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Effect Of Problem-Solving Teaching Approach On Secondary School Students' Perception Of Mathematics Classroom Environment In Vihiga County, Kenya

Dr. Ronald Ellumbe Mutange

B.Sc (Mathematics & Computer Science),
PGDE (Mathematics & Computer Education), M.Ed (Science Education),
PhD (Mathematics Education); Post Doctoral Fellow - Department of Science and Mathematics Education,
Masinde Muliro University of Science and Technology, Kakamega, Kenya

***Abstract:** The purpose of this study was to determine the effect of using Mathematical Problem-Solving (MPS) teaching approach on secondary school students' perception of the mathematics classroom environment in Vihiga County. A non-equivalent control group design under the quasi-experimental research was used to compare experimental and control groups drawn from Vihiga County. Mathematics Classroom Environment Questionnaire (MCEQ) and Classroom Observation Schedule (COS) were used to collect data from 146 Form Three students. Reliability of the instruments was established using Cronbach's Coefficient alpha formula and they were accepted as reliable at 0.7 and above. Validity of the instruments was established through expert judgment by the mathematics education faculty members. The students were randomly assigned in their intact classes to four groups namely; experimental groups 1 and 3 and control groups 2 and 4. All the groups were taught the same content of the topic Commercial Arithmetic in mathematics. However, groups 1 and 3 were taught by the MPS teaching approach while groups 2 and 4 were taught using convectional teaching approach. Groups 1 and 2 were pre-tested prior to the implementation of the MPS treatment. At the end of the topic, all the four groups were post-tested using MCEQ. Both qualitative and quantitative data were generated and hence both descriptive statistics and inferential statistics were used for data analysis and hypothesis testing. The results showed that increased students' learning and better perception of the classroom environment occurred among students where MPS teaching approach was used. The study concluded that MPS is an effective teaching approach. It was helpful in enhancing the teaching and learning of mathematics, facilitated in making the subject easily understandable to students, and improved the perception of their classroom environment and consequently their performance in the subject. It was therefore recommended that mathematics educators should encourage mathematics teachers to use it and teacher educators to make it part of the teacher-training curriculum. A study on the effect of MPS teaching approach on students' perception of the classroom environment in boys' only and girls' only classes would expound the understanding of the current study.*

***Keywords:** Problem Solving Approach, Students' Perception, Mathematics Classroom Environment.*

I. INTRODUCTION

A. BACKGROUND INFORMATION

Mathematics is one of the core subjects in the Kenya Secondary School Curriculum and it is an examinable subject for all students (Republic of Kenya, 1999). A lot of importance is attached to the subject by the society. This could be because mathematics as a tool finds its application in our daily lives at home, in the office, science, engineering, commerce, technological development and research. Since it is an important utilitarian subject, good mastery of mathematics

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implies effective learning of other science disciplines (Cockroft, 1982; Mutunga & Breakel, 1992; Mondoh, 1995). Githua (2002) posits that the subject is both academically and vocationally important for both males and females while Costello (1991) underscores that competence in mathematics is looked upon as a guarantee to career opportunities and good life.

Despite the aforementioned applications and importance of mathematics in everyday life, students have consistently performed poorly in the subject. This is evidenced through the mass failure at national examinations in the subject in the Kenya Certificate of Secondary Education (KCSE) examination results (Kenya National Examination Council [KNEC], 2010) as shown in Table 1.

Year	Mean Score (%)
2006	38.08
2007	39.46
2008	42.59
2009	42.26

Source: Adapted from KNEC (2010) Report

Table 1: Summary of KCSE National Mean Scores from 2006 to 2009 in Mathematics

From the statistics shown in Table 1, the mean score figures indicate that there was significant improvement in the overall mean score in the year 2008 compared to the previous years. However, the general performance in the subject is still poor as depicted by the low mean scores.

An analysis of the KCSE examination question papers indicates that questions on Commercial Arithmetic keep recurring year after year yet no remarkable improvement has ever been realised in terms of student performance in the topic and hence the general poor performance in mathematics (KNEC, 2006-2009). This in a way suggests that students have a problem in this topic. It is however important that students perform well in this topic since Commercial Arithmetic gives useful information applied in our daily life at home, in science, accounts, commerce, geography, industry, technological development and research. The topic is covered in Form One and Form Three in the mathematics syllabus (KIE, 2006). Thus, Commercial Arithmetic is applicable in our daily life, studied in the Forms One and Three mathematics' syllabus and examined in the KCSE mathematics examinations.

There is evidence that there is an instructional problem in mathematics and therefore, students have problems in conceptualisation of the learned knowledge and skills in the topic Commercial Arithmetic (Eshiwani, 1984; Changeiywo, 2001). The poor performance depicted by students in this topic portrays inadequate understanding of concepts in it. This is due to the poor instructional approaches used in teaching mathematics (Eshiwani, 1975; Mondoh & Yadav, 1998).

Eshiwani (1975) reported that girls scored higher on achievement tests when taught by use of Programmed Instruction (PI) method and Integrated Programmed Instruction (IPI) method, as opposed to boys who scored higher on achievement tests when the method of instruction was the Conventional Classroom Approach (CCA). Consequently, Eshiwani (1975) concluded that the method of instruction is an important influence on achievement and retention. Moreover, students' values, interests and behaviour are affected by the way the teachers handle the teaching and learning process (Oloyende, 1996).

Problem Solving Approach (PSA) has been widely accepted as the way to teach vocational agriculture. On effects of level of PSA to teaching on students' achievement and retention, Boone (1990) found that students' level of achievement and retention was highest when PSA to teach was used. In the same study, Boone found that for high level cognitive items, students taught by PSA exhibited lower achievement loss than those taught by subject matter approach. In an earlier study, Boone (1988) found that high school agriculture students taught using PSA first in an instructional series had higher achievement scores than those taught first using a subject matter approach. Consequently to achieve effective learning and good performance in mathematics, the topic of Commercial Arithmetic need to be taught using student-centred approach. Zechariah (2010) contends that instructional methods employed by the teacher play a significant role in the acquisition of skills and meaningful learning. Instructional methods such as lecture make students become passive and have less interaction with each other in doing tasks. Changeiywo (2001) asserts that the lecture method adopted in schools makes students to be isolated from one another, leading to low self-concept and a high failure rate in sciences and mathematics. Changeiywo is of the view that positive changes take place when a teacher changes the teaching method toward a more student-centred approach. Consequently, an alternative method for the delivery of mathematics knowledge is PSA.

According to Mangle (2008), PSA involves students working in small groups to achieve a common goal, under conditions of positive interdependence, individual accountability, appropriate use of collaborative skills and face-to-face interactions. PSA is the instructional use of small groups through which students work together to maximize their own and each others' learning. Problem solving has its foundation in social-constructivist perspectives of learning. In this approach, the classroom environment is characterized by co-operative tasks and incentives structures and by small group activities. It can be used to teach 'hard' topics in mathematics and also help teachers to accomplish important social learning and human relations goals.

PSA has been shown to lead to improved achievement in mathematics to senior students and those in colleges. Samuelsson (2008) found that Mathematical Problem-Solving (MPS) teaching approach is more effective than the conventional methods in the academic success of students and it enhances their mathematics self-concept. Segzin (2009) reported that in MPS sessions, students tend to enjoy mathematics, and this enjoyment motivates them to learn. Several researches on PSA have been on senior students and those in colleges in the Western environment. Hence, it was less clear whether PSA could be successfully applied to secondary school students in other countries in which social, religious, educational, and cultural practices are different from those of the Western countries.

From the foregoing, none of the studies so far sought to find out how Mathematical Problem-Solving (MPS) teaching approach affects students' perception of their classroom environment with an aim of promoting meaningful learning. In an attempt to fill this gap, the current study investigated the effect of MPS on students' perception of their classroom environment in Commercial Arithmetic in secondary schools in Vihiga County.

B. PURPOSE OF THE STUDY

The purpose of this study was to investigate the effect of Mathematical Problem-Solving (MPS) teaching approach on Form Three students' perception of their mathematics classroom environment.

C. OBJECTIVE OF THE STUDY

The specific objective that guided the study was; to determine whether MPS teaching approach has any effect on students' perception of their mathematics classroom environment as compared to the conventional teaching approach.

D. HYPOTHESIS OF THE STUDY

The following null hypothesis was statistically tested:

Ho1: There is no statistically significant difference between the perception of the mathematics classroom environment scores of students who are exposed to MPS teaching approach and those who are not exposed to it.

E. SCOPE OF THE STUDY

The study focused on investigating the effect of MPS teaching approach on students' perception of their mathematics classroom environment in Vihiga County. The study also focused on Form Three students selected randomly from sub-county secondary schools in Vihiga County. Commercial Arithmetic as a topic was the point of focus.

II. LITERATURE REVIEW

Studies have shown that conducive classroom environment is an important determinant of students' achievement in mathematics and sciences (Kiboss, 1997; Wasike, 2003; Wekesa, 2003). Specifically, Wasike found that a condusive classroom environment is vital for good performance in mathematics. Further, Wasike argues that a conducive classroom environment should exist to foster social interactions. This involves reciprocal contacts between the teacher and the learner whose interchange leads to meaningful teaching and learning. The teacher acts as a mediator between the students and the body of knowledge and this may vary from one teacher to another depending on his/her knowledge, experience and attitude.

Thus, it seems prudent that, an effective learning environment is one in which the teaching-learning process varies according to such factors as the role of the teacher, of the learner, and the nature of instructional activities (Kiboss, 1997). Kiboss further argues that student' perceptions about science and mathematics might be negatively affected by the way the teacher presents the subject matter. The arousal and maintenance of attention during instruction process may be achieved by embedding the proper perception of the lesson elements. Kiboss adds that attention is influenced by a variety of factors e.g. the level of student involvement, personal interests and prior knowledge, lesson complexity, novelty and familiarity and pacing.

Moreover, Ndirangu (2000) asserts that teaching and learning materials are inadequate especially for science subjects. This has made teachers resort to theoretical approaches. These approaches have contributed to negative perceptions by learners who view some science subjects as irrelevant and strenuous to learn. As such, the knowledge and understanding of the environmental aspects of the learner in the classroom situation were important for this study.

III. RESEARCH METHODOLOGY

A. RESEARCH DESIGN

The study involved a quasi-experimental research of a non-equivalent control group design. This is because secondary schools classes once constituted exist as intact groups and school authorities do not allow such classes to be broken up and re-constituted for research purposes (Gall, Borg & Gall, 1996). The non-equivalent group, pretest-posttest approach was used to partially eliminate the initial difference between the experimental and control groups (Gibbon & Herman, 1997). The design is the Solomon Four Group Design, which is considered rigorous enough for experimental and quasi-experimental studies. This is because it provides effective and efficient tools for determining cause and effect relationship, besides it provides adequate control of other variables that may contaminate the validity of the study. The design helped to achieve four main purposes: to assess the effect of the experimental treatment relative to the control condition; to assess the interaction between pre-test and treatment condition; to assess the effect of the pre-test relative to no pre-test; and to assess the homogeneity of the groups before administration of the treatment (Borg & Gall, 1989).

Sharma (2002) contends that the non-equivalent control group design is a particular strong quasi-experimental procedure. However, it is important that the groups be as similar as possible and that there be opportunity for both a pre-test and post-test in both the treatment and the control groups.

The quasi-experimental procedure control all major threats to internal validity except those associated with interactions of selection and history, maturation and instrumentation (Gibbon & Herman, 1997). In this study, no major event was observed in any of the sample schools that would have introduced interaction between selection and history. Random assignment of the groups to experimental and control groups was employed to control the interaction between selection and maturation (Borg & Gall, 1989). To control for interaction between selection and instrumentation, the instruments were administered under similar conditions across the schools (Sharma, 2002). Hence, there was reasonable control of the threats to internal validity of the study. The design is shown in Table 2.

Groups	Pre-test	Treatment	Post-test
1	O_1	X (MPS teaching approach)	O_2
2	O_3	C (Conventional teaching approach)	O_4
3		X (MPS teaching approach)	O_5
4		C (Conventional teaching approach)	O_6

Source: Adapted from Gibbon and Herman (1997)

Table 2: Solomon Four-Group Experimental Design

In this design, subjects were assigned randomly to four groups. Groups 1 and 3 received the experimental treatment (X) that was the use of MPS teaching approach in teaching. One experimental group (Group 1) received a pre-test (O_1) whereas Groups 2 and 4 received treatment (C) (teaching using Conventional teaching approach). Control Group 2 received a pre-test (O_3) and finally all the four groups received post-test (O_2, O_4, O_5 & O_6). The research design is a combination of two group designs, the post-test only and the pretest-posttest which control extraneous variables of testing, history and maturation (Gibbon & Herman, 1997).

B. POPULATION

The target population consisted of Form Three students from public schools in Vihiga County. The County has 114 schools: 2 national schools, 10 county schools, 97 sub-county schools and 5 private schools. Sub-county co-educational day schools were selected. This is because there are more sub-county co-educational day schools as compared to the other schools types, hence availability of subjects for the study (Education Office Vihiga [EOV], 2010). There were 40 such schools with an accessible population of 5,300 students.

C. SAMPLING PROCEDURE AND SAMPLE SIZE

a. *SAMPLING PROCEDURE*

The sampling frame consisted of sub-county co-educational day schools in Vihiga County. Purposive sampling was used to identify the secondary school type and the class level that formed the study population. However, simple random sampling technique was used to draw four schools out of the accessible 40 schools for this study. This technique was appropriate because it ensured that all schools had an equal chance of being included in the study sample (Mugenda & Mugenda, 2003). Because of the smaller number of schools to sample from, balloting method was employed. This involved assigning a numeral to each of the 40 schools, placing the numbers in a container and then picking a number at random with replacement. Schools corresponding to the numbers picked and having only one stream at the Form Three level were included in the study sample. However, the schools were required to be far apart to avoid interaction between the experimental and control groups.

b. *SAMPLE SIZE*

According to Mugenda and Mugenda (2003), at least 30 students per group are required for experimental research. Four schools were sampled and one stream from each school included in the study sample. Although it was assumed that the average enrolment was forty students per stream, giving the approximate sample size of the study as 160 students, the actual sample size that participated was 163 students. However during data coding, it was found that 17 students had incomplete data. Consequently, it reduced the sample size for data analysis to 146 students. These subjects were used in their four intact classes in the four schools that were randomly assigned to experimental groups 1 and 3, with 34 and 39 students respectively; and control groups 2 and 4, with 30 and 43 students respectively. Table 3 gives a breakdown of the sample size from the four secondary schools.

Group	Number of Students
1	34
2	30
3	39
4	43
Total	**146**

Table 3: Sample Size of the Study

D. INSTRUMENTATION

The instruments used in data collection were; Mathematics Classroom Environment Questionnaire (MCEQ) and Classroom Observation Schedule (COS).

a. *MATHEMATICS CLASSROOM ENVIRONMENT QUESTIONNAIRE (MCEQ)*

This students' questionnaire MCEQ, was adapted from Kiboss (1997). Kiboss developed an instrument to measure the students' perception of the classroom environment in Physics. The instrument was modified to suit this study for data collection on learners' perception of their mathematics classroom environment. It contained 20 structured items which addressed the mode of instruction, time adequacy, learning provisions, instructional materials and teachers' and students' learning activities which were measured on a five point Likert scale. This instrument was pilot tested in one co-educational day school (in Kakamega County) that did not participate in the actual study. Its reliability was determined using Cronbach's Coefficient Alpha method. It was found to have a reliability coefficient of 0.74, which was acceptable for use in the actual study (Borg & Gall, 1989).

b. *CLASSROOM OBSERVATION SCHEDULE (COS)*

A Classroom Observation Schedule (COS) was adapted from Flanders, as cited in Kathuri and Pals (1993) and Kiboss (1997) and modified to suit this study. COS was used to observe some lessons in Commercial Arithmetic for purposes of providing data on teachers' and students' activities during the instructional process. It had two sections: A and B, which provided data on the teachers' and students' activities respectively. This contained eleven teacher related items and thirteen student related items on teaching style, questioning, responding, reinforcement, talk-initiation, silence, organisation and communication skills, among others. Six lecturers from the Department of Science and Mathematics

Education validated the COS instrument before pilot testing for reliability. However, the reliability of the two sections of the COS was ascertained separately using Cronbach's Coefficient Alpha method. Specifically, reliability coefficients of 0.74 and 0.79 were obtained for sections A (Teacher Activity) and B (Student Activity) respectively.

Table 4 gives a summary of the Cronbach's reliability coefficients of the two instruments used in the study.

Instruments	Reliability Coefficients
Mathematics Classroom Environment Questionnaire (MCEQ)	0.74
Classroom Observation Schedule (COS)	
Teacher Activity	0.74
Student Activity	0.79

Table 4: Reliability Coefficients of the Instruments

From the results presented in Table 4, the reliability coefficients got are above 0.70 threshold for acceptable reliability (Fraenkel & Warren, 2015). Consequently, the tools were appropriate for use during data collection in the actual study.

E. DATA COLLECTION

To generate data required for this study, teachers involved in teaching the experimental group were in-serviced for a period of one week by the researcher as pertaining to the requirements and the use of the MPS teaching approach. This period was appropriate because the teachers involved in teaching the experimental groups were trained. MCEQ was first administered to students in the experimental group 1 and the control group 2 for purposes of ascertaining their entry level and homogeneity. Experimental groups 1 and 3 were exposed to a series of 22 lessons in teaching the topic Commercial Arithmetic using MPS teaching approach, while control groups 2 and 4 were exposed to the same using the conventional teaching approach, where learning was mainly teacher centred. In the process, the researcher observed some lessons and tallied the observations in COS. After all the students in this study had completed the topic, MCEQ was administered simultaneously to all the groups. The researcher scored and coded collected data for analysis.

F. DATA ANALYSIS

Data was analysed using both descriptive and inferential statistics. Raw data was analysed using means, standard deviations and percentages. Statistical tests of significance were determined using t-test and Analysis of Variance (ANOVA) at an alpha (α) level of 0.05. The ANOVA was performed to determine the differences in the four means of the post-test scores. An F-test was used to determine whether the differences were significant. When dealing with two means, a t-test was used because of its superior power in detecting differences between two means.

IV. RESULTS

A. RESULTS OF PRE-TESTS

The Solomon Four-Group Design used in this study enabled the researcher to have two groups sit for pre-tests. The aim for pre-testing was to ascertain whether or not the students selected to participate in this study had comparable characteristics before presenting the topic Commercial Arithmetic. To achieve this aim, the students in groups 1 and 2 sat for the pre-test MCE. This made it possible for the researcher to assess: whether there was any interaction between the pre-test and the treatment conditions; the effect of the pre-test relative to no pre-test; and the similarity of the groups before the administration of the treatment (Borg & Gall, 1989).

Table 5 shows the t-test of the pre-test scores on the MCE.

Group 1, N = 34 Group 2, N = 30

Variable	**Group**	**Mean**	**SD**	**t-value**	**P-value**
MCEQ	1	58.32[a]	5.37	1.378	0.17(ns)
	2	56.67[a]	4.05		

[a] denotes similar mean scores ($t_{tabulated}$ 1,62 = 1.96; $t_{computed}$ = 1.378)

Key: ns = not significant at p<0.05 level SD = Standard Deviation

MCE maximum score = 100

Table 5: Independent Samples t-test of the Pre-test Scores on MCE

As shown in Table 5, the pre-test mean scores of both groups 1 and 2 obtained were similar on MCE measure. However, a further analysis of these results was necessary in order to establish whether the mean scores were statistically different at 0.05 α-level. The t-test results analysis reveals that the pre-test mean scores for groups 1 and 2 on MCE measure are not statistically different at 0.05 α-level.

An examination of Table 5 indicates that the pre-test mean scores for groups 1 and 2 on MCE are not statistically different at 0.05 α-level. From the results presented in Table 6, it suffices that the pre-test MCE mean scores of students in the groups 1 and 2 are not statistically different at 0.05 α-level. This indicates that the groups used in the study were comparable and had similar entry behaviour, hence homogeneous. This made them appropriate for the study.

B. EFFECT OF MPS TEACHING APPROACH ON STUDENTS' PERCEPTION OF THEIR MATHEMATICS CLASSROOM ENVIRONMENT

The post-test MCE scores were analysed to determine the effect of MPS teaching approach on students' perception of their mathematics classroom environmental using one-way ANOVA. This was done in order to test hypothesis one (Ho1) that sought to find out whether there was any statistically significant difference between the perception of the mathematics classroom environment of the students who were exposed to MPS teaching approach and those who were not exposed to it.

Table 6 shows the MCE post-test mean scores obtained by the students in the four groups.

Group	N	Mean Score	SD
1	34	89.03[a]	4.29
2	30	58.43[b]	13.93
3	39	87.46[a]	3.99
4	43	57.74[b]	12.71
Total	**146**	**73.11**	**17.98**

[a, b] denotes similar mean scores

Table 6: MCE Post-test Mean Scores of Students in the Four Groups

An examination of the results in Table 6 show that the MCE post-test mean scores for experimental groups 1 and 3 (89.03 & 87.46) and that of the control groups 2 and 4 (58.43 & 57.74) respectively, are quite similar. However, the MCE post-test mean scores for the experimental groups 1 and 3 were much higher than that of the control groups 2 and 4. This indicates that the experimental groups (1 & 3) had higher MCE post-test mean scores than the control groups (2 & 4).

In order to determine whether the difference in the MCE post-test mean scores was significant, a one-way ANOVA was performed. The results of the one-way ANOVA are shown in Table 7.

Source of Variation	Sum of Squares	df	Mean Square	F	P-Value
Between Groups	33264.03	3	11088.01	115.55*	0.00
Within Groups	13626.22	142	95.96		
Total	46890.25	145			

** denotes significant mean difference at $p<0.05$ ($F_{tabulated}$ 3,142 = 2.68; $F_{computed}$ = 115.55)*

Table 7: ANOVA of the Post-test Scores on the MCE

An examination of Table 7 shows that the difference in the post-test MCE mean scores is significant ($F(3,142) = 115.55$, $p<0.05$). Having established that there was a significant difference between the MCE post-test mean scores, it was necessary to carry out further tests on the various combinations of the mean scores to find out where the difference occurred. Table 8 shows the results of the Least Significance Difference (LSD) post hoc comparisons.

	(I) Group	(J) Group	Mean Difference (I–J)	P-Value
LSD	1	2	30.60*	0.00
		3	1.57	0.50
		4	31.29*	0.00
	2	1	-30.60*	0.00
		3	-29.03*	0.00
		4	0.69	0.77
	3	1	-1.57	0.50
		2	29.03*	0.00
		4	29.72*	0.00
	4	1	-31.29*	0.00
		2	-0.69	0.77
		3	-29.72*	0.00

** = The mean difference is significant at the 0.05 level*

Table 8: Post Hoc Comparisons of the Post-test MCE Means for the Four Groups

The LSD post hoc comparisons indicate significant differences ($p<0.05$) between groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4. The differences between the MCE post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 are not significant at 0.05 α-level (Table 8). Since the MCE pre-test mean scores indicated that there was no significant differences between the entry levels of the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA).

Differences in the MCE post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not significant. It is also evident from Table 8, that the MCE post-test mean scores of the control groups 2 and 4 were almost similar and much lower than those of the experimental groups 1 and 3.

The results indicate that:

- ✓ The MCE pre-test did not interact significantly with the treatment conditions. If this were the case, the groups, which took the pre-test, would have obtained different results from those that did not take it (Borg & Gall, 1989).
- ✓ The pre-test MCE did not affect the students in the learning of the content. If this were the case, the students who sat for pre-test would have different results from the others. This made the pre-test suitable for the study (Kothari, 2003).
- ✓ The use of MPS teaching approach resulted in higher students' MCE post-test mean scores than the conventional teaching approach since the experimental groups 1 and 3 obtained significantly higher MCE post-test mean scores.

From the results presented in Tables 6, 7 and 8, it is evident that the MCE post-test mean scores obtained by students in the experimental groups 1 and 3 (89.03 & 87.46 respectively) were not significantly different at p = 0.05. Likewise, the MCE post-test mean scores of the control groups 2 and 4 (58.43 & 57.74 respectively) are not statistically different. However, the MCE post-test mean scores obtained by the students in the groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 are significantly different at p = 0.05. Thus, groups that were taught through the MPS teaching approach had higher MCE post-test mean scores than those that were taught through the conventional teaching approach. Therefore, the null hypothesis Ho1 indicating that there is no statistically significant difference between the perception of the mathematics classroom environment of the students who are exposed to MPS teaching approach and those who are not exposed to it is rejected.

Groups 1 and 2 responded to pre-test and post-test MCE. A comparison of their results is shown in Table 9, which also shows the corresponding paired samples t-test values for each group.

Scale	Overall (N = 64)	Group 1 (N = 34)	Group 2 (N = 30)
Pre-test Mean	57.55	58.32	56.67
Post-test Mean	74.69	89.03	58.43
Mean Gain	17.14	30.71	1.77
df	63	33	29
t-value	7.50	21.23	0.71
p-value	0.00	0.00	0.48

Table 9: Comparison of Pre-test and Post-test Scores in MCE and their Corresponding Samples t-values

An analysis of the results in Table 9 portrays that the experimental group 1 had a higher mean gain (30.71) in MCE than that of the control group 2 (1.77). The experimental group thus gained more than the control group. The paired sample t-test between the pre-test and post-test mean scores was not significant for the control group 2 (t (29) = 0.71, p>0.05). However, the experimental group 1 had a significantly higher post-test MCE mean (t (33) = 21.23, p<0.05). This indicated that the MPS teaching approach significantly improved the students' perception of the classroom environment more than the control condition where results showed no significant improvement in the perception of the classroom environment.

C. ANALYSIS OF TEACHERS' AND STUDENTS' ACTIVITIES DURING MATHEMATICS LESSONS

Classroom Observation Schedule (COS) was used to observe some lessons in Commercial Arithmetic for purposes of providing data on teachers' and students' activities. Data was collected from at least four lessons taken from each of the experimental and control groups respectively. The frequency of the classroom activities observed in the study was calculated as a percentage and the results are reported in Table 10.

Category	Group			
	1	3	2	4
Teacher Activity				
Reinforces behaviour	5.19	5.45	3.19	2.70
Asks question based on students' ideas	2.60	3.47	4.25	4.86
Demonstrates how to perform	5.19	5.95	8.52	10.80
Supervises activities	4.76	4.46	3.72	2.70
Gives directions	3.03	2.97	5.95	4.86
Explains or lectures	1.73	1.49	4.25	4.86
Encourages students to write facts of situation	2.60	1.98	1.06	2.70
Guides and shares in the process of solving problems	2.16	1.98	4.79	3.78
Promotes analysis, organisation and communication skills	4.76	3.96	2.66	3.24
Reviews solutions	3.90	5.45	3.72	3.24
Encourages students to make generalisations	4.33	4.46	3.19	2.70
Total	**40.26**	**41.58**	**44.68**	**46.49**
Student Activity				
Responds to questions	4.33	4.46	3.19	2.70
Follows instructions	15.16	9.91	16.67	16.76
Initiates classroom talks	7.79	8.92	5.86	7.02
Asks questions or seeks clarity over ideas presented	5.19	6.44	1.60	2.16
Expresses agreement or disagreement with action	3.03	2.97	4.79	4.32
Writes and/or copies notes	2.60	2.97	3.19	4.86
Periods of silence/inactivity	0.87	1.49	2.66	3.24
Consults other students	1.73	2.48	1.06	2.16
Identifies key information	4.33	4.95	2.66	2.16
Identifies what to solve	3.90	4.46	2.13	1.62
Makes a plan	3.46	2.48	3.19	2.16
Analyses method of solution	3.90	3.96	3.19	2.70
Constructs many solution processes	3.46	2.97	2.13	1.62
Total	**59.74**	**58.42**	**55.32**	**53.51**

Source: Researcher's computations from classes in the experimental and control groups

Table 10: Comparison of Teachers' and Students' Activities during Mathematics Lessons in Commercial Arithmetic by Percentage

A perusal of the results in Table 10 shows the classroom activities observed during the class instructions. The results suggest possible similarities and differences between the teachers' and students' activities in the experimental and control groups. It indicates that on overall, the teachers in the experimental groups 1 and 3 did less of the class activities (as depicted by 40.26% & 41.58% respectively) as compared to those in the control groups 2 and 4 (as depicted by 44.68% & 46.49% respectively). On the other hand, the students in the experimental groups 1 and 3 as compared to control groups 2 and 4 dominated the classroom activities. This is in evident of 59.74% and 58.42% and 55.32% and 53.51% for the experimental groups 1 and 3 and control groups 2 and 4 respectively. The differences in the teachers' and students' activities obtained by the experimental groups as compared to the control groups were due to the MPS treatment.

V. DISCUSSION

A. RESULTS OF THE PRE-TESTS

This study employed the Solomon Four-Group Design. The students were put in four groups such that groups 1 and 3 were the experimental groups while groups 2 and 4 were the control groups. Groups 1 and 2 took the pre-test while groups 3 and 4 did not take the pre-test. Such an arrangement enabled the researcher to determine the presence of any interaction between pre-test and the MPS treatment; determine the effect of the pre-test relative to no pre-test; determine the similarity of the groups before applying the treatment and generalise to the groups which have not received the pre-test (Sharma, 2002).

Sanders and Pinhey (1979) assert that when the two experimental groups (1 & 3) are similar to each other in the post-test as opposed to the two control groups, then the researcher is in a strong position to attribute the differences to the experimental condition. A greater difference in the post-test between groups 1 and 3 in comparison to that between groups 2 and 4 results if the pre-test interacts with the treatment. This is as a result of a sensitisation effect. The post-test students' perception results in this study did not indicate any interaction between the pre-test and the MPS treatment.

Higher post-test performance by groups 1 and 2 than that of groups 3 and 4 could have been the results if the pre-test provided a practice effect. This is not the case since a comparison of the post-test results of the four groups fails to indicate any practice effect provided by the pre-tests. The results therefore portrayed that the pre-test MCE was suitable for the study.

A comparison of groups 1 and 2 students' pre-test MCE mean scores revealed non-significant differences (Table 5). This results shows that the groups were quite similar before the administration of the treatment.

B. THE EFFECT OF MPS TEACHING APPROACH ON STUDENTS' PERCEPTION OF THEIR MATHEMATICS CLASSROOM ENVIRONMENT

The results of the study reveal that students who were taught through MPS teaching approach achieved significantly higher scores in the MCE than those who were not taught through it. This implies that the use of MPS teaching approach is more effective in fostering students' perception of their classroom environment than the conventional teaching approach.

Costello (1991) opine that students' perception of mathematics and the environment in which it is learnt might be negatively affected by the teachers' approach in presenting the subject matter. Consequently, the teachers' role in the lesson is a major determining factor of the classroom environment. According to Horn (1995), Okere (1996) and Ramogoro and Kiboss (1997), meaningful learning develops best in classroom environments that give students more opportunities for more participatory interaction. It seems likely that this is the reason why the teacher in the MPS treatment groups provided more student participation opportunities as is evidenced by Table 10. This resonates with Kiboss (1997; 2000), Wasike (2003) and Wekesa (2003) who found a strong relationship between the nature of the conducive classroom environment and the acquisition of the necessary knowledge, concepts and skills in sciences and mathematics.

The MPS teaching approach resulted in a conducive classroom environment. The teacher was responsible for restructuring and controlling the mathematics' classroom environment in order to allow the students to work interactively in collaborative groups. This led to improved students' achievement. Thus, this study has shown that the MPS teaching approach results in a better perception of the classroom environment. In view of this, it suffices to point out that the MPS teaching approach should be adopted for mathematics instruction in Kenyan secondary school classes. This is likely to cause a suitable classroom environment that will help students learn collaboratively, leading to improved performance at KCSE mathematics examinations. Hence, MPS teaching approach should be implemented in secondary school mathematics classes.

C. ANALYSIS OF TEACHERS' AND STUDENTS' ACTIVITIES DURING MATHEMATICS LESSONS

A good context for teaching and learning is that in which the teacher and the learner freely interact with, and the concepts to be acquired are simplified (Driver & Bell, 1986; Okere, 1996; Kiboss, 2000). The MPS teaching approach used in this study provided such an environment. The quantitative results indicate that the teacher, besides facilitating the teaching-learning process, structured a conductive classroom environment in which the learners organised meaning on personal levels. This concurs with Okere (1996) and Cooper and Robinson (2002) who contend that the teacher should serve as a facilitator, rather than a sole dispenser of facts as well as lower level cognitive information. In addition, the MPS teaching approach provided adequate opportunities for students' participation and that it fostered the spirit of co-operation. Perhaps this is the reason why the MPS treatment groups out-performed the control groups who were denied the treatment on the dependent measure.

VI. SUMMARY, CONCLUSION, IMPLICATION AND RECOMMENDATIONS

A. SUMMARY OF THE FINDINGS OF THE STUDY

There was one hypothesis set for this study. On the hypothesis, the findings of this study are in affirmative of a significant effect of the MPS teaching approach. The findings are in favour of the students exposed to the MPS teaching approach. The inferential statistics have revealed that there were differences between the mean scores obtained by the students in the MPS treatment groups (1 & 3) and those of the control groups (2 & 4) that were statistically significant. Therefore, the results show the effect of the MPS teaching approach in enhancing the students' perception of their mathematics classroom environment.

The MPS teaching approach for teaching and learning the topic Commercial Arithmetic enabled the students to acquire the needed knowledge, concepts and skills. Further, it was established that the students exposed to MPS teaching approach had a better perception of their mathematics classroom environment. This can be inferred from the higher mean gains obtained on the dependent measure by students exposed to it as compared to those not so exposed.

The results indicate that the MPS classroom environment was conducive for meaningful learning. The students' perceptions of the mathematics classroom environment show a significant difference between the MPS and the conventional classroom environments. The conducive classroom environment seen in the MPS classrooms facilitated mutual interactions during the lessons in the topic Commercial Arithmetic. The MPS teaching approach provided appropriate opportunities for interpersonal communication, interactions and relationship among the boys and girls. This is the reason why students in the treatment groups had significant learning gains unlike those in the control groups. The higher the mean scores in the students' mathematics classroom environment, in favour of the treatment groups, confirm that the MPS teaching approach had an effect on students' perception of their classroom environment.

B. CONCLUSION OF THE STUDY

Results from the study revealed that the MPS teaching approach positively affected the students' perception of their mathematics classroom environment by engaging them in interactive endeavours that resulted in their autonomous learning and subsequent ownership of the lessons.

C. IMPLICATION OF THE STUDY

The performance levels of the control groups have demonstrated the weaknesses of the conventional teaching approach. In contrast to this, the MPS teaching approach proved to be effective in promoting co-operative learning, which forms part of the solution to large classes in the context of inadequate human and material resources. The findings have shown that the MPS teaching approach has the potential of encouraging high student participation in mathematics lessons and problem-solving activities. The MPS teaching approach engendered social interactions that foster a sense of autonomous learning among students than the conventional teaching approach used in this study. Consequently, the MPS teaching approach promoted a conducive classroom environment that enhanced the development and acquisition of mathematical concepts and skills and active student participation.

D. RECOMMENDATIONS OF THE STUDY

Based on the findings and conclusion made in this study, it is recommended that the MPS teaching approach be adopted for mathematics instruction in Kenyan secondary schools. The MPS teaching approach exerted a positive influence on the students' classroom environment in comparison to the conventional teaching approach. This implies that the problem of unconducive classroom environment can be addressed by incorporating the MPS teaching approach in the teaching at the secondary school level. Arguably, the MPS classroom environment can also militate against the teaching-learning needs of both the teacher and the student. Moreover, Teacher Education curriculum developers should include the MPS teaching approach in the training syllabus, thus making it part of the mathematics teacher education curriculum content.

E. SUGGESTIONS FOR FURTHER RESEARCH

The study suggests that the MPS teaching approach can be effective in fostering the students' perception of the mathematics classroom environment. However, there are areas that warrant further investigation such as the following:

- ✓ Studies involving larger sample sizes in terms of the number of participating students, teachers and schools to confirm whether or not the present findings hold.
- ✓ An experimental study should be conducted to determine the effect of MPS teaching approach on students' perception of the classroom environment in boys' only and girls' only classes.

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