

Comparative Effectiveness of Problem Solving Approach on Students' Achievement in Mathematics: The Case of Single-Sex and Co-Educational Secondary Schools in Kenya

Dr. Ronald Ellumbe Mutange^{1*} Dr. Esokomi Solomon Nuni²

1.School of Education, MMUST, P.O. Box 190-50100, Kakamega, Kenya

2.School of Education, Tom Mboya University College, P.O. Box 199-40300, Homa-Bay, Kenya

Abstract

This study aimed at comparing the effectiveness of Problem Solving Approach (PSA) on students' achievement in mathematics in single-sex and co-educational secondary schools in Kenya. The study targeted a population of 10,500 students enrolled in 109 public schools in Vihiga County. Stratified random sampling was used to select twelve schools from the 109 schools. A sample of 1459 students was purposively and randomly drawn from the twelve schools. The study employed the Solomon's Four-Group Design. The respondents were assigned in their intact classes to experimental groups 1 and 3 and control groups 2 and 4. All the groups were taught the same content of the topic Commercial Arithmetic. However, experimental groups were taught using PSA while control groups were instructed by conventional method. One experimental group and one control group were pre-tested prior to the implementation of the PSA treatment. After the treatment, the four groups were post-tested. Mathematics Achievement Test 1 (MAT 1) and Mathematics Achievement Test 2 ((MAT 2) were used to gather data. The instruments' validity was determined by mathematics education experts. Reliability coefficients of 0.795 and 0.872 were obtained for MAT 1 and MAT 2 respectively using Cronbach's alpha. Data analysis involved the use of both descriptive and inferential statistics. Descriptive statistics involved means and standard deviations and inferential statistics involved an Analysis of Variance (ANOVA). The results revealed that PSA significantly improved students' mathematics achievement in the single-sex schools in comparison to those in the co-educational schools. It was concluded that PSA is a more effective and valuable teaching strategy to students in the single-sex schools. Therefore, the results attained in this study will allow re-focussing of the teaching strategies used in the co-educational schools so as to address the low students' achievement in mathematics. It was recommended that the Government of Kenya through the Ministry of Education should set up more single-sex schools and stream the current co-educational schools into single-sex classes and warmly endorse PSA as the classroom instructional strategy.

Keywords: Problem Solving Approach, Achievement, Single-sex schools, Co-educational schools.

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1. INTRODUCTION

1.1 Background to the Study

Mathematics is viewed by society as the wheel of social, economic and technological developments. According to Ker (2003), mathematical abilities are crucial for understanding other disciplines such as science, technology and engineering that are vital for new innovative professionals in the sciences and technological fields. Sa'ad, Adamu and Sadiq (2014) caution that without mathematics, there is no science, without science, there is no modern technology and without modern technology, there is no modern society. Thus, Kenyan education must emphasize on building capacity in mathematics skills to foster development in science and technology for competitiveness and economic development of the country. Moreover, Cockroft (1982) underscores that the knowledge of mathematics as a tool for use in everyday life is important for the existence of any individual and society. Mathematics in our society is a form of training for logical reasoning. Further, the logical designs of computing machines are mathematics oriented (African Curriculum Organization [ACO], 1979). Consequently, mathematics is required in all spheres of life; at home, in the office, sciences, engineering, commerce, military, technological development and researches of all forms.

In Kenya, mathematics is a compulsory subject at the secondary school level and is used as pre-requisite to enter any of the prestigious courses in tertiary institutions. Mathematics qualifications are commonly used as a critical entry requirement to employment and further training in Kenya. Despite the vital role it plays in society, there has always been students' poor performance in the subject during national examinations (Kenya National Examination Council [KNEC], 2010). The poor performance in mathematics is a barrier in achieving social and economic development of individuals and the country at large. It also implies that the quality of mathematics education is jeopardized. The dismal performance has been attributed to, among others; poor pedagogical approaches and teachers' weak content knowledge (Michael, 2015; Mazana et al., 2019); teachers' attitude and enthusiasm (Frezel et al., 2009); social-psychological environment (Topçu et al., 2016, Mazana et al., 2019),

students' aptitude and culture (Wadrip & Giddings, 1994); and ability grouping (Uysal & Banoglum, 2018). To improve the quality of mathematics education, tandem ways should be sought to improve students' learning experiences and consequently their performance.

Students' learning difficulties are attributed to ineffective or inappropriate cognitive processes. However, meaningful learning occurs when students choose to relate new knowledge to relevant concepts and propositions they already know (Novak & Gowin, 1984). This calls for commitment on the part of the learner to link new concepts with higher order and more inclusive concepts that are already comprehensible to the learner and thus can anchor new knowledge and assimilate new ideas. The significance of quality mathematics instruction cannot be undermined, since it boosts learning and fosters a sense of self-confidence among the learners (Ramsden, 1995). Mathematics instruction does not just concern itself about dispensing rules, definitions and algorithms for students to memorize. There is need to engage students as active participants through discussions and collaboration in problem solving among themselves. If learners are accorded the opportunity to explain or clarify mathematical ideas, then more meaningful learning crops up. Silva (2009) remarks that the 21st century pedagogical paradigm shift in mathematics education require instructional strategies that emphasize learners' active involvement. According to Johnson and Johnson (1995), to excel in learning mathematics, learners should be given the opportunity to communicate, share and reason mathematically so as to develop self-confidence to solve mathematics problems.

Successful mathematics instruction is associated with explicit teaching of a coherent conceptual framework rather than simply involving students in activities and hoping that meaningful learning results. Thus, it is important that mathematics instruction focuses on the quality of understanding rather than on the quantity of information presented. Unfocussed or purposeless activity in the classroom leads to little if any learning. Trobridge and Bybee (2004) agree with Duffy and Johassen (1992) to re-attest that learning is an active, constructive, cumulative, self-regulated and goal-oriented process in which the learner plays a critical role. Thus, teachers should develop instructional strategies that engage learners actively in the process of knowledge construction to enable them learn meaningfully. There is need to develop teaching strategies that conform to this new perception of learning to enhance meaningful learning and improve students' performance in mathematics.

In the same vein, Zechariah (2005) contends that instructional methods employed by the teacher play a pivotal role in the acquisition of skills and meaningful learning. Conventional methods such as lecture make students passive and have less interaction with each other in performing tasks. King'Arū (2014) contends that in conventional method, there is very little interaction between the teacher and the students or among the students themselves in the classrooms. It is mostly teacher dependent and examination oriented. This method impedes meaningful learning as it shows no regard for individual differences among the learners and does not provide opportunity for adequate class preparation in the instructional process. As a result, students learn comparatively little of what has been taught as they only hear and see the teacher. Further, the students are passive and boredom is easily associated with the method. Therefore the continual use of lecture method in schools reduces the ability of students to grasp relevant concepts. Furthermore, Onwusa, Eze and Ezenwafor (2020) concur with Changeiywo (2000) that the lecture method breeds dissatisfaction and inadequate knowledge construction. Thus students are not able to retain their learned knowledge and apply it to new situations. This may lead to high failure rate in mathematics. Positive changes take place when a teacher changes the instructional strategy towards a more student-oriented method. Consequently, an alternative strategy for the delivery of mathematics knowledge is Problem Solving Approach (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. It is in this PSA that learners work as a team to maximize their own and each others' learning. Moreover, the PSA classroom environment is characterized by co-operative tasks, incentives structures and by small group activities. It may be used to teach mathematics and also help teachers to accomplish significant social learning and human relations goals.

In studying students' achievement in mathematics, gender cannot be ignored. There is a cultural belief that boys are superior to girls in terms of mathematics achievement as a result of myriad factors such as; mathematics learning strategies (Carry & Jessup, 1997), biological factors (Mondoh, 2000), learner motivation factors (Githua, 2002; Ponera et al., 2011; Mazana et al., 2019), sex hormones on brain organization and symbolic gender (Kimura, 2002). Research evidences disagreed with this cultural misconception and posited that gender differences in mathematics achievement does not exist (Galadima & Yusha'u, (2007); Monica & Ofem, 2015).

The PSA teaching strategy if effectively used, it could revolutionize the classroom instructional process. It will make it more collaborative, active and interactive. It could as well improve students' achievement in mathematics regardless of the gender composition in the mathematics classrooms. The perceived gender differences in students' mathematics achievement may also be eliminated. These assumptions prompted the current study; comparative effectiveness of PSA on students' achievement in mathematics in single-sex and co-educational secondary schools in Kenya.

1.2 Aim of the Study

The aim of this study was to investigate and compare the effectiveness of Problem Solving Approach (PSA) on students' achievement in mathematics in single-sex and co-educational secondary schools in Vihiga county of Kenya. This was explored by using the four research questions and hypotheses formulated to guide the study.

1.3 Objectives of the Study

The main objective of the study was to determine whether there is any difference in mathematics achievement of students taught with PSA and conventional method in the single-sex and co-educational schools. Specifically, the study sought to determine:

- (i) The mathematics achievement mean scores of boys taught with PSA in boys-only schools in comparison to those in co-educational schools;
- (ii) The mathematics achievement mean scores of boys taught with conventional method in boys-only schools in comparison to those in co-educational schools;
- (iii) The mathematics achievement mean scores of girls taught with PSA in girls-only schools in comparison to those in co-educational schools; and
- (iv) The mathematics achievement mean scores of girls taught with conventional method in girls-only schools in comparison to those in co-educational schools.

1.4 Research Questions

The study intended to answer the following research questions:

- (i) What are the mathematics achievement mean scores of boys taught with PSA in boys-only schools and of those in co-educational schools?
- (ii) What are the mathematics achievement mean scores of boys taught with conventional method in boys-only schools and of those in co-educational schools?
- (iii) What are the mathematics achievement mean scores of girls taught with PSA in girls-only schools and of those in co-educational schools?
- (iv) What are the mathematics achievement mean scores of girls taught with conventional method in girls-only schools and of those in co-educational schools?

1.5 Statements of the Hypotheses

The following null hypotheses were formulated (to guide the study) and tested at 0.05 alpha levels of significance:

- HO₁:** There is no significant difference between the mathematics achievement mean scores of boys taught with PSA in boys-only schools in comparison to those in co-educational schools;
- HO₂:** There is no significant difference between the mathematics achievement mean scores of boys taught with conventional method in boys-only schools in comparison to those in co-educational schools;
- HO₃:** There is no significant difference between the mathematics achievement mean scores of girls taught with PSA in girls-only schools in comparison to those in co-educational schools; and
- HO₄:** There is no significant difference between the mathematics achievement mean scores of girls taught with conventional method in girls-only schools in comparison to those in co-educational schools.

2. METHODOLOGY

This study adopted Solomon's Four Group Design that employed the quasi-experimental procedures. This is because secondary schools classes once constituted exist as intact groups and school administrators do not allow such classes to be broken up and re-constituted for research purposes. Thus, the schools selected were randomly assigned to the treatment and control conditions as intact groups. The pre-test – post-test approach was used to partially eliminate the initial differences between the experimental and control groups (Gibbon & Herman, 1997)

The target population of the study comprised of 10,555 Form Three students from the 109 public schools in Vihiga County. The sampling frame constituted of all national, county and sub-county schools. The first stage was the purposive selection of Vihiga County and the two national schools. The remaining schools were stratified into boys' only, girls' only and co-educational schools. Balloting method was employed to sample ten schools from the remaining 107 schools. A sample size of 1459 students was then drawn from the 12 schools. The subjects were assigned to experimental groups 1 and 3, with 367 and 360 students respectively; and control groups 2 and 4, with 344 and 388 students respectively.

The instruments for data collection were Mathematics Achievement Test 1 (MAT 1) and Mathematics Achievement Test 2 (MAT 2). They were developed by the researcher and used as pre-test and post-test. They were face and content validated by six mathematics education experts, from the Department of Science and Mathematics Education in MMUST, who vetted the items in the instruments for language clarity, purposefulness and plausibility of the distracters. The reliability of the instruments was established using test-retest method, where MAT 1 and MAT 2 were pilot tested on 42 Form Three students drawn from the schools which were not part of

the population of the study. They yielded correlation coefficients of 0.795 and 0.872 respectively by using Cronbach's Coefficient Alpha method.

The researcher sought and obtained authorization permit from the National Council for Science, Technology and Innovation (NACOSTI) for the involvement of the schools and teachers in the study. Prior to the commencement of the actual study, the regular teachers were inducted on how to use the PSA treatment for two days by the researcher. Thereafter, they inducted the students in the experimental groups pertaining to the tenets of PSA for three days. The experimental group teachers were issued with instructional packages tailored towards Commercial Arithmetic. After the orientation period, MAT 1 was administered to the students in the experimental group 1 and control group 2. The pre-test scores were used to assess the entry level and homogeneity of the students in the randomly assigned experimental and control groups. The two experimental groups were taught with PSA for a three-week treatment period, while the two control groups were instructed using conventional method. At the end of the treatment period, MAT 2 was administered to the four groups after one-week laps. Data collected for the study were analysed using mean scores and standard deviations to answer the research questions while Analysis of Variance (ANOVA) was used to test the hypotheses at alpha (α) levels of 0.05. F-tests were used to determine whether the differences were significant.

3. RESULTS

3.1 Results of Pre-test

The Solomon's Four-Group Design allowed the researcher to have duo groups sit for the pre-test MAT 1 that ascertained the homogeneity of the participants. The t-test results of the MAT 1 pre-test mean scores are presented in Table 1.

Table 1: Independent Samples t-test of the Pre-test Scores on MAT 1

Variable	Group	Mean	SD	t-value	P-value
MAT 1	1	37.66 ^a	8.18	0.313*	0.754
	2	37.88 ^a	10.37		

^{a, b} denote similar mean scores * Not significant at $p < 0.05$ level Df = (1,709)

Basing on Table 1, the experimental group 1 (n = 367) and the control group 2 (n = 344) obtained means of 37.66 and 37.88 in MAT 1 respectively. From the results, the pre-test mean scores of both groups (1 & 2) attained were similar on MAT 1 measure. The t-test results analysis reveal that the pre-test mean scores for groups 1 and 2 on MAT 1 measure are not statistically different; since the t-value (0.313) is not significant at 0.05 α -level, Df = (1, 709). This indicates that the four groups used in the study were comparable and had similar entry behaviour, hence homogeneous. This made them appropriate for the study.

3.2 Comparison of the Achievement of Boys in the Co-educational Class with that of Boys in the Boys-only Class

The MAT 2 post-test mean scores obtained by boys were analysed in order to test hypothesis one (H_{01}) of the study that sought to find out whether there was any significant difference between the mathematics achievement mean scores of boys taught with PSA in boys-only schools in comparison to those in co-educational schools. Table 2 shows the MAT 2 post-test mean scores for the boys in the two types of schools.

Table 2: MAT 2 Post-test Mean Scores of Boys in the Experimental Groups based on School Type

School Type	N	Mean Score	SD	Mean Difference
Boys-only schools	256	59.15	7.97	12.56
Co-educational schools	144	46.59	8.70	
Total	400	54.63	10.21	

Table 2 illustrates that the boys who were taught with PSA in the boys-only schools were 256 while those in the co-educational schools were 144. An examination of the results shows that the boys in the boys-only schools had a mean of 59.15 which is higher than 46.59 that was obtained by the boys in the co-educational schools when they were taught with PSA. The net difference in the means between the two types of schools was 12.56. This indicates that the boys in boys-only schools achieved more than the boys in the co-educational schools.

In order to determine whether the difference in the MAT 2 post-test mean scores among the two types of schools was significant, an ANOVA was performed. The results of the ANOVA are presented in Table 3.

Table 3: ANOVA of MAT 2 Post-test Scores for Boys in the Experimental Groups based on School Type

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	14534.31	1	14534.31	214.90*	0.00
Within Groups	27025.19	398	67.90		
Total	41559.50	399			

*Denotes significant mean difference at $p < 0.05$ level Df = (1,398)

An examination of the results in Table 3 shows that the difference in the post-test MAT 2 mean scores is significant, the F-value (214.90) from ANOVA is significant at $p < 0.05$ α -level, Df = (1, 398).

The mean difference between the boys in the boys-only schools and the boys in the co-educational schools was significant in favour of the boys in the boys-only schools. Overall, the results showed that the boys in the boys-only schools attained significantly higher achievement in MAT 2 in comparison to those in the co-educational schools. This implies that PSA as a teaching strategy had a significantly higher influence on achievement among the boys in the boys-only schools. Therefore, the null hypothesis HO_1 indicating that there is no significant difference between the mathematics achievement mean scores of boys taught with PSA in boys-only schools in comparison to those in co-educational schools was rejected.

Analysis of the MAT 2 post-test scores of the boys in the control groups was also carried out. The MAT 2 mean scores for the boys in the two types of schools are shown in Table 4.

Table 4: MAT 2 Post-test Mean Scores of Boys in the Control Groups based on School Type

School Type	N	Mean Score	SD	Mean Difference
Boys-only schools	225	49.59	10.96	19.44
Co-educational schools	117	30.15	7.45	
Total	342	42.94	13.53	

Table 4 indicates that the boys who were taught with conventional method in the boys-only schools were 225 while those in the co-educational schools were 117. An examination of the results shows that the boys in the boys-only schools attained a mean of 49.59 which is higher than 30.15 that was obtained by the boys in the co-educational schools when they were taught with conventional method. The net difference in the means between the two types of schools was 19.44. This indicates that the boys in the boys-only schools performed better than the boys in the co-educational schools.

In order to determine whether the difference in the MAT 2 post-test mean scores among the two types of schools was significant, an ANOVA was performed. The results of the ANOVA are presented in Table 5.

Table 5: ANOVA of the MAT 2 Post-test Scores for Boys in the Control Groups based on School Type

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	29106.80	1	29106.80	296.86*	0.00
Within Groups	33336.91	340	98.05		
Total	62443.71	341			

*Denotes significant mean differences at $p < 0.05$ level Df = (1,340)

An examination of the results in Table 5 shows that the difference in the post-test MAT 2 mean scores is significant, the F-value (296.86) from ANOVA is significant at $p < 0.05$ α -level, Df = (1, 340).

The mean difference between the boys in the boys-only schools and the boys in the co-educational schools was significant in favour of the boys in the boys-only schools. Overall, the results showed that the boys in the boys-only schools attained significantly higher achievement in MAT 2 in comparison to those in the co-educational schools. This implies that conventional method as a teaching strategy also had a significantly higher influence on the achievement of the boys in the boys-only schools. Therefore, the null hypothesis HO_2 indicating that there is no significant difference between the mathematics achievement mean scores of boys taught with conventional method in boys-only schools in comparison to those in co-educational schools was rejected.

When the results for boys in the experimental schools were compared with those of boys in the control schools, they showed that PSA was most beneficial to boys in the boys-only schools than to the boys in the co-educational schools.

3.3 Comparison of the Achievement of Girls in the Co-educational Class with that of Girls in the Girls-only Class

The MAT 2 post-test mean scores obtained by girls were analysed in order to test hypothesis three (HO_3) of the study that sought to find out whether there was any significant difference between the mathematics achievement mean scores of girls taught with PSA in girls-only schools in comparison to those in co-educational schools. Table 6 shows the MAT 2 mean scores for the girls in the two types of schools.

Table 6: MAT 2 Post-test Mean Scores of Girls in the Experimental Groups based on School Type

School Type	N	Mean Score	SD	Mean Difference
Girls-only schools	239	52.70	7.21	4.69
Co-educational schools	88	48.01	11.47	
Total	327	51.44	8.80	

Table 6 depicts that the girls who were taught with PSA in the girls-only schools were 239 while those in the co-educational schools were 88. An examination of the results shows that the girls in the girls-only schools had a mean of 52.70 which is higher than 48.01 that was obtained by the girls in the co-educational schools when they were taught with PSA. The net difference in the means between the two types of schools was 4.69. This indicates that the girls in the girls-only schools performed much better than the girls in the co-educational schools.

In order to determine whether the difference in the MAT 2 post-test mean scores among the two types of schools was significant, an ANOVA was performed. The results of the ANOVA are presented in Table 7.

Table 7: ANOVA of MAT 2 Post-test Scores for Girls in the Experimental Groups based on School Type

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	1418.22	1	1418.22	252.18*	0.00
Within Groups	23820.49	325	73.29		
Total	25238.71	326			

*Denotes significant mean difference at $p < 0.05$ level Df = (1,325)

A perusal of the results in Table 7 shows that the difference in the post-test MAT 2 mean scores is significant, the F-value (252.18) from ANOVA is significant at $p < 0.05$ α -level, Df = (1, 325). The mean difference between the girls in the girls-only schools and the girls in the co-educational schools was significant in favour of the girls in girls-only schools. Overall the results showed that the girls in the girls-only schools attained significantly higher achievement in MAT 2 in comparison to those in the co-educational schools. This implies that PSA as a teaching strategy had a significantly higher influence on the achievement of the girls in the girls-only schools. Therefore, the null hypothesis H_{03} indicating that there is no significant difference between the mathematics achievement mean scores of girls taught with PSA in girls-only schools in comparison to those in co-educational schools was rejected.

Analysis of the MAT 2 post-test scores of the girls in the control groups was also carried out. Table 8 depicts the MAT 2 mean scores for the girls in the two types of schools.

Table 8: MAT 2 Post-test Mean Scores of Girls in the Control Groups based on School Type

School Type	N	Mean Score	SD	Mean Difference
Girls-only schools	263	38.82	7.29	10.36
Co-educational schools	127	28.46	10.25	
Total	390	35.45	9.67	

Table 8 depicts that the girls who were taught with conventional method in girls-only schools were 263 while those in co-educational schools were 127. A close look at the results shows that the girls in the girls-only schools had a mean of 38.82 which is higher than 28.46 that was obtained by the girls in the co-educational schools when they were taught with conventional method. The net difference in the means between the two types of schools was 10.36. This indicates that the girls in the girls-only schools performed better than the girls in the co-educational schools.

In order to determine whether the difference in the MAT 2 post-test mean scores among the two types of schools was significant, an ANOVA was performed. The results of the ANOVA are presented in Table 9.

Table 9: ANOVA of the MAT 2 Post-test Scores for Girls in the Control Groups based on School Type

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	9200.26	1	9200.26	131.43*	0.00
Within Groups	27160.11	388	70.00		
Total	36360.37	389			

*Denotes significant mean difference at $p < 0.05$ level Df = (1,388)

An examination of the results in Table 9 shows that the difference in the post-test MAT 2 mean scores is significant, the F-value (131.43) from ANOVA is significant at $p < 0.05$ α -level, Df = (1, 388).

The mean difference between the girls in the girls-only schools and the girls in the co-educational schools was significant in favour of the girls in the girls-only schools. Overall the results showed that the girls in the girls-only schools attained significantly higher achievement in MAT 2 in comparison to those in the co-educational schools. This implies that conventional method as a teaching strategy also had a significantly higher influence on achievement among the girls in the girls-only schools. Therefore, the null hypothesis H_{04} indicating that there is no significant difference between the mathematics achievement mean scores of girls taught with conventional method in girls-only schools in comparison to those in co-educational schools was rejected.

When the results for girls in the experimental schools are compared with those of girls in the control schools, they showed that PSA was most beneficial to girls in the girls-only schools than to those girls in the co-educational schools.

The results indicate that both PSA and conventional teaching methods significantly improved the achievement of boys and girls in the single-sex schools in comparison to those in the co-educational schools in mathematics. This implies that both the treatment (i.e. PSA) and the conventional teaching methods significantly influenced the achievement of boys and girls of the experimental and the control groups in the single-sex schools. Therefore the type of school does influence students' achievement in mathematics irrespective of the teaching strategy (PSA or conventional method) used.

4. DISCUSSION

4.1 Results of the Pre-test

This study employed the Solomon's Four-Group Design. The students were assigned to the experimental groups 1 and 3 and control groups 2 and 4. The pre-testing of groups 1 and 2 allowed the researcher to determine; the

presence of any interaction between pre-test and the PSA treatment; the impact of the pre-test relative to no pre-test and establish the knowledge threshold of the groups before applying the treatment and generalize to the groups that were not pre-tested.

Sanders and Pinhey (1979) posit that when the two experimental groups 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 the experimental groups in comparison to that between the control groups results if the pre-test interacts with the treatment. This is as a result of a sensitisation effect. The post-test students' mathematics achievement result in this study did not indicate any interaction between the pre-test and the PSA treatment.

A comparison of groups 1 and 2 pre-test MAT 1 mean scores of students revealed non-significant differences (see Table 1). The results revealed that the groups were quite similar before the administration of the treatment.

4.2 Comparison of Students' Achievement in the Co-educational Classes with that of Students in the Boys-only or Girls-only Classes

In the case of boys who were taught with PSA, the achievement results revealed that the mean score for boys in the boys-only schools was higher than that of boys in the co-educational schools. This difference was significant, $F(1,398) = 214.90$, $p < 0.05$. Moreover, for the boys in the control condition, the difference in the achievement mean scores between boys in the boys-only classes and those in the co-educational classes was significant $F(1,340) = 296.86$, $p < 0.05$ (see Tables 3 & 5). Results of this study show that the achievement of boys in the boys-only schools was higher than that of boys in the co-educational schools in the PSA group. This result is consistent with the control group results.

Similarly, for the girls who were taught with PSA, the achievement post test results revealed that the mean scores of girls in the girls-only schools was significantly different from that of the girls in the co-educational schools, $F(1,325) = 252.18$, $p < 0.05$. Likewise, for the girls in the control condition, the difference in the achievement post-test mean scores between the girls in the girls-only classes and those in the co-educational classes was significant, $F(1,388) = 131.43$, $p < 0.05$ (see Tables 7 & 9).

The results of this study revealed that the students who were taught mathematics using PSA in the single-sex schools attained higher achievement mean scores than those in the co-educational schools (see Table 2 & 6). This buttressed the fact that the use of PSA was more effective in improving the achievement of students in the single-sex schools than that of those in the co-educational schools.

The findings of this study further revealed that PSA was less gainful to the improvement of the achievement of the students in the co-educational schools. This was probably because students in the co-educational schools could be having their own successful strategies, which they failed to employ when they used PSA and thus got disadvantaged in the process. Tick (2007) remarked that the use of PSA was in itself a challenging process. It could thus be envisaged that the students in the co-educational schools needed a lot of in-service training to master its application if they had to derive any gains from it. Contrarily, the conformity of the students in the single-sex schools to the teachers' demands as well as their consistency in the application of the PSA tenets accelerated their mastery of the new techniques as opposed to those in the co-educational schools who were probably predisposed to employ alternative learning strategies. Thus the use of PSA as a teaching strategy in the study explained the improved achievement among the students in the single-sex schools.

On the other hand, for girls in the control condition, the co-educational girls' MAT post-test mean score was lower than that of girls in the girls-only schools. It is worth mentioning that the PSA teaching strategy improved the achievement of girls in the girls-only classes by a large margin, implying that it was particularly beneficial to girls in the girls-only schools. When the achievement of boys in the co-educational classes was compared to that of the boys in the boys-only classes, the results showed that the MAT post-test mean scores of boys exposed to PSA in co-educational classes was significantly lower than that of boys in the boys-only classes. The MAT post-test results in the control group also showed that the boys in the boys-only classes performed better than those in the co-educational classes. However, the results showed that the achievement of boys in both types of schools in the PSA cohort was much better than that of the boys in the control condition. This implies that PSA and conventional methods were most beneficial to the boys in the boys-only schools in comparison to those in the co-educational schools. It can therefore be deduced specifically that PSA had varying effects depending on the students' gender and the classroom composition. The students in the single-sex schools obtained the greatest gain from the PSA method.

The Forum for African Women Educationists (FAWE, 1999) in a study aimed at improving the participation and performance of girls in mathematics and sciences in primary and secondary schools, reported that girls achievement in mathematics in Kenya was much lower than that of boys partly due to their negative attitude towards mathematics. Moreover, it reported that the teacher in the normal competitive classes consciously and unconsciously discouraged girls' participation in learning. For example, some teachers assumed that girls would be unable to answer certain types of questions or perform certain mathematical activities. Other teachers made

remarks that indicated that girls were unintelligent and lazy. In addition, Fawe argued that girls were more anxious than boys when asked to solve unfamiliar mathematics problems and that most boys underestimated their own academic ability. They believe that boys were superior and more intelligent than they were and therefore more capable of handling subjects such as mathematics. Further, Campbell (1995) reaffirmed that boys received more praise and teacher initiated contacts while girls were criticised more frequently for the academic quality of their work. This differential treatment contributed to the faulty perceptions that mathematics was a male domain. However, a study by Wasanga (1997) found that girls in the co-educational classes were always active than the boys. In that same study, boys asked more questions in class and were called upon by teachers to answer questions or help in solving problems more often than girls. Another study by Sadker and Sadker (1986) attested to similar findings.

This study showed the interactivensness of the lesson components. In contrast with the earlier studies in America and Kenya, that indicated that some students had greater interaction with their teachers than others do (Maritim, 1984; Bracey, 2006), the findings of this study placed the students in the single-sex schools on the same level. This implied that the boys and girls in the PSA single-sex classrooms had equal opportunities to interact and participate fully in the lessons leading to their higher levels of achievement. Notably, Githua's (2002) findings confirms Wanjala's (2020) results that collaborative socialisation during the instructional process is critically significant to students' achievement. This seemed to have been the case for the boys and girls in the single-sex classes who were in both the PSA and control groups in the study herein.

Arguably, PSA assisted the mathematics teacher to balance the classroom interaction patterns among the boys and girls in the single-sex classes. By using PSA, the teacher was able to give similar attention to the boys and girls in the single-sex classes and this led to improved achievement by either gender in the single-sex settings. In this regard, it is evident that the disparity between girls and boys achievement in mathematics examinations can be arrested by setting up single-sex schools.

The results of this study implicates that PSA has the propensity to spur girls' confidence to solve mathematics problems especially those in the girls-only schools. Based on this, Fawe (1997) recommended the construction of more girls-only schools in Kenya with a view to improve their performance. This study strongly attests to the establishment of more girls-only schools if girls have to continue excelling in mathematics. The PSA helped in overcoming learning imbalances especially among girls in the girls-only classes by making positive interdependence and individual accountability the key factors in the learning environment resulting in higher girls' achievement.

The results of this study support the earlier findings of Ellison and Swanson (2010) that boys who attended single-sex schools performed better than their counterparts in the co-educational schools. Also, the findings of this study come in support of Hoxby (2000) and Lavy and Schlosses (2011), who found that single-sex schooling significantly boosted the performance of girls. Moreover, the reported findings affirm the results of Eisenkopt et al. (2012) that revealed that single-sex classes improved the performance of girls in mathematics and the positive effect increased if the single-sex classes were taught by male teachers. Additionally, in accord with the current study findings, Fryer and Levitt (2010) agreed with Booth and Nolen's (2012) findings that co-educational classrooms were a necessary component for gender inequality translating into poor female mathematics performance. Further, the present results confirm those of Huguet and Regner (2007) who discovered that when girls were led to believe that a task measured mathematics ability, they underperformed in mixed-sex groups but not in all-female groups. However, the findings of the present study are at odds with those of Hoxby (2000) and Lavy and Schlosser (2011) who unearthed that single-sex schooling boosted the poor achievement of boys. Furthermore, the results of the current study are inconsistent with the earlier findings of Lee and Lockheed (1990) that revealed that single-sex education negatively affected the mathematics achievement of boys.

Herreid (2003) opined that students' achievement was negatively affected by the teachers' approach in presenting the subject content. Consequently, the teachers' role in the classroom discourse was a determinant factor of the classroom environment. Chin and Chia (2004) averred that students' achievement developed best in classroom environments that gave them more opportunities for more participatory interaction. Sadker and Sadker (1986) revealed that male and female teachers gave more attention to boys than to girls in secondary schools. This practice had the effect of reinforcing in girls the belief that they were less capable, which in turn negatively affected their self-esteem and confidence resulting in poor performance in mathematics as was evidenced in the co-educational classes. Thus, the teacher restructured the classroom environment that permitted the students to work interactively in collaborative groups. This resulted to significant improvement in the achievement of the students in the single-sex schools.

The poor performance of students in the co-educational schools as compared to those in the single-sex schools was unexpected bearing in mind that effective instructional strategy (i.e. PSA) that encompassed students' participation in learning was expected to improve on the cognitive aspect of the students compared to the conventional method. One possible explanation for this perceived contradiction was probably the short three-week intervention period. Significant improvement on the students' achievement in the co-educational schools was

unlikely to be effected over such a short period of time bearing in mind that this is a cognitive characteristic that required reasonable period of time for the students to gain greater interest in the knowledge attained for it to be discriminated, assimilated and accommodated into the learners' old structures of knowledge before its application.

Though there were some positive results from the use of PSA in the co-educational schools, it was apparent that both teachers and students faced some challenges. Ngeow and Kong (2001) alluded that, as the PSA required students to adopt active learning principles and become more self-directed in their learning, students in the co-educational schools faced some challenges in adapting into critical thinkers. This in line with Wood (2003) who conceded that the use of PSA requires many instructors to be involved in teaching and therefore more teacher development particularly focusing on facilitation and management of group dynamics was required. Wood's findings are in agreement with Goodnough (2003) who found that the use of PSA with large groups was hard due to the difficult in ensuring that the groups functioned successfully. Due to time constraints, information was not always properly shared or fully discussed. There was resentment because some boys and girls in the co-educational classes shouldered more responsibility than others. This emanated from the unequal gender composition in some classes. Some students indicated discomfort with the process that there was not enough direction, they requested more feedback on the success of their efforts or were uncertain if they had covered all the relevant areas. However, this study has shown that PSA resulted in improved students' achievement in the two types of schools. In view of this, it suffices to point out that PSA should be adapted for mathematics instruction in Kenyan secondary schools so as to boost students' morale that positively resonates with their mathematics improvement.

The findings of this study have some practical implications to mathematics education. PSA engaged students in constructing and altering their own cognitive base that led to better perception of mathematics as a 'soft' subject. As a teaching strategy, PSA had profound effect on students in the single-sex schools by significantly improving on their mathematics achievement. There is need however to scrutinize the learning strategies of students in the co-educational schools in order to identify ways in which the gains of PSA as an instructional strategy can be harnessed to significantly boost their mathematics achievement too. Probably substantial number of gender-sensitive teachers and lengthy training sessions in the application of PSA and direct feedback given to students in the co-educational schools may accord them the opportunity to profit from its use.

The findings of this study also revealed that PSA as a teaching strategy had a positive and significant contribution to the development of achievement among students in the single-sex schools. This is not the case however with the students in the co-educational schools. This implies that in choosing an instructional strategy, it is imperative that mathematics teachers consider the uniqueness of each type of school in terms of gender composition in the specific classes when handling students. This is essentially necessary to avoid disadvantaging either gender particularly in the instructional strategies employed in the classroom interactions. It is worth mentioning that PSA as a teaching strategy was more advantageous to students in the single-sex schools because they were more conforming and consistent in its use within a short (three weeks) time span.

The enhancement of students' achievement required conducive learning environment. One way of fostering students' achievement in mathematics was by the use of PSA which constituted such an environment. The instruction in the PSA classrooms made mathematics more enjoyable and improved the achievement of students in the single-sex schools by offering them a collaborative environment and the opportunity to explore and try out alternatives. This is based on the anecdotal evidence from the research findings.

With reference to the findings of this study, there is empirical evidence that PSA can enhance the development of the cognitive abilities of the students in the single-sex schools. The students in the single-sex schools attained higher achievement mean scores in the post-test analysis. This means that mathematics as a subject in the secondary school curriculum does not appear to be a disliked subject, especially among the students in the single-sex schools. The findings implies that the perception of mathematics as a 'hard' subject in the secondary school curriculum can change for the better by either abolishing the co-educational schools and setting up single-sex schools or re-streaming them into single-gender classes. Mathematics educators in Kenya therefore should not entirely blame the poor performance of students in mathematics on the type of school. The current findings portrayed that students' achievement and the type of school influenced each other positively when PSA was employed in the class instruction. Consequently, Kenyan mathematics teachers have a pivotal role to play in maintaining and strengthening favourable trends in mathematics education by upholding positive interest among the students in the single-sex and co-educational schools. Negative disposition towards mathematics by the teachers affects students' mathematics achievement adversely. It is prudent therefore that mathematics teachers demonstrate positive attitudes at all times in their dealings with students (especially those in the co-educational schools), bearing in mind that teacher-student relationship and transaction is crucial for the students' high achievement in mathematics.

5. CONCLUSION

In the light of the foregoing analysis of the data, it is clearly evident that when PSA was used in mathematics instruction, the type of school significantly affected the boys and girls achievement, with boys in the boys-only

schools and girls in the girls-only schools attaining higher achievement mean scores. The study thus established that the PSA teaching strategy significantly influenced the achievement of students in the single-sex schools. It was concluded therefore that students' achievement in mathematics could be improved through the use of PSA which was found more valuable in boosting the achievement of the students in the single-sex schools than in the co-educational schools. Consequently, the results obtained in this study will allow re-focussing of the instructional strategies used in the co-educational schools to address the students' low achievement in mathematics.

6. RECOMMENDATION

The achievement of boys in the boys-only schools and girls in the girls-only schools was found to be significantly improved by the use of the PSA teaching strategy. Based on the study findings, it was recommended that the Government of Kenya through the Ministry of Education should set up more single-sex schools and stream the current co-educational schools into single-gender classes and warmly endorse PSA as the classroom instructional strategy.

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