Effects of Problem - Solving Approach to Teaching Mathematics on Students' Achievement in Secondary School in Murang'a County, Kenya

GAKINYA KIGAMBA JOHN

School of Education

Mount Kenya University

Abstract

This study examined the effects of problem – solving to teaching of Mathematics on students' achievements in secondary schools in Murang'a County. The study was guided by the following four objectives to: establish the preference for conventional strategies in teaching Mathematics over problem – solving strategies in teaching secondary school, compare students' performance in Mathematics for those taught using problem - solving strategies with those taught using conventional strategies, assess the students change in attitude towards Mathematics when taught through problem - solving strategies and develop a prototype lesson plan for problem – solving in teaching of Mathematics in secondary schools in Murang'a County.

KEYWORDS: Mathematics, Education Students, Examinations, Teachers

Background to the Study

Mathematics teaching involves the learner, teacher and the society. To achieve the intended aims and goals, the three must be involved (Lesh & Zawajewki, 2007). This study involved learners and teachers through problem – solving to obtain meaningful solutions to mathematical problems. The learner was involved directly in solving real life problems. This was done using problem - solving strategies in specified learning conditions in schools. These conditions provided different learning situations under controlled classrooms. In Plato's division of the liberal arts trivium which included Mathematics, Literature and Gymnasium. This historical perspective has shown that mathematical knowledge occupies the highest status in form of cognitive knowledge. These early fathers of Mathematics considered it to be most essential subject because it teaches students how to think, how to be creative and resourceful by providing them with tools to use (Microsoft Encarta, 2017). According to these early Philosophers, Mathematics is the subject that takes a significant position in developing the individual logical reasoning and plays a significant role in enhancing the country's socio-economic development. This means that social functions in our daily activities involve Mathematics. These social functions include merchants, economics, technology, engineering and biological sciences (Uchechi, 2013).

The core target of high quality Mathematics education is development of problem - solving abilities (Hull, Balka & Miles, 2011). Mathematics skills could be effectively passed through concentrated Mathematics instructional teaching strategies which promote learners retention and understanding. Therefore, in this study, the researcher focused on teaching Mathematics through problem-solving strategy to students in Kenya. The study found that Mathematics achievement was improved in secondary schools in Murang'a County through intervention in problem - solving. This study weighed the importance on teaching Mathematics through problem - solving in context and enquiry - oriented environments in which was characterized by teacher "helping students to construct mathematical ideas while given profound opportunity in learning process" (Lester, Masingila, Mau, & Raymond, 1994).

There is a general feeling that to live normal life in many parts of the world, you require everyday use of Mathematics of some kind. It is also believed that greater advancement of technology has an essential background in Mathematics. Therefore, Mathematics is considered as "servant" and "queen" of all sciences. Since all subjects depend on Mathematics, there is need to study it. However, Mathematics is part of education of life-long learning process which is necessarily essential in life (Cockcroft, 1982). What students learn in school is not enough to make practical live in Mathematics. They are able to learn how to arrange working, understanding and apply Mathematics knowledge they acquire in order to deal with complex and diverse questions in their daily life (Singer & Voica, 2013). The learners should have ability to distinguish how to use what they have learned and continue to learn and create "new information" to solve problems they meet when they leave schools. That is why it is important to use problem-solving strategy to teach Mathematics.

The study of Mathematics leads to good thinking, correctness of reasoning and originality. Mathematics becomes necessary tool in the investigation of the world around us. It is cited as the science of understanding models that exist within us and solving problems in our daily life (Agwu, 2015). NCTM (2006) proposed that students at secondary school level of education need to learn Mathematics to do extremely well at higher levels. This would provide the prospect to many countries of the world to remain competitive in terms of economy that is needed for social, scientific and technological development. National Council of Teachers of Mathematics (NCTM, 2012) maintained that every student should have equitable and optimal opportunities to learn Mathematics free from deliberate or unintentional based on race, gender, socio-economic status, or language. To close the achievement gap, all students need the opportunity to learn challenging Mathematics from a well-qualified teacher who would make connections to their background, needs, and cultures of all learners (NCTM, 2012).

Teaching Mathematics through problem–solving allows the learners enjoy to learning Mathematics amusingly than when it is self-generated and enforced by teacher or textbook (Lang & Evans, 2006). This study was carried out using problem – solving by students in teaching and learning Mathematics in secondary schools in Murang'a County. It also provided learners an opportunity to create, investigate and explore the solutions to unfamiliar problems. The learners worked in collaboration in small groups learning through plenty of discussion, solving problems in untried situations which were encouraged through problem - solving instructional strategy. This study will enable students to become resourceful aligned with the Country's National Goals of Education that learners should competently solve problems. The intention was to make Kenya middle earning economy with technological innovations (Kenya Vision 2030, 2010). However, despite this, there was a concern those Murang'a County secondary school students Mathematics achievements have been on plummeting. Bruce (2007) who studied ways to get better achieving students suggested that education experiences in Mathematics would explain that dialogue in Mathematics classrooms is very significant in student's achievements. Students in Mathematics classroom feel like a community where constructive ideas could be discussed, developed, questioned and understood (Bruce, 2007).

According to Singer and Voica (2013), in ordinary life, people naturally solve problems in order to satisfy their various needs. Problem- solving is a long – life process which is practised in and out of school. The main objective of secondary school education is to equip students with skills for solving problems to a pertaining variety of areas. Christy and Lima (2007), problem - solving involves higher cognitive skills organised in a systematic order applying an approach of collecting information in order to make a synthesized educated decision. A supportive teacher who engages students in a classroom environment is important to help in developing students' self-confidence in understanding mathematical concepts (Christy & Lima, 2007).

During the past four years KCSE results in Murang'a County have exposed that more than 70% of students succeeded to obtain grades D, D- and E, which are weak grades as assessed by KNEC. This achievement has been similar to National Mathematics performance according to KNEC results analysis. According to Kenya Educational system, Mathematics learned in form one and form two have adequate content for students to gain a desired grade C or better since form one and form two syllabus covers paper one and papers two about 60% of national examination. The results of Murang'a County have been on decline, although form one and two work is sufficient for someone to perform better than grade C. The numbers of secondary schools in Murang'a County were categorized as A, B, C, and D. These categories of schools were based on the past four years in KCSE examinations Mathematics performance prior to the time of this study. Table 1.1 shows the number of students' Mathematics KCSE entry in each category in secondary schools in Murang'a County during the period of 2014 to 2017. Table 1.2 shows results of each category. The mean score shown in the table reflect that few secondary schools perform extremely well whereas majority of the schools obtain below average grades.

Table 1.1: Student in Mathematics KCSE entry in secondary schools in Murang'a County

between 2014 and 2017

Category	2014		2015		2016		2017	
Mean score	Number of Schools	Number of students	Number of Schools	Number of students	Number of Schools	Number of students	Number of Schools	Number of students
A: $6 \leq X \leq 12$	20	3220	20	3430	20	3354	20	3697
B: $4 < X < 6$	35	3246	35	3241	35	3531	28	3450
C: $3 \leq X < 4$	60	3813	60	4724	60	4879	57	4094
D: $1 \leq X < 3$	195	10327	200	11410	208	11778	228	12301
Totals	310	20536	315	22845	323	23542	333	24633

Source: Murang'a County Education Office, 2018

The table 1.1 shows that most secondary schools in Murang'a County obtain mean grade below 3 which proves that majority of students achieve grade D. The past KCSE results have shown that more than 70% of students attain grades D+, D, D- and E in Mathematics each year. The national performance of Mathematics in secondary schools in Murang'a County in the years 2014, 2015, 2016 and 2017 were an expected. This national examination performance could be improved through studying Mathematics problem solving using situations happening in secondary schools in Murang'a County, whose Mathematics students' performance in KCSE were indicated that results during 2014 - 2017 as shown in Table 1.2 had same trend. The main results revealed that most mistakes made by students are misconception, misunderstanding and language interpretation. These mistakes pointed more to the pedagogical approach of teaching and learning Mathematics. Although most teachers in Murang'a County were trained in Diploma and Bachelor of Education graduates, the strategies they use had contributed to these declining results.

Table 1.2: Students' Performance in Mathematics in KCSE between 2014 and 2017 per category

in secondary schools in Murang'a County

Grades mean scores	Mean 2014	Mean 2015	Mean 2016	Mean 2017
A:$6 \leq X \leq 12$	7.284	7.471	6.748	7.418
B:$4 < X < 6$	4.346	4.638	4.184	4.591
C:$3 \leq X < 4$	3.39	3.24	3.044	3.316
D:$1\leq X < 3$	1.012	1.006	1.068	1.0023
Totals	4.012	3.941	3.460	3.629

Source: Murang'a County Education Office, 2015

They have a good command of content as well as teaching strategies. They have also participated in project and seminars in strengthening Mathematics and sciences in secondary schools (SMASSE). This was an indication that the cause of low achievement was due to methodologies employed by teachers. Since majority of schools performance is below average, the researcher investigated whether problem – solving approach would alleviate their Mathematics achievement. In the table 1.2, it means that student's performance is affected by the extreme values shown by the quality grades A - C+ in Mathematics (15%) which is the entry grades for University admission. These entry grades are important particularly in studying Science - oriented subjects including Business and Economics, (Kenya University & College Central Placement Service (KUCCPS), 2017).

Miheso O'Connor (2009) noted that students in Kenya are engaged in activities of demonstrated algorithm by their teachers in a procedural level which does not assist students develop conceptual understanding. However, this study involved learners in organized groups to face the challenges of learning Mathematics in secondary schools. Students who were weak found it significantly difficult, although normal rationalization is usually associated with poor Mathematics abilities. Their difficulties included basic Mathematics facts, reading and interpreting problems. This research through quasi - experiment on effect of using problem - solving strategies addressed the gap in the achievement through learners' involvement to construct Mathematics, ability to use Mathematics tools and change of attitude towards formation of Mathematics culture. According to Polya (1957), problem - solving needs practice when deciding on methods required to be used to solve problems. The first thing to do is to look for hints through guessing and experiences of similar problems. Hints are the most important skills in solving problems (Polya, 1957). This study investigated how teaching Mathematics through problem –solving in secondary schools in Murang'a County improves students' achievement. Uchechi (2013) submitted that the students' poor performance in Mathematics in Nigerian Public examinations in secondary schools is traceable to lack of content coverage and poor teaching methods by teachers. This is similar to Kenyan situations. Table 1.3 shows the grades of Mathematics in number of secondary schools in different categories in 2015 as a sample of grades obtained in Table 1.1.

Table 1.3: Students' Performance in Mathematics in KCSE in 2015 in Murang'a County

Category	Entry	A	B	C	D	E
A	3430	768	992	979	653	38
B	3281	90	500	879	1573	240
C	4724	66	317	801	2604	936
D	11410	46	302	742	5399	5136
Total	22845	970	2111	3401	10229	6134

Source: Murang'a County Education Office Mathematics Result Analysis, 2015

Table 1.3 shows Murang'a County Mathematics performance according to ranking, the top 20 schools seem to have reasonably quality grades particularly the 'A' grades within the County. In these schools, about 79.2% grades A whereas the remaining 19.8% to be shared by 295 schools in 2015. The instructional strategies used by these schools were investigated and compared with the ones used by the lower 295 schools. The weak performing schools have 93.6% grades D and E in secondary schools in Murang'a County. The tables also give emphasis of those secondary schools whose performance in more than 200 schools curriculum outcome in secondary schools in Murang'a County is below community expectations. The most important factors for improving Mathematics performance are students' involvement in creating and thinking through the problem (Polya, 2011). By involvement, it means how much time, energy and effort students dedicate to the learning process through problem – solving which this study propose to investigate. The main purpose of this study in the Murang'a County was to inspire learners to discover, cultivate and apply relevant Mathematics concepts after understanding through problem – solving. Students were directed all the way through the development of inquiry and problem – solving processes (Barbeau & Taylor, 2009).

In Malaysia, students' performances at secondary school level of education remained very low and continued to decrease. Mathematics achievement test in TIMSS in 2012 clearly indicates how well students in Singapore have done. The poor Mathematics performance of the students becomes a major concern among Malaysian educational stakeholders. This brings about the need for the government to look at the policy for teaching mathematics. This policy was then commenced and takes up properly after a period of five years in the level of education. In Nigeria, good performance in Mathematics is one of the basic requirements for admission into tertiary institutions (Adeyemi, 2011). Candidates with distinction and good credit grades in five subjects including Mathematics and English language possess the required grades for admissions into Nigerian universities. Emaikwu (2012) in his research 'Effectiveness of three teaching methods in the measurement of students performance in Mathematics in Nigerian secondary schools' there has been drastic drop in the achievement level of learners in Mathematics for the past decades. Uchechi (2013) proposed that students' poor performance in Mathematics in Nigerian public examinations is traceable to lack of content coverage and poor teaching methods by teachers.

In Kenya, the language instruction in learning Mathematics at secondary schools contributed to low outcome in Mathematics curriculum. The students need to learn mathematical language to be meaningfully able to interpret Mathematics problems (Benson & O'Connor, 2015). This could be provided by exposing learners to problem solving. The resultant effect is the poor performance and low retention level in learners' achievement at the national examinations. In view of this observation, there is a serious and great concern among the educational stakeholders and parents. Mathematics is compulsory in Kenya secondary schools curriculum despite the difficulties in the teaching and learning. The poor curriculum outcome in Mathematics may affect individual future career development (Ministry of Education, MoE, 2002). Low performance in Mathematics in Murang'a County would affect future generation on career choices. Therefore, because increasing weak performance in most secondary schools in Mathematics in Murang'a County, there was need to study the instructional strategies preferred by practising teachers and the prominence of problem -solving teaching strategy to improve students' achievement in Mathematics. Secondary schools students being unsuccessful in Mathematics might have caused by misuse of instructional strategies in which problem-solving strategy was not correctly applied. Through reasonable argument the question is "Why do incompetent teachers engage learners in problem-solving?"Most teachers argue that they do not understand the breadth of problem-solving activities well enough to connect and support learners in them. Problem-solving has never been sufficiently articulated in the instructional strategies (Martin, 2007). The behaviorist practices are emphasized in transmission of knowledge and stress the pedagogical value of formulae, procedures drill and product rather than processes.

2. Methodology

The study employed quantitative quasi – experimental design. The Solomon Four Group design in which 16 schools were sampled according to the category in their previous four years KCSE performance. The target population was 104562 students and 1365 Mathematics teachers in 340 secondary schools in Murang'a County. Form three students comprising 28,475 were sampled. Four schools randomly sampled represented each category where two schools were experimental and two schools were control comprising a sample size of 544 students and 16 teachers. Eight schools participated in pre-test and all 16 schools received post- test Mathematics achievements tests after intervention. Delphi questionnaire was used to collect data on Mathematics teachers' preferred conventional methods of teaching Mathematics. Students' Mathematics attitude questionnaire was used to collect data on students' attitude towards Mathematics in both control and experimental groups. Data from the research instruments were coded and analysed using Statistical Package for Social Sciences (SPSS) version 22. Analysis of Variance (ANOVA) was used test hypotheses where more than three or more, independent t-test was used to test hypotheses at 0.05 level of significance where two variables were involved, Kendal –tau for comparison of used on preferred strategies and Cohen's d. was to determine the effect of power test. Analysis of data generated from students pre-test revealed that, the effect of problem - solving performance was insignificant ($t\ (273) = 0.924$, Cohen's $d = 0.17$ which is small, $p > 0.05$).

3. Research Findings and Discussions

Students Mathematics Performance

The second objective of the study was to compare performance of students in Mathematics for those taught using problem - solving strategies with those taught using conventional method in secondary schools in Murang'a County. These are considered as being conceptual and cognitive growths were determined by the achievement test using pre-test and post-test questionnaires. The students' were expected to learn Mathematics through problem - solving strategy or other conventional strategies. This study suggested that the students' conceptual understanding was developed better using problem – solving than on procedural knowledge using conventional methods in secondary schools in Murang'a County.

Experimental and Control Groups Pretests

The various combinations of tested and untested groups with treatment and control groups allowed the researcher and extraneous factors to have not influenced the results. E1, C1, E2, and C2 are exactly the same in all four categories according to their previous national examination. They were drawn four similar schools with the same standards. The first hypothesis was that there was no difference in performance to Mathematics achievement (performance) test between the experimental group and the control group. The pre-test involved experimental, E1 and control, C1 groups. The results are shown in table 4.6.

Table 4.6: Pre – test performance per category

	Experimental			Control		
Category	No of respondents	Mean	Standard deviation	No of respondents	Mean	Standard deviation
A	33	54.67	6.79	45	50.44	8.79
B	35	44.94	11.09	35	42.57	10.74
C	40	28.75	13.36	40	30.48	7.71
D	20	25.55	15.15	27	14.70	9.65
Combined	128	39.36	16.39	147	36.57	15.79

Source: Field study, 2018

Table 4.6 shows that there is no difference between groups except from the categories which are due to entry point at secondary school from primary schools where category A are those in national and extra - County schools. The other three categories are from county and sub – county secondary schools. I tested this hypothesis by carrying out a two – sample t –test on the mean scores of the pre –test between the combined experimental group and the control group and the results as shown in table 4.7.

Effects on Students Performance by Experimental and Control Groups Pre-tests

The study employed the Solomon Four - Group design. These had enabled the researcher to have two groups in each category to sit for pre- tests as recommended by Borg and Gall (2003). The two groups were Experimental group (E1) and Control group (C1). A pre-test was conducted before commencement of the treatment therefore; it was administered to schools involved in groups E1 and C1 prior to the experiment. The pre-test contained 20 items that sought to test students understanding of numbers, number patterns, basic algebra, geometry, measurement and arithmetic which were the focus of this study. The mean scores and standard deviation of the two groups (E1 and C1) were computed. The results were recorded in table 4.7.

Table 4.7: Pre – test performance per group

Combined group	NUMBER	MEAN	VAR	STDEV	Standard error	95% Confidence	T–value
E1	128	39.36	268.66	16.39	1.454	36.52 - 42.20	1.43
C1	147	36.57	249.22	15.79	1.307	43.02 - 39.12	
Combined	275	37.87	259.26	16.10	0.969	35.97 - 39.77	
Difference		2.79					

Pr (T > t) = 0.17

Source: Field study, 2018

VAR: Variance

STDEV: Standard Deviation

Table 4.7 shows that students from experimental group E1 performed slightly better than students from control groups C1 in the pre-test Mathematics performance. This was affected by the mean score of schools in category D, since mean is usually affected by extreme values. To test whether there was a significant difference on effect on students' performance between experimental group E1 and control group C1 in the pre-test, a t-test was computed. In table 4.7 the independent t-test reveal a statistically insignificant difference in the mean scores of pre - test for the experimental (E1) and control groups (C1) at $t (274) = 1.43$, $p = 0.0233$ at $\alpha = 0.05$ where $p > 0.05$. This clearly indicated that students' performance in the pre - test was similar and their level of understanding in problem - solving is the same. Table 4.7, also shows that there was no means difference between groups. The slight mean difference was not statistically significant at $\alpha = 0.05$ as $t = 1.43$ with a small effect size of $d_s = 0.17$ from Cohen's power test interpretation. This shows that the groups were of the same strength in terms of performance of Mathematics achievement test before intervention was initiated.

Thus, the hypothesis which stated that, there was no significant difference on the effects in students' performance for those taught using problem - solving approach and others taught using convention method was retained. This finding agrees with Njoroge & Githua (2013) who in their study found that there was no statistical significance between experimental and control groups' difference in the pre - test Mathematics Achievement Test before commencement of the intervention on Cooperative learning strategy. The study was also interested in determining the attitude of students taught using problem - solving approach had no significant difference in students' attitude before commencement of the treatment using only experimental groups E1 and E2.

Effects of Post – test Students' Performance

The researcher employed the Solomon Four Group designs where all groups experienced the post - test. The comparison between the post–test results of groups E2 and C2; allows the researcher to determine if the actual act of pre – testing influenced the results. To further investigate the stated objective number one and hypothesis one. The post - test was administered to the same categories of students in their schools. The post-test contained 20 items which were based on topics set in the pre -test. The topics discussed during intervention were similar to both pre- test and post -test. The post – test topics included the similar topics that were used during the intervention period and further practice given using textbooks. The intervention topics included natural numbers, number patterns, Algebra, geometry, fractions and integers which provoke learners' creativity.

Analysis of the post - test results are tabulated in table 4.8, table 4.9 and table 4.10 which gives the mean score of students' performance in the post-test of groups E1, C1, E2 and C2. To find out whether there is significant difference in the performance.

Table 4.8: Pretest E1 & C1 and Post – test C2 performance per group

Combined group	NUMBER	MEAN	STDEV	Standard error	95% C -I	T – value
E1 pre-test	128	39.36	16.39	1.454	36.52-42.20	
C1 pre- test	147	36.57	15.79	1.307	34.02 – 39.12	
C2 post - test	143	34.92	14.53	1.219	32.54-37.30	
Combined	418	40.66	15.40			

Source: Field study 2018

Table 4.8 shows that students of experimental group E1 and control C1 pre - test have same performance as control group C2 in the post -test. The claim that C2 control group has the same mean at post - test as it was with experimental group E1 and control C1 group pre - test. To test this, hypothesis I used ANOVA. The null hypothesis to test the differences in more than two normally distributed populations. S^2_B means variations between the means which implies variations of the group means about the overall mean, GM. S^2_W the variations within group variations. This is where variations of the individual values about the group means. Table 4.9 shows the ANOVA table to show that the groups in the study have a common entry point at any first test.

Table 4.9: ANOVA Pre – test E1 and C1 and Post – test C2 performance on three groups

	Variation	Df	Mean square	$F = \frac{S_B^2}{S_W^2}$	P -value
Between groups	3.2391	2	1.62	0.0138	
Within groups	242.10	415	0.583		
Total	245.34				

Source: Field study 2018

I accepted the null hypotheses since there is enough evidence that the three mean scores had no difference between the groups before any treatment is done. The critical value at F (2, 415) is 3.018, whereas the tabulated F = 0.014 (0.014 < 3.018). The null hypothesis is accepted that means are the same for both experimental and control groups before intervention. It also revealed that control group E1 has better performance than C1 as shown in table 4.10 of the post-test. This is a clear indication that the pre-test has had some effect upon the result of post - test. Table 4.10 shows that if there is effect in achievement after treatment of experimental group E1 and control C1 both groups received pre - test before intervention was commenced. The two groups also received post - test immediately after intervention. The claim is that there is no significant difference in Mathematics between students Mathematics using problem -solving approach and those taught using conventional strategies in secondary schools in Murang'a County.

Table 4.10: Statistics for Mathematics Achievement assessment paired differences post test experimental group E1 and control group C1

Variable	Mean	Standard deviation	Standard error	95% confidence interval		t	Degree of freedom
				Lower	Upper		
PosttestE1	48.91	15.42	1.368	46.24	51.58	5.334	274
PosttestC1	38.15	16.26	1.346	35.52	40.78		
Combined	43.53	15.82	1.245				
Difference	10.76						

Pr (|T| > t) = 0.68

Source: Field study 2018

According to table 4.10, it can be seen that there is a significant improvement in students' problem – solving performance after the intervention period. It is obvious that problem - solving can enhance students' problem – solving performance in Mathematics. The result from observation rating scales of problem – solving and students showed the changes of students' behaviour. Observation results showed an average ability of students who could read the problem carefully throughout the intervention period. But she\he used different strategies to persevere with problems and never checked solutions. During intervention period, the learner tried problem better and better getting closer to solution while peer partners gave her/him opportunities to see the different ways to approach mathematical problems. The hypothesis is rejected that the mean scores of post - test for both experimental group E1 and control group C1 are the same. There was a significant difference, since 5.334 > 1.967. The mean of experimental group was significantly higher than that of control group at post - test. The Cohen's d is 0.68 which shows that there is moderate positive effect size of the means difference.

Table 4.11 shows the post - test of experimental group E1 and control C2. The hypothesis that problem solving strategies in teaching and learning Mathematics have no significant effect on the students' performance in secondary schools in Murang'a County.

Table 4.11: Statistics for Mathematics achievement assessment paired differences post test

Experimental group E1 and control group C2.

Variable	Mean	Standard deviation	Standard error	95% confidence interval		t	Degree of freedom
				Lower	Upper		
PosttestE1	48.91	15.42	1.368	46.24	51.58	T = 7.663	
PosttestC2	34.92	14.53	1.219	32.54	37.30		
Combined	41.92	14.90					
Difference	13.99						

Pr (|T| > t) = 0.94

Source: Field study 2018

The analyses of the post – test results are shown in table 12. The table shows there was statistical difference in the mean scores between the two groups as $p > 0.05$ and $t = 7.663$. This shows that $7.663 > 1.96$, reject the null hypothesis on the basis that differences are significant that there evidence that the means are not equal. The Cohen's d of 0.94 which shows that there is large positive effect size of the means difference which shows that the pre - test has slight effect compared with table 4.11 where C1 had received pre - test.

Table 4.12: Statistics for Mathematics Achievement assessment paired differences post – test

experimental group E1 and experimental group E2.

Variable	Mean	STDEV	Standard error	95% confidence interval		t	Degree of freedom
				Lower	Upper		
Posttest E1	48.91	15.42	1.368	46.24	51.58		127
PosttestE2	45.80	14.24	1.274	43.31	48.29		125
combined	47.37	14.90	0.937	45.54	49.20	T= 1.67	252
difference	3.11						

Pr (|T| > t) = 0.2087

Source: Field study 2018

Table 4.12 shows the two experimental groups E1 and E2. The groups' commenced treatment at the same time, but E2 did not receive pre - test. The hypothesis is that there is no significant difference in means of the students' Mathematics achievement after the post - test when the two groups underwent treatment. The critical value t at 95% confidence limit in degree of freedom DF = 252 is 1.967 by interpolation. When $t = 1.67$ ($1.67 < 1.9670$), the hypothesis is accepted and there is enough evidence that the means do not have any difference. The Cohen's d of 0.21 which shows that there is small effect size of the means difference which might have affected by the pre - test.

Table 4.13 shows the post - test of control group C1 and control group C2. The hypothesis that there is no difference between mean of C1and mean of C2 on the students' performance in secondary schools in Murang'a County.

Table 4.13: Statistics for Mathematics Achievement assessment paired differences post - test

control group C1 and control group C2

Variable	Mean	Standard deviation	Standard error	95% confidence interval		t	Degree of freedom
				Lower	Upper		
PosttestC1	38.15	16.26	1.346	35,52	40.78	1.775	288
PosttestC1	34.92	14.53	1.219	32.54	37.30		
Combined	36.26	15.49	0.911	34.48	38.04		
Difference	3.23						

Pr (|T| > t) = 0.2085

Source: Field study 2018

Table 4.13 has shown that the two post - test for control groups C1 and C2. The groups did not receive any treatment at the same time, and C2 did not receive pre - test. The hypothesis is that there is no significant difference in means of the students' Mathematics achievement after the post - test when the two groups did not undergo treatment. The critical value t at 95% confidence limit in degree of freedom DF = 288 is 1.968 by interpolation. When t = 1.775 (1.775 < 1.968), the hypothesis is accepted and there is enough evidence that the means do not have any difference. The Cohen's d of 0.21 which shows that there is small effect size of the means difference which might have affected by the pre - test.

Table 4.14 shows achievement of post - test for combined experimental groups and combined control groups. Table 4.12 and table 4.13 have already shown that there are no significant differences in means of E1 and E2 or means of C1 and C2.

Table 4.14: Mathematics achievement post–test for combined experimental and control groups

Variables	No of respondents	Mean score	Standard deviation	Standard error	95% confidence interval	
					Lower	Upper
Post – test E1	128	48.91	15.42	1.368	46.24	51.58
Post – test E2	126	45.80	14.24	1.274	43.31	48.29
Combined	254	47.37	14.90	0.937	45.54	49.20
Difference		3.11			-2.46	2.70
Post – test C1	147	38.15	16.26	1.346	35.52	40.78
Post – test C2	143	34.92	14.53	1.219	32.54	37.30
Combined	290	36.56	15.49	0.911	34.48	38.04
Difference		3.23			-2.42	2.59

Pr (T > |t|) = 0.287

The control groups C1 and C2 have t value 1.775 which is less than critical 1.96 at 95% confidence interval. As t – score is within this value, there is nothing to suggest that there is any difference between the two means and the hypothesis is accepted.

Table 4.14 shows that students of experimental groups E1 and E2 have better performance than control groups C1 and C2 in the post - test. When this two experimental E1 and E2 combined and two control C1 and C2 combined yielded Cohen's d 0.71 which had moderate positive effect. It also revealed that experimental group C1 had better performance in the post - test than C2 because of pre - test before post - test. This established that there are some external factors which have caused minimum temporal increment. The slight difference between E1 post - test and E2 post - test shows the effect that pre - test has had upon treatment. Further, it shows there was statistical difference in the mean scores between the experimental group E1 and control groups C1 and C2. The difference also existed between experimental group E2 and control groups. This is a clear indication that experimental groups E1 and E2 who were exposed to problem solving approach have shown a better performance than the control groups C1 and C2 respectively. The implication here is that when learning Mathematics through problem - solving strategies, students' performance increased. This was supported by results of Lesh and Zawojewski, (2007) observation that engaging students in mathematical problem - solving activities would help them discover mathematical ideas. Hence students' achievement is enhanced. Table 4.15 shows post - test performance per group and ANOVA hypothesis testing is applied. It also shows the tabulated values for ANOVA.

Table 4.15: Post – test performance per group

Combined group	Number	Mean	Standard deviation	Standard error	95% C -I	T – value
E1	128	48.91	15.42	1.368	46.24-51.58	
C1	147	38.15	16.26	1.346	35.52-40.78	
E2	126	45.80	14.24	1.274	43.31-48.29	
C2	143	34.92	14.53	1.219	32.54 - 37.30	
Total	544					

Source: Field study 2018

Table 4.15 shows that there are significant differences between the post - test experimental groups mean scores and the post - test control groups mean scores, with ($t = 1.967$) and ($t = 1.96$) and small effect size of $f = 0.18$. The post - test items develop on higher order thinking skills that required students to reason before applying procedure for getting solutions. The assessment involving synthesis and evaluation levels as according to Blooms (1956) taxonomy of cognitive objectives categorization. This shows that a problem – solving strategies to teaching and learning Mathematics can assist students to reason and help them to develop creative and critical thinking which improves their understanding of Mathematics concepts and hence improvement in performance. Students' achievements and understanding are significantly improved when teachers are aware of how students construct knowledge familiar with the intuitive solution methods that students use when they solve problems. Teachers should utilize this knowledge when planning and conducting instruction in Mathematics allowing students' collaborative interactions.

To test hypothesis one (H1) which states that, there is no statistically significant means difference in the effect of problem approach solving on secondary schools students performance on those taught using conventional strategies. Analysis of variance

(ANOVA) was carried out on post - test scores. Table 4.16 gives the result of the ANOVA of the difference in the post test scores.

Table 4.16: ANOVA Post – test performance on four group

	Number	Mean	Variance	Between groups	Within groups
E1	128	48.91	237.72	583.17	229.82
C1	147	38.15	264.39		
E2	126	45.80	202.80		
C2	143	34.92	211.03		
Combined	544	41.95			

Source: Field study 2018

S_B^2 : The between group Variations

S_W^2 : The Within group Variations

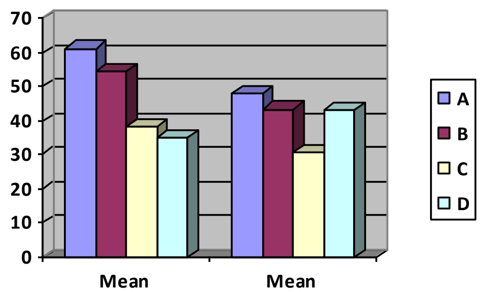
Table 4.16 shows that there was a significant mean difference in the student performance in the post - test between the 4 groups, $F(540) = 2.537$, $p = 0.01$, $\alpha = 0.05$ where $p < 0.05$. The study concluded that using problem - solving in teaching and learning increases students achievement (performance) in Mathematics. Therefore, the hypothesis (H2) which states that, there was no significant difference in students' performance in Mathematics taught using problem - solving approach and those taught using conventional strategies in pre - test and post - test in secondary schools in Murang'a County was rejected. Since this result was statistically significant, the acceptance of that teaching through problem – solving improves the student Mathematic achievement agreed with Kirtikar (2013). Kirtikar reacted on the criticism that conventional teaching did not trigger critical thinking. The cognitive skills and holistic learning environment for students through problem – solving. This study had shown that teaching through problem - solving the students improved the Mathematics achievement. The tables 4.17 and table 4.18 had shown that it existed in the categories and with or without pre - test respectively.

Table 4.17: Post – test performance per category

	Experimental E1 and E2 combined				Control C1 and C2 combined			
Category	NO.	Mean	STDEV	C.I.	NO.	Mean	STDEV	C.I
A	66	61.14	8.66	59.05 - 63.23	90	46.60	11.2	44.29 - 48.91
B	62	54.46	9.58	52.07 - 56.84	61	43.31	9.53	40.92 – 45.70
C	72	38.42	9.64	36.19 - 40.65	77	31.63	10.87	29.20 – 34. 06
D	54	34.32	14.14	30.55 - 38.09	62	28.67	12.32	15.60 - 21. 74
Combined	254	47.37	14.90	45.54 - 49.20	290	36.56	15.49	34.78 – 38.34

Source: Field study 2018

Figure 4.1: ***Category comparisons*** experimental E1 & E2 and ccontrol C1 & C2



Experimental E1 & E2: Control C1 & C2

Figure 4.1: Category comparisons

Table 4.17 has shown that students' who were presumed to be of low ability, the study shows that there significant gains in Mathematics achievement after intervention of E1 & E2. The control groups C1 & C2 did not improve the Mathematics achievement. The effect size is Cohen's d is 0.71 which is a moderate positive effect in the combined groups. Therefore, the evidence is enough to accept the null hypothesis that the mean scores between control groups and experimental groups are significant.

Figure 4.1, reveals that each category improved after intervention despite the ability of students. The bar graph shows almost a similar increments spread throughout the categories. These shows that teaching Mathematics through problem – solving has a positive impact on the student achievement. The respondents of control groups scored less mean score compared with experimental groups. The importance of these statistics is to show pictorial perspective of each category.

Table 4.18: Solomon Four Group Pre - test and Post - test comparison performance

	Number	Mean
Pre-test experimental E1	128	39.36
Post-test experimental E1	128	48.91
Pre – test control C1	147	36.57
Post – test control C1	147	38.15
Post – test experimental E2	126	45.80
Post – test control C2	143	34.92

Source: Field study 2018

There was no significant difference in performance between the experimental category groups. Similarly, was no significant difference between category control groups. The study found that classrooms community and culture promote students Mathematics achievement in all types of schools. The findings conclude that there is significant improvement in Mathematics achievement between those students who used problem - solving and those students who used conventional strategies.

Figure 4.2: ***comparisons*** *Experimental E1 & E2 pre –test and post - tests and*

Control C1 & C2 pre-test and post -tests

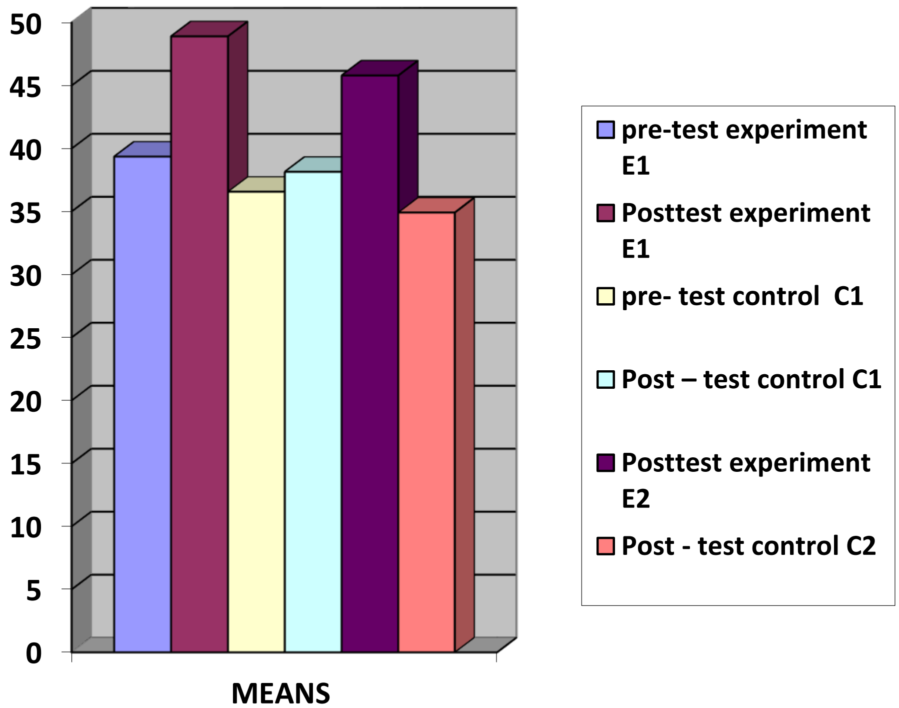


Figure 4.2: comparisons of all tests

Figure 4.2 presents findings on the availability of physical facilities that had affected teaching and learning of Mathematics in secondary schools through creating environment for problem - solving. The category comparison confirms that improvement of Mathematics achievement was almost the same in respect of the schools.

Attitude towards Mathematics

The third objective of the study was to assess students change in attitude towards Mathematics when taught through problem – solving approach with those taught using conventional methods. This study compared the attitudes toward Mathematics between the two groups (experimental and control) at both pre - test and post – test levels. Table 4.19 shows the summary of the mean scores and standard deviation for pre – test results. Table 4.19 has shown that there is no statistical difference between the pre – test experimental group (E1) mean score and pre – test control group (C1) mean score , with $t = 0.16$ at $\alpha = 0.05$. This shows that the attitude of the students were at the same level.

Table 4.19: Two – sample t –test with equal variances on the mean scores of the pre –test for

Experimental E1 and control group C1.

Variable	No of respondent	Mean score	Standard deviation	Standard error	95% confidence interval	
					Upper	Lower
Pre – test E1	128	45.6	3.04	0.19	45. 07	46.13
Pre – test C1	147	45.52	4.07	0.30	44.86	46.18
Combined	275	36.99	3.61	0.17	36.56	37.42
Difference		0.08			-0.5	0.68

$P > 0.05$ $P(|T| > |t|) = 0.02$ $t = 0.16$

The attitude questions were distributed into three sub- scales. These scales were for monitoring students' attitude to learning Mathematics through problem – solving. These subscales include Mathematics behaviour (MB), Mathematics confidence (MC) and Mathematics Engagement (ME). The elaborative feedback on treatment of experimental and control groups was given by computing experiences separately instead of giving total score. The post - test attitude could be reported as individual item rather than aggregate results (Ross & Morrison, 2002). Table 4.20 shows post - test results according to individual items MB, MC and ME in percentage scores. The students interacted and discussed during intervention so they gained confidence, changed behaviour and they were engaged in Mathematics.

Table 4.20: Posttest comparison attitude of experimental groups E1&E2 and controlC1 &C2

	Number	Percentage
Experimental MB	254	24.5%
Experimental MC	254	34.5%
Experimental ME	254	21.5%
Control MB	290	20.5%
Control MC	290	27%
Control ME	290	18%

Source: Field study 2018

There was significant improvement in attitudes towards Mathematics and students achievement when taught through problem - solving. This was in agreement with Dutton who claimed that most standardized achievement tests in Mathematics were obtained in subtests in attitude on problem - solving. The study shown on table 21 revealed that Mathematical attitudes was promoted through problem - solving. Attitude assessment towards Mathematics revealed that experimental groups after post - test at 80.5% against control groups 65.5%.

*Figure 4.3: **Students' attitude Mathematics Behaviour, Confidence, and Engagement***

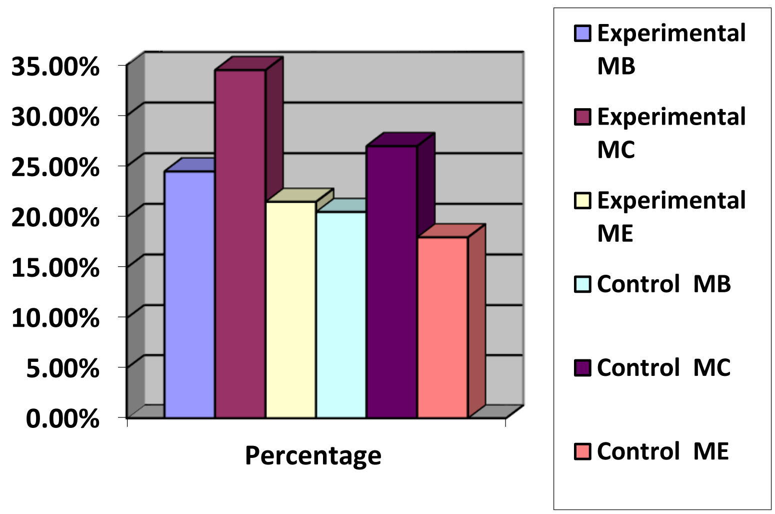


Figure 4.3: Students' attitudes

The chart shows that experimental components were all better than in control groups after intervention. Mathematics behaviour included the students' reaction on the subject while Mathematics confidence increased. The activities during intervention improved learners' engagement.

Prototype Lesson Plan

The fourth objective of the study was to develop a prototype lesson plan for problem –solving in teaching Mathematics in secondary schools in Murang'a County. Problem – solving model lesson plan consist of a structural systematic approach. This is first to ensure that there is consistency in students participation. The teachers and students are required to know what process others are using to keep the process more scientific. Second, the model provide a focus for the group activities where the individual contribution in making – decision to arrive at consensus. The group having considered are possible causes of a problem and all possible solutions. The model uses a series of logical steps to help a group identify the most important causes of the best solutions.

Third, the model will provide avenues to test all the steps and eliminate those which can work in a given situation. This model presents process improvement activities to arrive at a better solution. The model is developed using Bloom's cognitive taxonomy domain. The steps are as follows:

Step one: The learner has acquired knowledge to enable her/him to define the problem. The problem is diagnosed and redefined according to student experiences. If the concept is not familiar the teacher guides the students.

Step two: The student determines the root causes of the problem related concepts. The student must synthesize what he\she has learned and apply it to a new situation.

Step three: The student generate the solutions which are related to the concept. The student can develop alternative solutions and attempt to work the problem backward. The algorithm followed and devised plan can be explored further through students' interactions.

Step four: The student select a solution which is acceptable. The heuristics plan of carrying out problem –solving by selecting suitable strategies.

4 Conclusions

The study has shown that a general problem - solving strategy has been successful in school practice even in the lower category (D). This was confirmed by Lesh and Zawojewski (2007) who suggested that there is need to teach more specific problem - solving strategies to let students effectively deploy their problem – solving strategies and content knowledge. Peer partners and small problem - solving groups gave learners opportunities to see the different ways including teammates approach to mathematical problems. First, the study concluded that a well-developed, planned and executed problem -solving instruction can significantly improve students' achievement in Mathematics.

Second, an effective mathematical problem - solving strategy can be used to promote Students' interest in Mathematics. The teacher would be fully prepared since the strategy is more of student - centred rather than teacher - centred.

Third, problem - solving as the strategy enhances students performance in Mathematics since there will be better improved understanding of the problem and even compute Mathematics in classroom community. The fourth conclusion was that problem solving instruction should be developed and used to enhance deeper understanding and achievement on students'.

REFERENCES

Adeyemi, T. (2011). A comparative study of students' academic performance in public examinations in secondary schools in Ondo and Ekiti States, Nigeria. *Current Research Journal of Economic Theory* Vol. 3(2).pp.36 - 42

Anderson, J., & White, P., (2004). Problem solving in learning and teaching Mathematics, In B Research in Mathematics education in Australasia, 2000 – 2003.

Artzt, A., Armour –Thomas, E., & Curcio, F. (2008). *Becoming a Reflective Mathematics Teacher.* New York Lawrence Erlbaum Associates

Benson, W. & O-Connor, M. (2015). Effects of Mathematical Vocabulary Instruction on Students' Achievement in Mathematics in Secondary Schools of Murang'a County, Kenya. *Journal of Education and Practice* Vol. 6 (18).

Bloom, B., (1956) *Taxonomy of Educational Objectives* NY: Longmans, Green. (Internet source: November 2014).

Brahier, D. (2009) *Teaching Secondary and Middle School Mathematics* Pearson Education, Inc.p52 -53

Dewey, J. (1954). *Experiences and Education*, a Touchstone Book, Kappa Delta Ps, New York Downloaded www.ascd.org.publication, 23rd May 2014.

Dursun, S., & Dede, Y, (2004). The factors Affecting Students Success in Mathematics: Mathematics Teachers Perspectives. *Journal of Gazi Educational Faculty*

Ellen, A., (2011). Validity and Reliability in Social Science: Research in Education and Research

Perspectives. Vol.38 (1) 105-120.

Fonsnot, C. (2014). *Models of Intervention in Mathematics Reweaving the Tapestry*, USA: National Council of Teachers of Mathematics, Pearson.

Gakinya, K. (1987). *Instructional Strategies Used in Teaching Secondary School Mathematics*. M.Ed. Thesis in Kenyatta University.

Goldstein, E. (2011). *Cognitive Psychology, connecting mind research and every day experience* (3rd ed.). Australia Wadswrith Cangage learning

Heason, K. (2004). *Constructivist teaching strategies for diverse Middle –level classrooms* Boston: Pearson Education.

Kenya *Institute of Curriculum Development, (2002) Secondary education syllabus Volume two*, Nairobi, Kenya: KICD (MoE).

Kenya National Examination Council, KNEC, (2018).*The year 2017 KCSE examination report* With question papers and marking schemes. Volume 2: Mathematics & Science: the text Development department KNEC, Nairobi Kenya.

Lawson, A. (2016*). The Mathematical Territory between Direct Modeling & Proficiency Student Achievement*. Downloaded http/www.edu.gov.ca/eng

Marzano, R., Frontier, T. & Livingstone, D., (2011) *Effective Supervision; supporting the art And sciences of teaching* Alexandria, VA: ASCD.

Mbugua, Z., Mungiri, M., & Reche, N., (2012). Factors Contributing to Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Baringo County, Kenya. *American International Journal of Contemporary Research*; Vol. 2 (6) 87-90.

National Council of Teachers of Mathematics, (NCTM, 2012). Closing the Opportunity Gap in Mathematics Education

National Centre for Educational Achievement, (2010). *Best Practice Framework*. Accessed online at http://www.just4kids.org/en/texas/best practices/framework.cfm, January 24, 2010

Njoroge, N., & Githua, N., (2013). Effects of Cooperative Learning/ Teaching Strategy on Learners` Mathematics Achievement by Gender. *Asian Journal Social Sciences & Humanities;* Vol. 2 (2).pp.569-571.

Odindo, F., (2013). *Teaching and Learning Mathematics through Problem - Solving Activities in Kenya Secondary Schools.* Lambert publishers.

Polya, G., (2004). *On solving Mathematics Problems in High School.* In S. Krulik (Ed), Problem- Solving in School Mathematics, Reston, Virginia: NCTM.

Protheroe, N. (2007). "*What Does Good Mathematics Instruction Look like?"* Principals and Education Research service

Saeed, M., Shahvarani, A. & Behzadi, H., (2012). *The role of problem solving method on the Improvement of mathematical learning.* Mathematical Education Trends and Research.

Singer, M. & Voica, C. (2013). *A Problem – solving Conceptual Framework And it's Implications in Designing Problem posing tasks*: Educational Studies in Mathematics.

Slavin, R., (2007). Educational research in an age of accountability, Boston Pearson Education.

Smith, M. & Kay, M., (2011). Practices for orchestrating productive Mathematics discussion. (National Council of Teachers of Mathematics)

Uchechi, F., (2013). Enhancing Mathematics Achievement of Secondary School Students using Mastery learning Approach. Journal of Engineering Trends in Educational and Policy Studies., 4 (6).pp. 848-854.

Umameh, M. (2011). Survey of students' poor performance in Mathematics Bristol: University of Bristol.

Umay, A. (2007). *EskiArkadasimizOkulMatematigininYeniYuzu*, Aydan Web Tesisleri, Ankara.

Voica, C., & Singer, F., (2013). *Problem modification as a tool for detecting cognitive Flexibility in school children* ZDM, 45(2)

Voica, C., & Singer, F., (2014). Problem posing: A pathway to identifying gifted students. In MCG8 Proceedings (pp. 119–124). Univ. of Denver, Colorado, USA.

Vula, E. & Berdynaj, L. (2011). *Collaborative action research: Teaching of multiplication and* Division in the second grade of primary school. Turkish online Journal of Qualitative Inquiry, 2(2), 7-16.

Walker, J. & Lofton, and S. 2003). *Effect of Problem based Learning Curriculum on Students'* Perceptions of Self - directed Learning, Issues in Educational Research, University of Mississippi Medical Centre.

The Effects Of Holidays On The Ghanaian Equity Market

Alexandra Fafali Kudjawu

Department of Finance, University of Ghana Business School, University of Ghana, Legon, Accra, Ghana. Email: afkudjawu001@st.ug.edu.gh

Charles Andoh*

Department of Finance, University of Ghana Business School, University of Ghana, Legon, Accra, Ghana. Email: candoh@ug.edu.gh

Saint Kuttu

Department of Finance, University of Ghana Business School, University of Ghana, Legon,Accra, Ghana. Email: skuttu@ug.edu.gh

Abstract

This paper sought to determine if the Ghanaian equity market is a semi-strong efficient market by investigating whether or not the holiday effect exists by adopting an ARMAX (2, 2) - GARCH (1, 1) model with GL^+ innovation. The results show that there are significant positive pre-holiday and post-holiday effects which may not be as a result of bearing higher levels of risk. This finding is important to investors to assist strategise better in order to take advantage of this calendar anomaly discovered on the Ghanaian equity market.

Keywords: ARMAX, calendar anomalies, efficient market hypothesis, GARCH, GL^+ innovation, holiday effect.

JEL classification: C22 E37 G14

Introduction

Efficiency of the stock market is one of the fundamental concepts in finance that is used to explain and understand how the stock market functions. In his effort to explain the concept of efficiency, Fama (1970) proposed the Efficient Market Hypothesis (hereafter, EMH). It refers to the notion that capital markets are efficient and that these efficient markets follow the random walk theory, and past information cannot be used to predict the future. The EMH is categorised into three forms that are conditional to three types of information; strong-form efficiency, semi-strong efficiency and weak-form efficiency. Out of these three forms, the weak-form is believed to be the most acceptable due to the attention and weight it has drawn from the academic society (Jarett, 2010). The EMH states that it is extremely difficult and highly impossible to predict stock prices precisely because of the assumption that the market participants are rational, and the determination of the stock prices are as a consequence of the changes in demand and supply. The EMH has currently become one of the significant areas in financial literature, and as a result, there exists much research on this concept (Mlambo & Biekpe, 2007; Lee, Lee & Lee 2010; Jovanovic, Andreadakis & Schinckus, 2016; Jackson & Kremer, 2007; Hung, 2009).