement Test (MAT), the Mathematics Skill Test (MST) and the Mathematics Classroom Environment Questionnaire (MCEQ) were used to assess students' academic achievement in understanding statistics, their

skill performance and perception of the learning environment during the topic statistics. The dependent measures were developed for purposed of this study and reviewed by a group of seven experts knowledgeable in mathematics and mathematics education. MAT, consisting of 25 items was developed based on the table of specification designed for the topic statistics. These items were analysed for difficulty level and discrimination indeces. It was established that the items difficulty level (between 0.42 and 0.65) and discrimination index (between 0.21 and 0.35) were within acceptable range of 0.3 - 0.7 and 0.2 – 0.5 respectively (Kothari, 2003; Koul, 1992).

Similarly, MST consisting of 10 items on science process skills relevant to statistics was developed. On analysis of the items, the difficulty and discrimination indices of between 0.40 – 0.59 and 0.25 – 0.45 respectively were obtained. The student affective domain i.e. perception of the mathematics learning environment was measured by MCEQ. This consisted of a checklist of 25 items on a five –point Likert-type scale. This was also vetted by six experts knowledgeable in science and mathematics education.

On the whole MAT, MST and MCEQ were piloted on a group of 20 students in one school that didn't take part in the actual study. The piloting of these instruments yielded reliability coefficients of 0.78, 0.79 and 0.77 for MAT, MST and MCEQ respectively using K-R 21 formula. This indicate that all the dependent measures were valid and reliable because the reliability coefficients obtained were higher than the recommended level of 0.70 (Koul, 1992).

RESULTS AND DISCUSSION

The effectiveness of language-based programe presented from this study was ascertained by the one-way Analysis of Variance (ANOVA) and confirmed by post hoc multiple comparison tests. All the analysis was done using the Statistical Package for Social Sciences (SPSS) computer program whose results are presented in tables and discussed in the sections that follow.

RESULTS ON MAT

Table l compares the results of pretest and post test scores obtained by the subjects on MAT. An examination of this result shows that the subjects in E1 and C1 groups attained similar mean scores on pre-test. This indicates that the subjects had similar characteristics before exposure to the topic statistics.

A close examination of the results in Table 1 shows that the subjects in E1 group attained a mean gain score of 38.87, which is higher than the mean gain score of group C1 (26.84). Thus the latter is less than the overall mean gain (33.40) for the whole after correcting for lack of the pretest in groups E2 and C2. The result also indicates higher mean scores for the treatment groups than for the control groups. The mean scores of the two treatment groups are quite similar. This is probably due to the program to which they were exposed.

Table II indicates significant difference for treatment groups from the control groups. The mean scores of the treatment groups yielded t- values of t (1,73=2.74), t (1,86=3.54), t (1,68=2.32) and t (1,83=3.93) at $p<0.05$. A further analysis of the difference using Turkey's Honest Significant Difference (THSD) test also revealed the following trend:E1=E2 $\geq$ C1=C2. This suggests that students exposed to the treatment outperformed those denied the treatment and hence significant learning gains may be attribute to the treatment administered to the groups.

Results on MST

The purpose of the MST instrument was to measure the psychomotor aspects of the learning outcomes before and after the commencement of the topic statistics.

A perusal of the results in Table III shows that the pre-test mean scores obtained by the students in group E1 (52.38) and C1 (51.22) were similar before teaching the topic statistics. After exposure to the topic, students in treatment group E1 (78.68) and E2 (77.28) scored higher mean scores than those in control groups C1 (69.22) and C2 (68.75). The mean gains of process skills for E1 (26.27) and for the whole group (21.75) were both higher than C1 (18.00). This suggests differences in the mean scores obtained by treatment groups (E1 & E2) and control groups (C1 & C2).

An inspection of Table IV indicates significant difference in the mean scores obtained by the subjects on MST. However, this does not show the direction of the difference. An analysis of the difference using the independent sample t-test reveals that the mean scores obtained by the treatment groups were significantly different from and higher than those in the control group. A comparison of post test t-values of t(1,73 = 3.58), t(1,86 = 3.06), t(1,67 =3.54) and t(1,83=3.80) at $P< 0.05$ level were obtained. Moreover, the THSD test also confirms the trend E1 = E2 > C1 = C2 at 0.05 level. This suggests that students exposed to the treatment had better learning outcomes in mathematics process skills in statistics.

Results on MCEQ

The purpose of the MCEQ was to assess the affective aspect of the learning outcome before and after exposure of the subjects to the topic statistics. The results of the students' checklists on MCEQ were quantified and presented in Table V.

An examination of results in Table V reveals that pretest mean scores of E1 and C1 and post test mean scores of groups E1 and E2, and C1 and C2 are quite similar. However the mean gain for E1(21.71) was higher (by 7.34) than that of C1 (14.37). The mean gain for E1 is higher and close to overall mean gain than that of C1. This suggests difference in the perception of the learning environments. This was perhaps possible because the program exposed to the treatment

groups was designed to offer the students opportunities to interact more frequently during the lessons and exercise language skills than passively go through the lessons as in regular programs (Wasike, 2003). Contrary to the regular learning program, the program under study was meant to simplify and harmonize the language during mathematics instruction.

Thus this program has proved that students' academic achievement and affective learning gains are improved when learners participate actively in the learning process. From the results, there is evidence suggesting that the language-based program significantly affected the mean scores of the treatment groups on the cognitive and affective variables. It may therefore be concluded that the significantly higher mean scores obtained by the treatment groups as opposed to those of control groups and the similarity in the mean scores of the treatment groups is not coincidental but probably influenced by the program administered.

CONCLUSION

An attempt has been made to use the results of a study on the effects of a socialized mathematical language module on students understanding of mathematics and their perception of the learning environment.

The findings have demonstrated that the use of a well designed language based program can be effective in improving students knowledge and performance in statistics as well as their perception of the learning environment. The differences between the mean gains of students exposed to the program and those denied the program on all the dependent measure are in the affirmative. The inferential statistics used revealed that differences in the mean scores obtained by student in the treatment groups and those in the control groups were statistically significant. This seems to have demonstrated the effectiveness of a language-based program in engendering cognitive and affective gains in mathematics. This is consistent with earlier findings that show that learning outcomes may be enhanced by restructing the classroom environment (Kiboss, 1997; Wasike, 2003; Wekesa, 2003). Given the huge class sizes and inadequate resources as the key characteristics of most Kenyan classrooms, this program may be handy in improving student understanding of mathematics. However, this being the first program of the kind in Kenya, future studies should make attempts to ascertain whether or not the present findings are incidental or genuine.

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Table I. Comparison of Means, Standard Deviation (SD) and Mean Gain Obtained on MAT

Scale	Overall	E1	C1	E2	C2
Pretest Mean	38.71	38.93	38.49	-	-
S.D	8.99	9.45	8.53	-	-
Post test Mean	71.35	77.80*	65.30	77.10	66.70
S.D	11.35	10.84	11.40	11.32	11.84
Mean Gain	33.40	38.87	26.84	-	-

* Denotes similar means

Table 2. independent sample t-test for Posttest mean scores on MAT

Groups	t-value
E1 Vs E2	0.12
E1 Vs C1	2.74*
E1 Vs C2	3.54*
C1 Vs C2	0.45
C1 Vs C2	2.32*
E2 Vs C2	3.93*

* denotes significant at P<0.05.

Table 3. Comparison of Means, Standard Deviations (SD) and Mean Gain obtained on MST.

		Groups			
Scale	**Overall**	**E1**	**C1**	**E2**	**C2**
Pretest Mean	51.83	52.38	51.22	-	-
S.D	2.78	2.77	2.45	-	-
Post test Mean	73.48	78.65	69.22	77.28	68.75
S.D	6.15	3.95	4.32	3.25	4.17
Mean Gain	21.65	26.27	18.00	-	-

Table 4. ANOVA test of Post test Mean Scores on MST

Source	Df	SS	MS	F-value
Between Groups	3	1065.36	355.12	9.11*
	153	5966.07	38.99	-
Within Groups	156	7031.43	-	-
Total				

* denotes significant difference at P<0.05

Table 5. Comparison of Means, Standard Deviations (SD) and Mean Gain by subjects on MCEQ.

		Groups			
Scale	**Overall**	**E1**	**C1**	**E2**	**C2**
Pretest mean	56.36	56.78	55.94	-	-
S.D	9.61	8.74	10.48	-	-
Post test mean	74.68	78.49	70.31	76.41	71.52
S.D	8.43	8.09	8.38	8.12	9.13
Mean Gain	18.32	21.71	14.37	-	-

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