



EFFECT OF PROBLEM SOLVING STRATEGY ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CIRCLE GEOMETRY IN EMUHAYA DISTRICT OF VIHIGA COUNTY

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Abstract

The study examined the effect of problem solving strategy on Secondary school students' achievement in Circle Geometry in Emuhaya district of Vihiga county, Kenya. Two research objectives were used in the study to make the investigation. These were: (i) To determine if there is any significant difference in students' achievement when taught using a problem solving strategy and conventional methods, and (ii) To determine students' attitudes towards mathematics when taught using a problem solving strategy and when taught using conventional methods. This study was based on the Constructivist learning theory which originates from works of cognitive scientists like Jean Piaget and John Dewey. Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. According to this theory, learners are the makers of knowledge and meaning. The study was a true experimental research design based on Solomon Four-Fold design. The purpose of the study was to investigate the effect of using problem solving method on secondary school students' achievement in mathematics. Since the poor performance in mathematics is as a result of the decimal performance in the key topics, this study used circle geometry to establish any effect of the method. Two mathematics teachers with equal qualifications, teaching experience and considerably equal teaching potential were selected and trained to teach the two groups. Same lesson plans and worksheets were developed and used along with the direct teaching strategies for both groups. The control group was kept under a control condition by providing traditional competitive situation in class while the experimental group was provided with the Problem solving method as a treatment. The academic achievements of the control and experimental groups were examined through a post-test. In the experimental groups, one group was pretested, treated then post-tested while the other one was only treated then post-tested. In the control groups, one group was pretested then post-tested while the other one was only post-tested. Several implications of the findings are highlighted in the study as reported in this paper. The findings showed that problem solving had a significant effect on students' achievement. It was found out that students taught through problem solving had a better achievement than those taught through the conventional methods. The study also found out that the attitudes of students were positive when taught using problem solving than when taught using conventional approaches. The researcher recommends that teachers should inculcate problem solving skills in their students to help them be better problem solvers in mathematics.

Key words: Problem solving, Achievement, Problem solving strategy, Conventional methods, traditional methods, Attitude. Circle geometry.

INTRODUCTION

Mathematics is a leading logical science upon which other sciences like Chemistry, Physics, Biology and Geography depend. It's considered a basis for social life and the exploration of the entire universe. It has been regarded as an essential part of the Kenyan schools education curricula. In spite of this importance, the performance in the subject in national examinations is still poor compared to other science subjects. This continues to jeopardize the students' post-secondary school career placements since mathematics is heavily

emphasized as a basic requirement. According to the KNEC reports of 2008 and 2009, most students showed inabilities in answering application questions related to some key topics in mathematics. Questions on Circle geometry which constitute 38% of the mathematics curriculum in Kenyan secondary school are the worst performed according to the KNEC reports. SMASSE baseline survey of 2004 holds the same view that KCSE candidates over the last decade show lack of competence in their solutions to questions relating to

circles, chords and tangents and vectors. In 1998, SMASSE INSET programmes for mathematics and science teachers were rolled out countrywide. Despite these initiatives, the performance was still wanting. These two reports informed the government's initiatives to mitigate the problem

Mathematics being a service subject has some considerable influence in future courses or employment opportunities for all students. Poor performance in the subject means that a large number of students are being examined for purpose of selection for further studies and employment opportunities where they may not excel. In spite of this enormous importance, performance in mathematics has not been impressive. This in effect has led to a general perception in some quarters that the teaching of mathematics at secondary school level have not made sufficient effort to deal with the backgrounds and needs of present day students. All the education stakeholders and the general public have expressed a lot of concern about the poor performance in mathematics. Kiragu (1986, asserts that: "Despite national efforts made in developing a curriculum that is responsive to the needs of this country, coupled with teacher training efforts, performance in secondary school examinations have been relatively poor over the last ten or so years and particularly in mathematics".

Besides, despite the concerns raised and efforts made to improve results in mathematics, performance in the subject have continued to be poor over the years. The 2009 KCSE results indicated that out of the 337404 candidates, only 13371 scored A- and above, which constituted only 3.9629% of the total candidature. The results also indicated an 18.1% mean score for girls compared to the boys' 23.63%. The overall mean score for mathematics in 2009 KCSE examination stood at 21.13% (KNEC, 2010). This performance is not good especially for a country gearing for industrialization and realization of Kenya vision 2030. Wasike (2006) observes that mathematics plays a central role in scientific progress and development. Its fundamental role lies in its everyday application in most social sciences and engineering, biological sciences, medicine, military, aerodynamic advancements and household chores.

There is a need to consider remedial methods of teaching quite different from the routine ones. Problem solving method is one such a remedial method that enhances the students' active role in the lessons. In the conventional approaches, problem solving is one of the two broad methods of teaching, the other one being transmission or expository method. In the teaching of mathematics, problem solving have been expanded to include other techniques such as Problem-Based Learning (PBL), cooperative learning, collaborative learning and team teaching. Polya (1957) sees a great opportunity through problem solving instructions for the learner to discover his mathematical talents. He asserts that if the teacher challenges the curiosity of his students by setting problems proportionate to their knowledge and

Helps them solve their problems with stimulating questions, he may give them a taste for and some means of thinking.

This suggests that a properly planned and executed problem solving instruction enables learners to:

- (a) Reflect on their past experiences to determine if the latter can be applied on the present problem situation.
- (b) Support their problem solving actions with evidence or valid arguments rather than anything for granted.
- (c) Consider other possible ways of solving a particular problem.
- (d) Try varying conditions of the problem to see if the same solutions procedures will be required.

It is therefore through problem solving that learners' thought processes can be shared and translated into action, thereby making them develop confidence in their ability to solve mathematical problems. However, if the teacher spends most of the time drilling learners in routine operations, he kills their interest, hampers their acquisition of independent thinking and denies them the opportunity of discovering their talents.

Similarly, Burton (1984) has observed that: The overwhelming importance of problem solving . . . is the opportunity it provides for teachers and pupils to enter into the spirit of enquiry, and through that spirit to establish different styles of teaching and learning.

Through problem solving, learners are exposed to different strategies of solving problems. They become curious to see the nature of solutions they get to challenging problems. With time, the learners are motivated to solve variations of given problems and then more complex problems. This means that learners refine and sharpen their problem solving skills by solving more problems and this forms the basis for future problem solving endeavours. Under the problem solving method of teaching, there are specific strategies that are used during the instruction. These include Problem-based learning (PBL), cooperative learning and collaborative learning, all which embrace learner-centred approaches.

Circle geometry constitutes 38% of the mathematics curriculum and it is the worst performed topic in KCSE mathematics examinations making the overall subject performance very poor. Since the topic involves a lot of applications to real world situations and proofs, it is problem solving method that can best handle the difficult and challenging concepts. The poor performance in the topic have been due to the teacher-centred methods of teaching revolving around lecture methods, speedy syllabus coverage and explanatory approaches keeping the students as mere recipients of knowledge as the teacher remains the dispenser of the same. These conventional methods have been in use since the advent of the teaching practice. Table 1 shows Emuhaya District 2009 KCSE mean scores of selected subjects.

As seen in Table 1, the performance in Mathematics for the period 2007-2009 have been low compared to other subjects. The mean score of 2.170, 2.824 and 3.480 translates to a mean grade of D for the three years,

Table 1: Emuhaya District KCSE Mean Scores of Selected Subjects

	ENG	KIS	MATH	BIO	PHY	CHEM
2009	5.700	6.063	3.480	4.169	4.408	3.506
2008	4.963	5.250	2.824	4.810	4.632	3.884
2007	4.498	4.765	2.170	4.665	4.546	3.809

Source: KNEC, 2009 Examinations Report.

which is far below a mean grade of C+ which is the basic requirement for studying majority of science based courses at tertiary institutions.

In Kenya, the Mackay Report of 1981 recommended a change from 7- 4 - 2 -3 system of education to the current 8-4-4 system of education. This change in the general education system also necessitated a change in the mathematics curriculum. In the 8 - 4 - 4 mathematics curriculum, one of the main focus is on learner centred teaching methods. Teachers are urged to give due attention on these teaching and learning approaches in their planning and teaching.

One of the interventions made to mitigate the recurrent failure in the KCSE mathematics examinations is the Strengthening of Mathematics and Sciences in Secondary Education (SMASSE) project which was launched in 1998. This project was borne out of the need to improve performance in key subjects of mathematics and sciences through national and district In-Service Education and Training (INSET) programmes. In spite of all the changes in the school mathematics curriculum, the creation of more facilities, many years of the SMASSE INSET programmes, performance in Kenya Certificate of Secondary Education (KCSE) have continued to be poor nationally. This implies that the interventions seem to have had little impact and the solution still remains elusive. Several studies conducted in Kenya have indicated the continued use of the traditional methods among secondary school Mathematics teachers (Too ,1986; Kiragu 1986; O'Connor, Kanja & Baba (Eds),2000). For example, Too (1986) in a study of the availability and use of instructional media in Kenya found that the traditional/conventional methods were dominant in most mathematics classrooms. Similarly O'Connor, Kanja and Baba (Eds) (2000) in a survey of SMASSE project reported that whole-class instruction was the dominant approach used by most mathematics teachers in Kenyan secondary school classrooms. They also found out that the main role of the teacher is to dispense knowledge according to traditional form of prescription.

This picture of Mathematics teaching and learning portrayed above contrasts with the recommended methods in mathematics education. Here problem solving is presented as a major theme for the curriculum. This view of the importance of problem solving in mathematics education is parallel with the opinion put forward by several mathematics educators (Lester, 1977; Begle, 1979; Cockroft, 1982). Begle (1979), for example,

is of the opinion that the core of teaching mathematics is problem solving. Official reports such as NCTM (1980), Agenda for Action and the Cockroft Report (1982) recommends the adoption of problem solving approach to the teaching and learning of mathematics. According to the KNEC reports of 2008 and 2009, most candidates exhibit inabilities in tackling application questions related to some key topics in mathematics that are common in the KCSE examinations. Questions on Circle Geometry which constitutes 38% of the secondary mathematics curriculum are the worst performed according to the report.

Strengthening of Mathematics and Sciences in Secondary Education (SMASSE) report in The SMASSE Baseline Survey of 2004 and 2006 pointed out Circle Geometry and Vectors as topics in which a majority of KCSE candidates lacked competence and performed very poorly. The two reports by KNEC and SMASSE informed the government's initiatives to alleviate the poor performance trend by setting up more in-service training sessions, workshops and training of more professional teachers of mathematics. However, despite all these initiatives and awareness, the performance continues to remain poor.

Since the performance in Circle Geometry is the worst hit, it follows that the overall performance in mathematics which heavily relies on the topic cannot be any better. This poor scenario is well pronounced in Emuhaya District of Vihiga county. Despite the above mitigation efforts to reverse the performance trends, the students continue to perform poorly in their national examinations. The many efforts being put in place by individual schools, including remedial, holiday tuition and even early syllabus coverage do not seem to provide a lasting solution. Mathematics teachers have undergone several in-service training and the textbooks resource bases in many schools are commendable. Currently, many teachers complete their syllabus quite on time, thus having an ample time for revision before the national examinations. After all this is done, the performance continues to worry many stakeholders leaving us with the big question, 'why?' As a review of the teaching and learning methodology, this study therefore seeks to investigate the effect, if any, of problem solving strategy on students' achievement in mathematics. As a result, Circle geometry will be used in this study as one such topic which poses the greatest challenge to students and its application of the six levels of cognitive domain; knowledge, comprehension, application, analysis,

synthesis and evaluation.

Purpose of the Study and Objectives

The purpose of this study was to investigate the effect of using problem solving strategy on secondary school students' achievement in mathematics. The study specifically finds out that there are significant differences in students' achievement in mathematics between those exposed to problem solving and those not exposed. Besides, attitudes of students were positive when taught using problem solving and negative when taught using traditional methods. The objectives of the study were to determine if there is any significant difference in students' achievement when taught using a Problem-Solving strategy and conventional methods and determine the attitudes of students towards mathematics when taught using problem solving and conventional methods.

Research Hypotheses

The following two hypotheses were used to test the achievement of the above objectives at an alpha level of 0.05 significance:

HO₁: There is no significant difference in mathematics achievement between students taught mathematics using conventional methods and those taught using problem solving method.

HO₂: There is no significant difference in students' attitudes when taught using problem solving and conventional methods.

The Study Area

The study was carried out in Emuhaya district of Vihiga County, Kenya. The district was chosen as a study area for various reasons. First, there is very little known classroom research particularly on the area of problem-solving in mathematics which have been done in the District. Secondly, performance in mathematics in the district have been poor, having recorded an average of D (plain) in the last three years KNEC (2009). Thirdly, the nature of the study which involved live classroom instruction and long visits within the limited time and finances, the researcher found it appropriate to confine the study to this area. Fourthly, the district was found to have a higher number of secondary schools of all the three types, District, Provincial and National schools.

The formidable problem currently facing the teaching and learning of mathematics is the dire need to improve students' mathematics performance. The dominant mode of instruction within the district is the conventional (didactic) approach, hence the need to employ problem solving and other learner-centred methods.

Sample and sampling procedures

The study was carried out in four public secondary

schools within the district. These included one girls' school, one boys' school and two mixed schools. Eight trained practicing mathematics teachers, two from each of the four schools were involved in the study. The student sample population was 160, with each school producing 40 students. One of the teachers was trained for the control group and the other one for the experimental group. In total, four teachers were trained to teach the study groups.

The study employed multi-stage sampling techniques. Stratified sampling was used to identify one boys' school and one girls' school. Simple random sampling was used to identify the two mixed schools from the available thirty schools. In each of the selected schools, simple random sampling was used to get the two mathematics teachers. The Form Three class was purposively selected because it is at this class that the aspects of circle geometry; circles, chords, tangents and their properties are taught. Simple random sampling was used to select each stream in the Form Three class. Since the students were admitted in form one on merit, their entry behavior was assumed to be the same. A short test of 20 marks was administered to the students and the results used to pick the best 40 students for the study.

The four schools formed the four groups to meet the Solomon (1949) Four-Fold Group design's requirement. From a total of 1376 Form Three students' enrolment in the district, this sample constituted 30.06%. Of the four secondary schools, two were provincial schools while two were district schools. The district and provincial categories provided a platform for comparisons in performance and achievement according to school type.

RESEARCH DESIGN AND METHODOLOGY

This study adopted an experimental design, which involved collection of quantitative and qualitative data in an attempt to answer the research questions. The experimental design chosen for the present study is Solomon Four-Fold design, which is considered rigorous enough for experimental and quasi-experimental studies (Ogunniyi, 1992; Ary et. al, 1982; Cook & Campbell, 1979). Solomon Four-Fold design is believed to be robust in eliminating variations that might arise due to differences of experiences and contaminate the internal validity of the study (Ogunniyi, 1992; Tuckman, 1988). The design helps avoid some of the difficulties associated with the pretest-posttest designs. It is a factorial design that randomly assigns participants to four groups. It is a standard pretest-posttest only group design and the posttest only control design. In this design, the study population was divided into four groups. Two served as Experimental groups while the other two were control groups.

In the experimental groups, one group was pre-tested, treated then post-tested while the other one was only treated then post-tested. In the control groups, one group was pre-tested and then later post-tested while the

Table 2: Mean, Standard Deviation and t-test for Mixed Schools comparisons

Analysis	Mixed 1 Control	Mixed 2 Treatment	Critical t-value	Calculated t-value	Result
Mean(pre-test)	45.74	45.69			
Mean(post-test)	47.575	69.338			
SD	9.941	9.490			
Highest Score	66%	86%	1.67	9.633	*9.633

$n_1 = 40$, $n_2 = 40$, $\alpha = 0.05$, Tail: one – tail, critical t-value = 1.67.

*Significant

Table 3: Achievement scores of control and experimental group in pre-test

Group	N	Mean	SD	t-value
Experimental Group	40	45.69	12.28	*0.0182
Control Group	40	45.74	12.79	

*Not significant df = 78 t-value at 0.05 = 1.67

other group was only post-tested. The various combinations of tested and untested groups with treatment and control groups allow the researcher to ensure that confounding variables and extraneous factors do not influence the results (Shuttleworth, 2009). The two control groups act as controls for their respective pretested and non-pretested treatment groups.

Instruments.

Questionnaires, Mathematics Achievement Test and an interview schedule were used to collect information from the subjects. The scores were used to compare the groups taught using the problem solving strategy and those taught conventionally.

Data analysis

The data obtained from the study were analyzed in terms of quantitative and qualitative descriptions. Descriptive statistics consisted of percentages, means and standard deviations. Inferential statistics used here included analysis of variances (ANOVA), t-test which were employed to determine the significance of the differences in students' achievement, interests and attitudes during mathematics lessons.

RESULTS

The first objective is to determine if there was any significant difference in students' achievement when taught using problem solving and conventional method. The results are outlined in Table 2:

The pre-test scores of the control group and the experimental group did not show any significant differences. This was assumed that the two groups started out with equivalent means. That is, they had the same ability and capability from the start.

The results in Table 3 shows the difference of means of the two groups on pre-test. The calculated t-value is 0.0182 which is less than the tabulated value that is 1.67. There was no significant difference in the achievement of the two groups on pretest implying both groups have equal mathematics knowledge.

The post-test scores showed that the experimental group had higher scores than the control group. The t-test for independent samples was carried out to test whether the experimental and control groups differed significantly on the post-test. The experimental group scored a mean of 69.338% while the control group scored 47.575%. The calculated t-test value was 9.633 at a degree of freedom of 78 ($n_1 + n_2 - 2 = 78$) which is greater than the critical value of 1.67. Figure 2 shows the degrees of significance of the four sample groups. The results showed that the scores of the experimental group were consistently higher than those of the control group while the standard deviation was lower. Hence the significant level above the critical t-value of 1.67. The results in Table 4 shows that there was a significant mean improvement by the experimental group on MAT compared to that of the control group.

When the independent sample t-test for post-test mean scores on MAT was done, the results were as shown in Table 5

It was therefore found that there was a significant difference between the academic achievement of the students taught through the conventional methods and problem solving strategy. The null hypothesis, 'There is no significant difference in mathematics achievement

Table 4: Comparison of Means, Standard Deviation (SD) and Mean Improvement on Mathematics Assessment Test (MAT)

The Scale	EG 1	CG 1	EG 2	CG 2	Average
Pre-test Mean	47.10	43.65	-	-	45.38
SD	12.28	12.80	-	-	12.54
Post-test Mean	69.34	47.58	65.28	49.16	57.84
SD	9.49	9.94	9.53	8.99	9.49
Improvement	*22.24	3.93	-	-	12.46

*Significant Mean improvement

Table 5: Independent sample t-test for Post-test Mean scores on MAT

Groups	t-values
EG 1 Vs EG 2	1.644
EG 1 Vs CG 1	*9.6330
EG 1 Vs CG 2	*9.6334
CG 1 Vs CG 2	0.4710
CG 1 Vs EG 2	*7.812
EG 2 Vs CG 2	*7.722

*Significant at $\alpha = 0.05$, critical $t = 1.67$

between students taught using problem solving and those taught using conventional methods', was therefore rejected. It was also found out that the academic achievement of the students taught through problem solving was better than those taught through the conventional methods.

The second objective was to determine students' attitudes when exposed to both problem solving and conventional methods of instruction. This survey was developed to assess the students' 'levels of motivation and their effect on achievement. The first version of the Achievement Motivation Survey (AMS) developed by Acikgoz and Ellez was performed on university students in 1999. This survey was adapted to the 160 students. It consisted of 32 items: 13 items were for "endeavouring"; 13 items were for "will to work" and 6 items were for "participating". For the Likert-type survey, the student read a statement and decided on the degree of importance using a 5-point scale. This survey included questions about students' motivation and its effect on achievement. After this survey, the mean and standard deviations of two sampled groups were calculated to find the meaningful differences. According to the results in Table 4 above, there were no significant differences in the mean and standard deviations on the pre-tests, meaning the groups were equal in ability. Significant differences were found for the endeavouring ($t = 4.21$), will to work ($t = 4.69$) and participating ($t = 3.98$).

The experimental group scored 6.86% (endeavouring), 10.03% (will to work) and 8.9% (participating). The mean scores of the experimental group were consistently

higher than those of the control group while the standard deviations were consistently lower. Figure 1 shows the levels of attitude for the experimental groups with reference to Table 6.

Besides, Cohen's d values support this outcome by large effect size. The low endeavouring, low will to work and minimal participation indicated that the students in this group had a negative attitude and this eventually affected their performance. Figure 2 shows the levels of attitude for the control groups.

The control group students had unique characteristics from the experimental group. In this group, learning was characterized by the teacher controlling everything in class with learners being passive. Most of the activities were teacher centred and the teacher ended up solving most of the questions. These resulted into poor results as opposed to the experimental group. In the experimental group, students were freely solving problems and asking questions because of the enabling environment of collaborative learning, group discussion and individual participation. Their results were good. These good results motivated them to like the subject. Therefore students develop positive attitudes when taught using problem solving method unlike when taught using conventional approaches.

Interpretations

According to the available data, there was no significant difference in general performance on MAT between the two groups on pre-test. However after the treatment, there was a significant difference on the achievement test between the control and the experimental groups. The results therefore suggested that the students who were taught mathematics using problem solving performed significantly better than those taught using the conventional methods. The results showed that the experimental treatment groups obtained significantly higher scores than the control groups. Therefore, the null hypothesis (H_{01}) suggesting that there is no significant difference in students' achievement when taught using problem solving and conventional methods have been rejected. The finding of the study indicates that (i) the use of problem solving resulted in significant achievement and learning gains. The students who were taught using problem solving method ended up

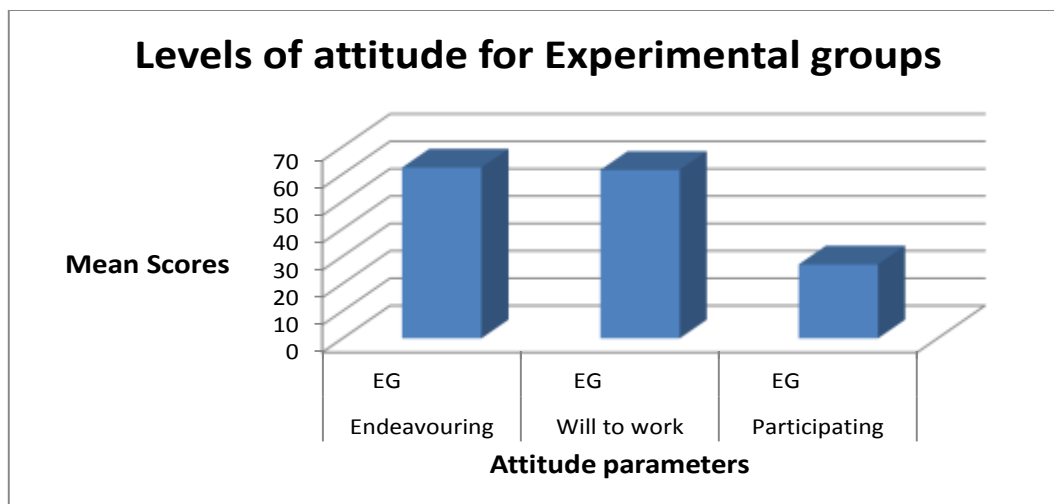


Figure 1: Attitude levels for Experimental groups

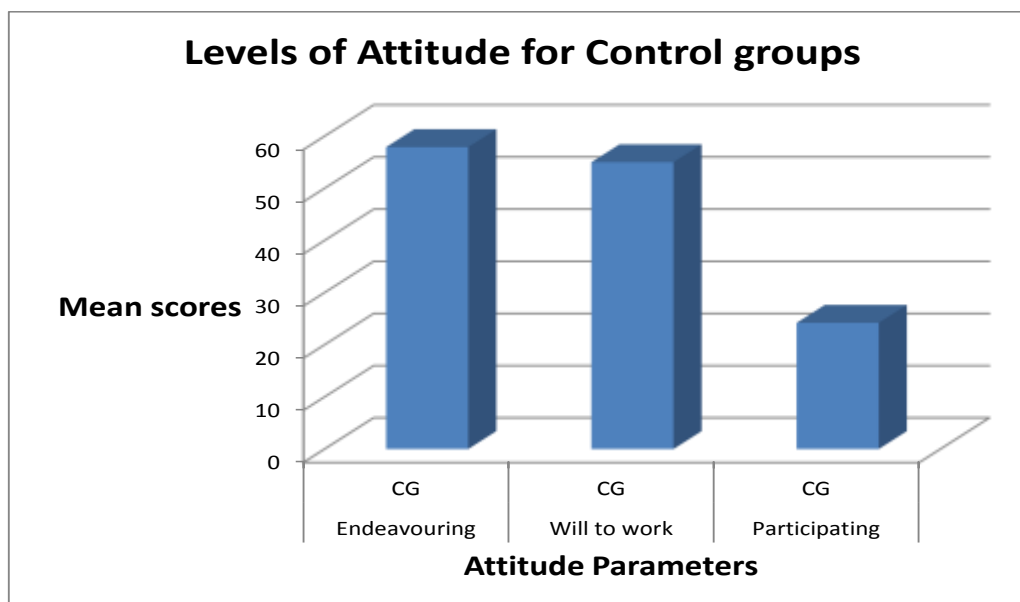


Figure 2: Attitude levels for Control groups

performing much better than their peers under the conventional methods.

Different teaching methods draw attention to different learning outcomes (Cobb, 1998; Case, 1996; Suchman, 1997; Vygotsky, 1934/1986; Boaler, 2002. Samuelsson, 2008). The current study provides support for this view. Problem solving is significantly better for improving students' performance in conceptual understanding, strategic competence and adaptive reasoning, aspects that are critical to challenging problems. Students who worked in problem solving classes were exposed to a higher level of reasoning, and that they accepted this reasoning as valid. In the control group where traditional methods were employed, students generally interacted

with the teacher. In the experimental group, students interact with both their peers and their teachers (Oppendekker & Van Damme, 2006). Therefore students in the experimental group were operating at a higher achievement advantage compared to their counterparts in the control groups.

The students develop positive attitudes when taught using problem solving method unlike when taught using conventional approaches. Problem solving techniques like cooperative learning and problem-based learning engendered healthy classroom dynamics resulting in increased conceptualization, increased creativity amongst students, good teacher-student interactions, thus improving learners' interests and responsibility

Table 6: Means and standard deviations of pre-test and post-test on Levels of Motivation

ITEM	GRPS	MEAN Pr-test	SD Pr-test	MEAN Ps-test	SD Ps-test	t-values	Cohen's d
Endeavouring	EG	58.56	4.80	62.36	2.17	4.21	1.26
	CG	61.42	12.29	57.90	4.47		
Will to work	EG	54.52	6.76	61.52	3.21	4.69	1.41
	CG	54.52	8.48	55.00	5.67		
Participating	EG	23.76	3.88	27.00	1.82	3.98	1.20
	CG	23.52	3.88	24.23	2.71		

during Mathematics lessons.

The study have provided useful empirical basis for improving the teaching and learning of Mathematics in the Secondary Schools through adoption of effective instructional approaches. For example, the results on MAT, indicating a significant difference in achievement of the students taught using problem solving approaches and those taught conventionally. The interview schedule also indicated that students exposed to the problem solving approaches had positive attitudes towards both the subject and the teacher, thus enabling them to develop interest and liking for learning.

CONCLUSION

On the basis of the findings in this study, the following conclusions were drawn:

- (i) There exists a significant difference in the achievement of mathematics students taught through problem solving method and conventional method. Students taught through problem solving method achieved better than those taught by conventional method.
- (ii) The difference between achievement levels is due to the problem solving method; otherwise both groups have equal basic knowledge of mathematics.
- (iii) The characteristics of problem solving method are learner-centred and hence enhance their team work, peer interactions and raises their learning interests. Therefore the students' attitudes towards mathematics are positive when taught using problem solving approaches. On the other hand, they are negative when taught using conventional approaches.

RECOMMENDATIONS

The findings of this study are considered as invaluable contributions to the teaching and learning of mathematics. On the basis of these findings, the following recommendations are hereby suggested:

- (i) This study showed that problem solving is a more effective method of instruction for teaching and learning mathematics as compared to conventional (traditional) method of teaching. Therefore the teachers

of mathematics should be encouraged to use problem solving method to improve the academic achievement of their students.

- (ii) The government through the Kenya Institute of Education should develop appropriate instructional materials and activities to be in tandem with the learner centred system of instruction.

- (iii) The government through its relevant agencies should transform the textbooks of mathematics into problem solving forms so as to meet the criteria of problem solving approach

- (iv) Extensive and results oriented training programmes, seminars and workshops on circle geometry and other challenging topics should be organized for mathematics teachers in secondary schools.

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