CHAPTER 10

EFFECT OF A SOCIALISED MATHEMATICAL LANGUAGE MODULE ON STUDENTS' UNDERSTANDING OF MATHEMATICS AND THEIR PERCEPTION OF THE LEARNING ENVIRONMENT

Dancun Wasike Wekesa **and** *Helen Omondi Mondoh*

Abstract

There is evidence that students have problems in understanding and interrelating symbols and special language structure as used in mathematics. The study or which the paper is based was designed to develop and explore the instructional potential of a Socialised Mathematical Language (SML) module in teaching and learning of statistics in mathematics. A quasi-experimental approach adapted from the Solomon Four Group Experimental Design was employed to compare experimental and control groups drawn from schools in Bungoma district. Four different instruments namely achievement test, students' questionnaire, teachers' questionnaire and observation schedule were used to collect data from 156 Form Two students selected for the study. Both descriptive statistics (means, standard deviations, & percentages) and inferential statistics (t-test & the Analysis of variance) were used for data analysis. The findings indicate that the SML module resulted in significant learning gains better perception of the environment and provided appropriate opportunities for student participation and interaction. The study concluded that the SML module was helpful in enhancing the teaching and learning of mathematics. The module was found to facilitate in making the subject more understandable to students and hence improved student performance in the subject.

Introduction

The general performance in mathematics among secondary school students in Kenya has been poor for many years (KNEC 2000a; 2000b). This means that Kenya may not achieve her goal of industrialisation by the year 2020, for which mathematical knowledge is necessary. Studies conducted on students' performance in mathematics reveal that the language of mathematics is one of the major factors responsible for the poor performance in the subject (Eshiwani 1983). No specific and precise language of instruction has been developed to facilitate students' understanding of mathematical concepts and skills. It is not clear what language would be appropriate for mathematics instruction in secondary schools. However, it was important to begin somewhere in an attempt to come up with such a language.

Since the topic Statistics is applicable in many fields of study and also in everyday life, and uses a lot of mathematical language, it provided a starting point for the study. A Socialised Mathematical Language (SML) module to enhance students understanding of mathematical concepts and skills in statistics and perception of their learning environment; was thus developed and tried out.

The purpose of the study was to investigate the effect of the integrated mathematical language module (developed during the study), herein referred to as the Socialised Mathematical Language (SML) module for teaching and learning statistics on students' understanding of concepts. The effect of SML on students' perception of their learning environment was also determined.

Methodology

The study involved 166 Form Two students selected randomly from four district schools .in Bungoma district during 2002. The selected students were drawn as a single stream randomly drawn from each of the four selected schools.The district has 25 provincial, 93 district and seven private schools. The accessible population was 2,400 students. The district was selected because students' performance in mathematics has been poor (District Education Office Bungoma, 2001). Available statistics showed a performance index of 2.580, 3.125, 3.025, 3.485 and 3.640 for 1996, 1997, 1998, and 2000 KCSE examination respectively. Although these figures indicated an improving trend, they represented less than a third of the maximum aggregate score of twelve points.

The study focused on public secondary schools in the district category This is because there are more district secondary schools as compared to provincial and private schools, thus assuring availability of respondents for the study. Besides, students admitted into these schools have almost the same qualification based on their Kenya Certificate of primary Education (KCPE) examination performance. This would provide a basis for generalisation of the results. Form two students were chosen because the topic 'statistics' chosen for study is taught at this level (KIE 1992). 'Statistics' was selected because students' performance in the topic is relatively poor in KCSE examinations and consequently, the topic is rated among the most difficult ones in mathematics (Kamau 2000; KNEC 2000b). In addition, 'statistics' has a lot of mathematics symbols, and terminology of which students seem to hold an inadequate understanding.

Research Design

Quasi-experimental design adapted from the Solomon Four-Group Experimental design was employed for this study. This design is considered appropriate for quasi-experimental studies because it provides the most effective and efficient tools available for determining cause and effect relationship (Ary *et al.,* 1972; Borg 1987; Koul 1992; Ogunniyi 1992). Besides, the design provides adequate control of other variables that may contaminate the validity of the study. The design involves a random assignment of intact classes of subjects to four groups with two groups being experimental and the other two as controls. Table 1 illustrates this study design.

Table I: Solomon Four-group experimental Design

Group	Pre-test	Treatment	Post-test
El	01	X	02
E2		X	03
C1	04		05
C1			06

Source: Ary *et al.,* (1972) p.247

As shown in Table 1, four groups of subjects: the experimental Group One (El), the Experimental Group Two (E2), the control group one (C1) and the control group two (C2) were used. Groups El and E2 formed the experimental group while CI and C2 were the control groups. Groups El and C1 received a pre-test(Ol & 04) to ascertain whether or not the groups under study had comparable characteristics while El and E2 got treatment (X) that was an exposure to the SML module.

All groups in this study received a post-test that facilitated comparisons between the groups. However, to avoid interaction of subjects from different groups, one class from a school constituted one group of subjects, hence the requirement of four schools for the study. There was random assignment of selected classes to both groups because schools chosen for the study did not allow intact classes to be split.

The Design of the SML Module

The development of the SML module for this study took four weeks. The module was developed for teaching and learning the topic statistics in mathematics. The content of the module was based on the KIE approved syllabus, the teachers guide and students' textbooks. The main concern of the SML was to simplify the language used in presenting the concepts and skills in statistics in three areas namely data collection and organisation, measures of central tendency and data representation. These content areas were presented in twelve lessons (two double lessons of 80 minutes each and eight singles of 40 minutes each) and taught to form two students for over a period of two weeks. The language used in this module integrated the ordinary English language and the mathematical language in the context of teaching and learning the topic statistics in mathematics.

Instruments

In the study, four instruments were used to collect data. These were the students' questionnaire, teachers' questionnaire, an observation schedule and achievement test. The students' questionnaire referred to as the Student Perception Questionnaire (SPQ) was a five-point Likert-type tool consisting of 20 structured items, which solicited views of students about their learning environment during statistics lessons. The teachers' questionnaire referred to as the Teacher Evaluation Questionnaire (TEQ) was a five-point Likert-type instrument consisting of 25 items that solicited teachers' views, feelings and opinions about the SML module.

The observation schedule namely:- the Mathematics Classroom Observation Schedule (MACOS) guided classroom observations during statistics lessons. It contained six items on teacher-related activities and eight items on student-related activities. The Mathematics Achievement Test (MAT) had a total of 25 items testing skills in data collection, data organisation, measures of central tendency, and data representation.

Data Analysis

The study generated both qualitative and quantitative data that was analysed both descriptively and inferentially. Raw data were summarised in form of tables showing means, standard deviations and percentages. A one-way Analysis of Variance (ANOVA) was used to ascertain statistical significance. In order to establish exactly where the mean differences lay and the direction of the difference, an independent samples t-test was performed.

This was further confirmed by the Turkey's Honest Significant Difference test. These tests were chosen because they provide simple and accurate results. All tests of significance were conducted at $\alpha=0.05$ level. In addition, brief presentations in tabular form and narrations of the qualitative data collected were done to test hypothesis four. Also, the analysis of the teachers' evaluation of the SML module was analysed qualitatively.

Background

Despite its importance in the school curriculum and everyday life, mathematics is a subject that seems to be little understood by many secondary school students in Kenya. This can be inferred from the poor performance levels as depicted by the

Kenya Certificate of Secondary Examination (KCSE) results (KNEC 2000c) shown in Table 2.

Table 2: Summary of KCSE Performance from 1996 to 1999 by %

Near	Piper	Mean score	Standard deviation
1996	1	17.43	17.09
	2	19.09	16.59
	Overall	36.24	32.99
1997	1	17.44	16.69
	2	15.50	15.49
	Overall	32.62	31.59
1998	1	19.59	18.23
	2	15.64	15.25
	Overall	35.04	32.71
1999	1	13.46	13.85
	1	11.46	11.76
	Overall	24.45	24.94

Source: KNEC (2000b: 2000c) reports

The mean scores indicate that on the overall the students scored an average of about 35 marks while the standard deviations figures show that on the overall the students varied by 32 marks above and/or below the mean scores during the years indicated. This implies that the candidates who sat for the examination during these years had mastered less than 35% of the prescribed syllabus (KNEC 2000c). Further scrutiny of the results by KNEC shows that the most poorly performed topics in mathematics were algebra, 3-dimensional geometry and statistics (KNEC 2000b; 2000c).

An analysis of the KCSE examination question papers indicates that questions on statistics as compared to other topics keep recurring year after year yet no remarkable improvement has been realised in terms of student performance. Since Statistics is essential in many sectors, it is important that students are encouraged to excel in it.

Many of the serious problems faced by secondary schools with regard to instruction in mathematics today may not be attributed to deficiencies in the curriculum, teaching or assessment. This is in agreement with scholars who have expressed the view that learning difficulties in mathematics spring from language considerations rather than inherent conceptual difficulties of the subject (Bunyi 1994; Eshiwani 1983; 1984; Gihua 2002). This provides evidence to suggest that there is a language problem in mathematics and students have problems in understanding and inter-relating the symbols and the special language structure used in mathematics. Although 'statistics' owes much from the theory **of** probability, the topic on probability is among the better-performed topics. Indeed, statistics has a lot of symbols and notations for which students may have inadequate understanding.

Githua (2002) concurs in arguing that the specialised language in mathematics tests and examinations is one factor that could contribute to poor performance. The KNEC report (2000b) has advised teachers to break down the complex language contained in mathematical concepts to a language that students can comprehend. It argues that one of the principle problems of language in mathematics is that meanings to be conveyed are often complex. The reason being, English words take different meanings when used in different contexts.

Further, teachers have difficulty in communicating mathematical ideas or even simple instructions to students because they have difficulty in comprehending the mathematical language. Consequently, in order for the teacher to communicate with the learner well, a good command of language is very important. Students' perception of mathematics and the environment in which it is learnt might be negatively affected by the teacher's approach in presenting the subject matter. In addition, Githua (2002) argues that the sentence structure, length and unfamiliar symbols and terminologies make mathematics textbooks difficult to read and comprehend. Thus, the foregoing discussion suggests that there is an inadequate understanding of both the English language and the mathematical language as used in mathematics instruction

Language of Instruction

Research by Keraro, Okere and Mondoh (2004) shows that language interferes with science learning, especially when English is used as a medium of instruction to second language users. Thijs and Van den Berg (1995) and, Ramorogo and Kiboss (1997) have argued that cases where English has been used in teaching science, teachers and learners need to have a good command of the English language for meaningful learning to take place.

This is in agreement with Tobin (1995) who says that learners with limited proficiency in the use of English often face enormous challenges of making sense of instruction while at the same time building an understanding of science. He further alludes that science is a form of discourse that incorporates a language characterised by concepts and facts, ways of providing knowledge claims and ways of communicating what is known among participants in a community. This suggests that ordinary English may not be the best medium for science instruction. This is because English words take different meanings when used in different contexts.

Arguably, learners' meaning of some words is different from that of scientists. In some cases, pupil's meanings are narrower and confined to meanings often used in their everyday language. Elsewhere, studies show that any language could be used for instruction. Rutherfold and Nkopodi (1990) reported that the use of English enhanced the recognition of science concepts. Conversely, Rolnick (1990) reported that the use of mother tongue (Siswati) rather than English facilitated the learning and expression of science concepts among Swazi students. In Kenya, studies (Bunyi 1994) reveal that the use of Mother Tongue for teaching **and** learning mathematics has a positive effect on enhancing students' acquisition of concepts and performance.

However, based on the school language policy in Kenya; that language **of** instruction is language of catchment area at lower primary renders such findings inapplicable at the secondary school level. Indeed, learners tend to construct their knowledge by observing others and co-participation in a community (Roth, 1995). Given the multilingual and multicultural classrooms currently characterising most schools in Kenya, language is a formidable constraint if learners who **do not** understand the English language are expected to construct and participate in **the** classroom mathematics activities. Perhaps a socialized mathematical language could enhance student understanding of mathematics in Kenya.

Language of Mathematics

Mathematical language appears to pose a problem to students and teachers in **the** process of teaching and learning. The vocabulary of mathematics includes **words** and symbols that have multiple meanings. Consequently, pupils often fail to interpret these words and symbols as teachers intend them. Therefore understanding of mathematical words in prose seems to be a major **problem.** Lawing (1983) however asserts that, in order to translate a sentence into **a** mathematics problem, one needs to know what the words in the sentences **mean.** He argues that most problems are not difficult to solve when written in mathematical terms but the difficulty arises when the problem is stated in prose.

Copeland (1984) claims that whatever you say to mathematicians, they translate it into their own language and forthwith it becomes something different. He argues that the transfer of what has been learnt in one problem situation to another is important and necessary in understanding mathematics because such cognitive structures as seriation, conservation, commutatively and transitivity are basic parts of many mathematics problems.

This means that words are probably not a shortcut to understanding because **when a** student comes across word problems in textbooks and examinations, which **test** application and generalisation, the stimulus is not readily apparent. Hence **finding** the appropriate response of the problem becomes difficult to some students **while** others, who have developed some working procedures and processes on their **own,** tackle them with success.

Results, Discussions and Conclusions

Results

The Effect of the SML Module on Students' Achievement

The main objective of the Mathematics Achievement Test (MAT) was to ascertain whether or not there was a significant difference between the students' understanding as measured by their knowledge and skill performance. Section A was concerned with assessing students' knowledge in statistics. The hypothesis tested was whether the SML module had significant effect on students' achievement in statistics. The results obtained are summarised in Table 3.

Table 3: Comparison of the mean pre-test and post test scores and standard Deviations obtained by student on section A of the MAT

Scale	Overall		Group		
Pre-Test	38.71	38.93a	-	38.49a	-
SD	8.99	9.45	-	8.53	-
POST-TEST	71.73	77.80b	77.10b	65.30c	66.70c
SD	11.35	10.84	11.32	11.40	11.84
MEAN GAIN	33.02	38.87	-	26.81	-

a, b, c denotes similar mean scores

Table 3 shows that the post-test mean scores for groups El and E2 and that of CI and C2 respectively, are quite similar. On overall, the groups mean gain on student's achievement in knowledge of statistical concepts was 33.54. However, the mean gains for group El (38.87) was significantly higher (by 12.06) than that of group C1 (26.81). This suggests that the experimental group gained more than the control group. In order to determine whether the difference in mean scores was significant, a one way ANOVA was performed. Table 4 summarises the results of the ANOVA.

Table 4: Results of One-ANOVA of the post-test scores of the groups on section A of the MAT

Source	D.F	SS	MS	E-ratio	P-Value
Between Groups	3	623.88	207.96	7.46*	**0.00**
Within Groups		153	4265.16	27.88	
Total			**156**	**4889.04**	

• Denotes significant mean difference at $P<0.05$ (F tabulated 3.153=2.67; F computed=7.46)

The results in Table 4 reveal that the differences in the post-test scores in section A of the MAT are statistically significant for the experimental and control groups. However this analysis does not show the direction of the difference. In order to determine where the mean score difference lie and the direction of the difference, a post hoc multiple comparison test for an independent sample t-test was performed and the results obtained are reported in Table 5.

Table 5: Results of Independent Sample t-Test of Post-Test Mean Scores Obtained By the Groups

Groups	DF	t-Value	2-Tail	C-Value
EI. vs E2	69	0.12	0.27	1.99
EI.vs. CI	72	2.74*	0.86	1.99
El. vs ,C2	85	3.54*	0.01	1.99
C I. vs. C2	83	0.45	0.66	1.99
CI. vs. E2	67	2.32*	0.00	1.99
CI. vs. C2	82	3.93*	0.26-	1.99

*** Denotes significant at p<0.05**

The t-test analysis reported in Table 5 reveals that the mean scores obtained by the students within the treatment groups (El & E2) and control groups (CI & C2) respectively were not statistically different. However, there were significant differences between the mean scores of the experimental groups and control groups such that the mean scores obtained by the treatment groups were significantly higher than those in the control groups.

A comparison of the post-test mean scores 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 farther analysis of the difference using Turkey's - Honest significant Difference (THSD) test also revealed the following trend: E1+E2>C1=C2, thus suggesting that the students who were exposed to the SML Module out-performed those who were not exposed to it in section A of the MAT.

Considering the results presented in Tables 3,4 and 5, it was found that the post-test mean scores obtained by students in Groups El(77.80) and E2(77.10) were not significantly different at P=0.05. Also the mean scores of groups C1 (65.30) and C2(66.70) are not different. However, the mean scores obtained by the students in groups El and C!, El and C2, E2 and C1 and, E2 and C2 are significantly different at p<0.05. In addition, the t-values confirm that the difference between the means obtained by students in the treatment groups and those in the control groups in section A of the MAT is statistically significant. In view of these findings the null hypothesis suggesting that the SML module has significant effect on student's achievement in statistics is rejected.

The Effect of the SML Module on Students' Skill Performance

Section B of the MAT was developed to ascertain whether or not there was a significant difference between the students' skill performance before and after the commencement of the topic statistics between the students exposed to the **SML** module and those not exposed. This was meant to test the hypothesis that the **SML** module has no significant effect on students' Skill performance in statistics. The results on students' skill performance are reported in Tables 6, 7 & 8. The interpretations are made below each table.

Table 6: Comparison of the Means & Std. Dev. of Pre-test and Post-test Scores obtained by students on Section B of the MAT

Scale		Overall			Group
		El	E2	C1	C1
PRE-TEST	21.80	22.38a		21.27*	
S.D.	2.78	2.77		2.45	
POST-TEST	73.48	78.65b	77.28	69.22*	68.75*
S.D	6.15	3.95	3.25	4.32	4.17
MEAN GAIN	51.62	56.27	.	48.00	.

*** abc denotes similar mean scores**

Results in Table 6 show that the pre-test mean scores obtained by the students' in group El(22.38) and C1(21.27) were similar before teaching the mathematics topic on statistics. After the exposure to the topic, the students in the experimental group scored a higher mean score El (78.65) than those in groups C1 (69.22) and C2 (68.75). Similarly, Group E2 scored a higher mean score (77.28) than those in groups C1 and C2. The mean gain of statistical skills for group El (56.27) and for the whole group (51.75) were both higher than that of group C1 (48.00).

This suggests that there were differences in the mean scores obtained between the experimental groups (El &E2) and control groups (C1& C2); implying that the skill performance of the students in the SMI. treatment groups was better than those in the control groups. In order to establish whether the differences were significant, a one-way ANOVA was done. The result as summarised in Table 7.

Table 7: Results of ANOVA of the Post-Test Scores of students on Skill performance

Source	DF	SS	MS	F-value	P-value
Between Groups	3	1065.36	355.12	9.1 1*	0.05
Within groups	153	5966.07	38.99		
Total	**156**	**7031,43**			

Means significant at p<0.05

From the results in Table 7, the F-value (F3, 153=9.11, p<0.05) indicates that the mean scores of the groups were significantly different. However, this analysis does not show the direction of the difference. In order to determine the direction of the difference, the independent samples t-test was performed and results obtained are reported in Table 8.

Table 8: Independent Sample T-Test of Post - Test Mean Scores on Students' Skill Performance

G roups	DF	t-VALUE	2-TAIL SIG	C-VALUE
El vs E2	69	0.33	0.75	1.99
El vs C1	72	3.58*	0.86	1.99
El vs C2	85	3.06*	0.96	1.99
CI vs C1	83	0.12	0.15	1.99
CI vs E2	67	3.54*	0.77	1.99
El vs C2	82	3.80*	0.67	1.99

* Significant at $p>0.05$

Table 8 reveals that the mean scores obtained by the students in the experimental groups were significantly different from and higher than those in the control groups. A comparison of the post-test t-values of t (1, 72 = 3.58), t (1,85=3.06), t (1,67=3.54) and 1,82 = 3.80) at $p<0.05$) level were obtained. A further analysis of the difference using THSD test also confirmed the trend E1=E2>C11=C2 at 0.05 level. This implies that the students who were exposed to the SML module performed better in section B of the MAT than those not exposed.

From the results presented in Table 6,7 and 8 it suffices to say that the post-test mean scores of the experimental groups (El=78.65 & E2=77.28) are not statistically different at p=0.05. Also the mean scores of the control groups (CI =69.22 & C2= 68.75) are not statistically different at the same level. However, there is a statistically significant difference between the experimental groups and the control groups at p=0.05 level, where the former scored significantly higher values than the latter. In addition, the t-values confirm that the difference between the mean scores obtained by the students in experimental and control groups on skill performance statistically significant at 0.05 level. In view of the foregoing presentation and interpretation of the results on skill performance, the null hypothesis indicating that the SML module has no significant effect on students' skill performance in statistics is rejected.

The Effect of SML Module on Students' Perception of Their Mathematics Learning Environment

The aim of the Sudents' Perception Questionnaire (SPQ) was to ascertain whether or not there was a significant difference between the mathematics learning environment before and after the topic "statistics" between the students exposed to the SML module and those not exposed. The null hypothesis tested was that the SML module has no significant affect on students' perception of their learning environment. Table 9 shows the mean scores on students' perception as measured by the SPQ.

Table 9: Comparison of Mean Scores & Std. Dev. of Students' Perception as Measured the SPQ

Scale	Overall	Groups			
		E1	E2	C1	C2
PRETEST	56.56	56.78a	—	55.94a	—
SD	9.61	8.74	—	10.48	—
POST-TEST	74.18	78.49b	76.41b	70.31b	71.52c
SD	8.43	8.09	8.12	8.38	9.13
MEAN GAIN	17.82	21.71	—	14.37	—

a,b,c, denotes similar mean scores.

An analysis of the results in Table 9 reveals that the pretest mean scores of E1 and CI and the post-test mean scores of group El and E2 and, C1 and C2 respectively are quite similar. However, the mean gain for group El (21.71) was higher by 7.34 points than that of group CI (14.37). Overall, the mean gain on the SPQ was 17.82. Hence, the former group is closer to the overall mean gain for the whole group than the later. The results suggest that the perception of the students in the treatment groups on SPQ was different from those in the control groups (E1=E2>C1=C2). A further analysis of the post-test mean scores using the ANOVA gave the following results.

Table 10: Results of ANOVA of the Post-test Scores on the SPQ

SOURCE	DG	SS	MS	F-RATIO	P-VALUE
BETWEEN GROUPS	3	1806.11	602,04	5.90*	0.001
WITHIN GROUPS	153	15503.50	102.10		
TOTAL	**156**	**17309.61**			

*Means significant at p<0.05

The result in Table 10 confirms that the mean scores between the groups on the SPQ differ significantly at p<0.05 level. However, the results do not show the direction of the difference. In order to determine the direction of the difference, an independent samples t-test was performed. Table 11 suggests ;he possible difference and direction of the difference.

Table 11: Results of the Independent Samples t-test

Group	DF	t-value	2 TAIL SIG
El vs E2	69	0.32	0.42
El vs C2	72	4.38*	0.00
E2 vs C2	85	4.77*	0.00
Cl vs C2	83	0.56	0.12
Cl vs E2	67	2.47*	0.75
E2 vs C2	83	2.48*	0.45

- Means significant at p<0.05.

An examination of the results in Table 11 reveals that the t-values of El and E2 (t=0.32) and that of CI and C2 (t=4.77), CI and E2 (t=2.47) and E2 and C2 (t=4.38) indicate statistically significant difference in the post test mean scores on SPQ in favour of the treatment groups. A further analysis of the difference using the THSD test also confirmed that E1=E2>C1 = C2 at 0.05 level.

From the foregoing presentation, it can be noted that although El and C1 groups were pre-tested, there post-test mean scores are not significantly different from those of E2 and C2 respectively. This means that the pre-test did not exert any impact on the post-test mean scores of the SPQ. Therefore, the significantly higher mean scores obtained by the treatment groups compared to the control groups were due to the SML module rather than chance. Therefore, the null hypothesis indicating that the SML module had no significant effect on the students' perception of their learning environment is rejected.

The Effect of the SML Module on Classroom Interaction during Mathematics Lessons

The purpose of the mathematics classroom observation schedule (MACOS) was to assess lessons of the experimental and control groups during class instruction on the topic statistics. Data on student - teacher student and material interaction were collected from at least three lessons taken from each of the SML and regular classroom respectively. The hypothesis tested was that the SML module has no significant effect on classroom interaction during mathematics lessons. The frequency of the classroom activities observed in this study was calculated as a percentage and the results are reported in Table 12.

Table 12: Comparison of Teachers' and Students Activities during Mathematics Lessons in Statistics by Percentage

Category	Groups			
	El	E2	CI	C2
Teacher activity	9.9	10.8	5.8	5.4
Reinforcing behaviour	6.3	6.2	11.3	10.2
Giving directions	9.6	9.4	6.9	5. 8
Supervises activities	6.6	6.6	6.8	6.9
Asks questions	4.8	4.2	9.9	8. 4
Guides/demonstrates skill	3.1	3.6	10.8	9.2
Explains concepts and skills	40.1	40.8	45.5	44.9
Total				
Student Activity				
Responds to questions	9.5	9.2	7.6	6.9
Follow instruction	8.4	8.7	11.8	10.9
Initiates classroom talk	7.2	8.4	4.7	4.6
Asks questions	12.7	10.6	3.2	3.4
Writes or copies notes	7.1	7.4	1.2	7.7
Expresses agreement	9.1	8 8	12.4	11.8
Periods of silence inactivity	1.6	1.3	5.8	5.9
Consults other students	4.2	4. 8	1.8	2.9
Total	59.9	59.2	54..5	56.9

Table 12 shows the classroom activities observed during the class instructions. The table suggests possible similarities and differences between the teachers' and students activities in the experimental and control groups. It indicates that on overall, the teacher in groups El and E2 did less of the class activity as compared to groups C1 and C2. On the other hand, the students in El and E2 as compared to C1 and C2 dominated the classroom activities.

However, in order to ascertain whether there were differences in interaction patterns during the mathematics activities observed in the lessons, the frequencies obtained were transcribed into a score. The scores for each classroom lesson observed in each group were then used to determine whether the SML augmented classes differed from the regular classes in the way teachers and students interacted in a normal classroom setting. Table 13 shows the respective means and Standard deviations for the groups.

Table 13: Means and Standard Deviation Obtained By Groups on MACOS

SCALE	E1	E2	CI	C2
MEAN	76.75a	75.04a	61.88b	61.38b
SD	11.07	10.78	9.30	8.28

a and b denote similar mean scores

Table 13 compares the mean scores obtained by the groups on MACOS. A close examination of these results indicates higher mean scores for treatment groups than for control groups. Also, the mean scores between the treatment groups (El =76.75

& E2 = 75.04) and the control groups (C1 =61.88 & C2 = 61.38) are not similar unlike within the groups. The treatment groups have similar results due to the same SML treatment to which they were exposed. In order to ascertain the significance of the difference between the groups, a one-way ANOVA test yielded the results summarised in Table 14.

Table 14: Resuts of ANOVA of the MACOS Mean scores

SOURCE	DG	SS	MS	F-RATIO	P-VALUE
BETWEEN GROUPS	3	63.15	21.05	5.95*	0.00
WITHIN GROUPS	14	49.59	3.54		
TOTAL		17	112.74		

*** Significant at 0.05 level**

Result of the ANOVA indicate the F-value to be significant at $p<0.05$. This means that the mean scores obtained by the SML treatment and Control groups were statistically different. However, the ANOVA test does not show the direction of the difference. As such, an independent samples t-test was performed and the results reported in Table 15.

Table 15: Results of Independent Samples t-test of Post-test Mean scores obtained on MACOS

Group	DF	t-value	SIG
El vs E2	69	0.34	0.50
El vs C2	72	7.43*	0.00
E2 vs C2	85	8.62*	0.03
C1 vsC2	83	0.51	0.76
C1 vs E2	67	6.54	0.00

*** Denote Significant at p<0.05**

Table 15 confirms where possible differences and the direction of the differences are. It shows that there are differences between the experimental and control groups which are significant. There are however no significant differences within the experimental and control groups. Similar results were obtained using the Turkey Honest Significant Difference (THSD) test revealed the following trend: CI = C2<E1=E2 at 0.05 levels. This suggests that the SML programme had similar effects on both experimental groups.

From the foregoing presentation and interpretation, the significantly higher mean scores obtained by the treatment groups as compared to the control groups was due to the SML treatment. Therefore, the null hypothesis indicating the SML module has no significant effect on classroom interaction during the mathematics lessons is rejected.

Discussion

There were four hypotheses set for this study. For all the hypotheses, the findings of this study are in the affirmative of a significant effect of the SML module. The findings are in favour of the students exposed to the SML module. The inferential statistics have revealed that there were differences between the mean scores obtained by the students in the SML treatment groups (El & E2) and those of the control groups (C1&C2) that were statistically significant. Therefore the results show the effect of the SML in engendering cognitive, affective and psychomotor gains.

The SML module developed for teaching and learning the topic 'statistics' in mathematics was found to be readable, understandable, clear and simple in presenting statistical concepts and skills on the part of students. Teachers on the other hand found the module to have clear and elaborate lesson notes that were simplified for students understanding even on their own. This implies that the module succeeded in simplifying the language used in presenting mathematical concepts and skills in the topic 'statistics'.

It was further established that students exposed to this module acquired the needed knowledge, concepts and skills. This can be inferred from the higher mean gains obtained on all the dependent measures by students exposed to it as compared to those not so exposed. On achievement, the results show a positive influence on students' knowledge and skill performance in favour of the module. This is an indication that SML module had an effect on students' understanding of the topic "statistics".

Nonetheless, the results indicates that the SML learning environment was conducive for meaningful learning. The students' perceptions show a significant difference between the SML and regular learning environments. This is the reason why students in the treatment groups had significant learning gains unlike those in the control groups. The higher mean scores in the students perception scores in favour of the treatment groups confirm that the SML module had an effect on students' perception of their learning environment.

The learning environment provided in the 'SML' classrooms facilitated mutual interactions during the lessons in the topic statistics. This follows from the tabulated results and narrations reported earlier. Specifically, the SML module provided appropriate opportunities for interpersonal communication and relationship. Both the quantitative and qualitative results ascribe the effect of the SML module on classroom interactions during mathematics instruction.

From the teachers' evaluation of the module, there is no gender bias in treatment groups. Both boys and girls had equal opportunities to participate in the lesson activities. On the whole, the foregoing suggests an effect of the SML module on students, understanding of mathematics and perception of their learning environment.

The teacher's role in the lesson is a major determining factor of the classroom environment. According to Ramorogo and Kiboss (1997), meaningful learning often develops best in classroom environments that give students more opportunities for more participatory interaction. Perhaps, this is the reason why the teacher in the SML treatment groups provided more student participation opportunities as seen in table 16 and the subsequent narration in the excerpts. This is in agreement with Kiboss (1997; 2000) who found a strong relationship between the nature of the condusive classroom environment and the acquisition of the necessary knowledge and skills.

This study has shown the interactiveness of the lesson components. Contrary to earlier studies in Kenya which indicate that some students have greater interaction with their teachers than do others (Sanga 1982), the findings of this study have placed all the students on the same level i.e. all the students in the classroom (irrespective of their gender) have equal opportunities to interact and participate fully in the lesson(s). In addition, the results have shown that teachers have to explain terminologies and phrases used in the subject.

The KNEC reports (2000b; 2000c) have made similar views whereby they advise teachers to break down the complex language contained in mathematical concepts to simple language that students can comprehend easily. Indeed, studies have shown that collaborative socialization during the teaching and learning process is critically important in students, performance (Johnson & Johnson 1991; Kiboss 1997; 2000; Kirembu 1991).

Conclusions and Recommendations

Conclusions

The following conclusions have been reached from the analysis of the data presented in the previous chapter. First and foremost, the pre-test mean scores of El and CI were identical while their post-test mean scores with respect to MAT, SPQ and MACOS were statistically different. However the post-test scores within the experimental groups (El & E2) and control groups (C1 &C2) respectively regarding the same variable were quite similar. Although El and C1 had an increase in the post-test mean scores, there were higher increase realized in El that were similar to E2 denied the pre-test. The increase in the mean score of the C1 that was similar to C2 was as a result of exposure to the content. Therefore, the pre-test did not have any effect on the post-test. Hence, the difference in the posttest mean scores of the treatment and control groups is attributed to the SMI. treatment.

Secondly, there were significant learning gains obtained by the students exposed to the SML module on both sections of the MAT instrument as compared to the low learning gains obtained by those students not exposed to the SML treatment. Unlike the mean scores of the two treatment groups El and E2, the mean scores of the control groups C1 and C2 were similar and significantly different from those of the former with respect to MAT, SPQ and MACOS measures.

In contrast to the subjects in control groups (C1 &C2), the students' perception of their learning environment as measured by SPQ in the treatment groups **(E1** & E2) was quite encouraging. Similar conclusions are reached regarding the Students, participation as observed during the lessons. It has been concluded that the teacher in the regular classroom tends to dominate the classroom activities and talks whereas in the SML augmented classes, the students tend to dominate both the classroom activities and talks. In addition, the SML module affected the students' understanding of mathematics and their perception of the learning environment by engaging them in interactive Endeavour's that resulted in their self-actualisation and subsequent ownership of the lessons. Indeed both quantitative and qualitative data have shown that the SML enhanced the students' interpersonal communication and interaction.

Furthermore, the effect of gender and age did not seem to exert any significant influence on the students' knowledge, perception and interaction in the topic statistics. An analysis of the TEQ suggests that the SML provided equal opportunities for both boys and girls to collaborate, support and interact together. The teachers' role was shifted from the role of transmitter of knowledge to that of a facilitator in the teaching-learning process.

Recommendations

Based on the findings and conclusions, the study recommended that the SML approach be adopted for mathematics instruction in Kenyan secondary schools. This follows from the significant learning gains obtained by students exposed to the SML module. Teachers should explain the terminology and symbols in mathematics, as opposed to their usual meaning in English. Although the MoE and KNEC has formally recognised that there is a language problem in Mathematics Education, there is need to familiarise teachers, students, authors and publishers on the usefulness of popularising the use of SML as a teaching and learning strategy.

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