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Effects of Teaching through Problem-Solving on Students Mathematics Attitude Achievement in Secondary Schools in Murang'a County, Kenya

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Abstract
Mathematics low performance at Kenya Certificate of Secondary Education (KCSE) in Murang'a County has been of concern to parents, teachers and other stakeholders. This is because the performance in Mathematics determines student's participation in science oriented programmes in post-secondary level. Many interventions have been put in place but low performance persevered. Mathematics have been targeted by the country (Kenya) to support their development agenda as described in the current vision 2030 which includes social, economic, technological and industrial development. The study examined the effects of teaching through problem – solving on students' achievements in Mathematics in secondary schools of Murang'a County. The study was guided by the following objective to: assess the students change in attitude towards Mathematics when taught through problem - solving strategies rather than other conventional strategies in teaching of Mathematics in secondary schools in Murang'a County. The study employed quasi – experimental design using Solomon Four Group design. The target population was 104562 students and 1365 Mathematics teachers in 340 secondary schools in Murang'a County. Accessible population was Form Three students comprising 28,475. Four schools were randomly sampled from four categories stratified according to their previous four years KCSE performance giving a total of 16 schools: 8 schools experimental and 8 schools control. Total sample size of 544 students and 16 teachers. Students' Mathematics Attitude Questionnaire was used to collect data on students' attitude towards Mathematics in both control and experimental groups. Eight schools participated in pre-test and all 16 schools received post- test Mathematics achievements tests after intervention. Data from the research instruments were coded and analysed using Statistical Package for Social Sciences (SPSS) version 23. To establish if there is any significance means difference between students taught through problem – solving and those taught through conventional strategies t –tests was carried out and in order to establish the effect of problem – solving method approach of teaching Cohen's d. The study established that students pre-test means differences insignificant (t (273) = 0.16) and Cohen's d = 0.17 which is small effect P > 0.05. The post – test revealed that students' performance improved significantly (F (540) = 2.537, p = 0.0025, α < 0.05) and Problem – solving skills helped to change the students' Attitude towards Mathematics Cohen's d of 0.88 which is large. There is overall improvement on Mathematics achievement which benefits students' in secondary schools in Murang'a County to pursue their future career choice. The study recommends that students and teachers should embrace problem – solving rather than conventional methods for better achievement in Mathematics in secondary schools of Murang'a County.

Key Words: Problem – solving, achievement; attitude; Mathematics.

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I. Background

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). The focus of this study investigated the role problem – solving as an approach which may improve students Mathematics achievement. 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 live as a community in Mathematics classroom where constructive ideas could be discussed, developed, questioned and understood (Bruce, 2007).

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).

The performance of Mathematics in secondary schools in Murang'a County triggered this study to examine effects of teaching through problem – solving approach on students' Mathematics achievement. The learners of Mathematics in Murang'a County could not allowed to take the responsibility of their work which is ideal situation contributing to good performance has been observed. The seriousness and urgency of this current situation of continuous decline of students' Mathematics achievement in secondary schools in Murang'a County prompted this study. Methods applied by Mathematics teachers in Murang'a deserved to be known to rectify the situation. The students' attitude towards Mathematics was also investigated.

This study investigated how teaching Mathematics through problem – solving in secondary schools in Murang'a County may improves students' achievement. This study focused on providing background that engage in an important recreation role to effect on teaching Mathematics through problem – solving approach to improve achievement in Mathematics in secondary schools in Murang'a County. The idea of improving students' Mathematics achievement became driving force for this study to be undertaken to fill this gap. This research has shown that learners enhanced their content transfer and improved their achievement through learning through problem - solving.

1.2 Purpose of the Study

Purpose of the study examined effects of teaching Mathematics through problem – solving approach on students' achievements in public secondary schools in Murang'a, County, Kenya.

1.3 Objectives of the Study

The study was guided by the following objectives: To assess students' attitude towards Mathematics when taught through problem - solving strategies in secondary schools in Murang'a County;

And tested the hypothesis:

There is no significant difference in students' attitude towards Mathematics for students' taught Mathematics using problem – solving approach and those taught using conventional strategies in public secondary schools in Murang'a County.

1.4 Justification of the Study

Mathematics is considered as significant individual everyday life having an effect on family together with social existence. Individual citizens come across mathematical problems in their daily lives as consumers and workers (Wathall, 2016). Results point out that living in this modern digital world, someone requires advanced mathematical and technical skills in many career successes in achieving necessary tools for national economy and social life (Wismath, 2014). This is a scientific process which demands analytical and synthetical skills in problem - solving to have critical creative and reflective thinking abilities in which all disciplines must embrace (Posamentier & Krulick, 2009).

The rationale of this study was to prepare students for action in the classroom, give them better understanding, learning experiences in order to improve their Mathematics achievement. Problem – solving strategies involve students in exploration and promoting thinking about mathematical concepts rather than telling them key Mathematics ideas. Students explore problems with their partners or groups and are guided in that exploration by their teacher, communicate their ideas, contribute their insights, apply their previously learned knowledge to new unfamiliar situations, reflect on their experiences and discover new Mathematics idea (Polya, 2011). When students can express their ideas and represent their thinking both orally and visually when solving problems, they are better to construct deeper mathematical understandings.

According to Vision 2030 where national ethical values for education aims, objectives and philosophy for good governance in quest for economic, social and political aspirations were articulated through problem - solving. This sustains the Kenyan nation through her commitment to democracy and the rule of law by achievement of national goals of education (Kenya Vision 2030, 2010).

1.5 Significance of the Study

This study of effects of learning Mathematics through problem - solving enabled learners and teachers alike to effectively acquire new and relevant practical skills. The learners in particular become innovative and responsible Mathematics problem solvers. Hence improve their achievement in Mathematics. This was important to Murang'a County and the Ministry of Education to include problem - solving in Mathematics as it promotes students' confidence to improve their Mathematics achievement through meaningful interactions. It would be expected that with assistance of principals, Quality Assurance officers and Standard directorate in the endeavour to improve Mathematics, achievement and skills in problem - solving within the County would be appreciated.

Researchers have noted that lack of familiarity with word problem structures and language may have contributed to poor students Mathematics performance. This study moderated teaching Mathematics through problem - solving which encourages students' participation in development of mathematical concepts. This was through emphasis on Polya's Model relating understanding, devising plan, carrying out the plan and looking back. Students would develop tasks which encourages teamwork and collaborations among teachers and students in improving to produce activities that promote quality learning concepts improving students' achievements. When students develop conceptual understanding they perform better on procedural knowledge.

II. Literature Review

The students attend school from different backgrounds with differing needs that are derived from home environments background, religion and languages. They possess varied capabilities and perspectives creating Mathematics culture. The teacher is a single human resource who takes an important role in developing students' mathematical identities. Teachers use their experiences to manipulate students develop positive attitude towards Mathematics. Students' performance is raised by positive attitude rather than comfort levels that Mathematics is difficult. It also enable students to gain greater confidence as well as their capacity to learn Mathematics to make sense in problem - solving.

The students take responsibility for their own learning as they are encouraged by their teacher's giving guidance. In the classroom, students simplify their challenges through interaction with each other and their teacher (Watson & Geest, 2005). Those challenging tasks which require students to think deeply for Mathematical ideas which they connect with confidence rather than depending on their teacher answers. These opportunities help students to find Mathematics enjoyable and relevant to their attitudinal change.

Classroom traditions play vital position in developing students' mathematical way of thinking and acceptable judgment of their ideas. Students' everyday exercises engaging them to contribute solutions in a mathematical enquiry promotes problem – solving activities in cooperation. According to Angier and Povey (Angier & Povey, 2010), teachers need to clarify their expectations about how their students should contribute and participate in the development of their concepts and how others might respond. The development of students' mathematical proficiency is guided by teachers showing interest in their learners' ideas which help them express and develop those skills (Singer &Voica, 2008). The modeling of ideas through practice and evaluating their application are encouraged to discuss with others in order to make mathematical judgments using suggestions voiced by their classmates.

Teachers will promote students positive attitude towards learning Mathematics by creating conducive environment and encouraging the community action. This information shows widely acceptable relationship between classroom situations to improve academic achievement in Mathematics through effective student's incentive in learning Mathematics. Researchers have shown that students' inspiration is highly related to Mathematics achievement in learning environment (Colakoglu & Akdemir (2008), enthusiasm is closely related to Mathematics achievement which may be the cause of decreasing trend in Mathematics performance in Murang'a County. The decline in Mathematics performance may be associated with students' interest.

III. Research Methodology

The precise method applied in this research study respond to research hypotheses or research questions referred in the design (Privitera, 2014). The quasi – experimental method in which, effects of independent variables were used in class moderated by intervening variable to improve the dependent variables (Creswell, 2014). The researcher was interested to find out whether teaching Mathematics through problem – solving strategies in classroom environment would manipulate students' attitudes, improve achievements and promote collaboration The researcher used quasi – experimental design. The researcher preferred this design because it dealt with students in a school setup whose arrangement the researcher had no control.

The study specifically used Solomon Four Group design in quasi – experimental setting. Since participants schools admitted students in Form one and classes are formed (Creswell, 2014). Solomon Four Group design was preferred by researcher to overcome the problem of pretest sensititation while maintaining the benefits associated with conducting pretest. It also avoids other difficulties connected with the posttest. The design achieves this objective by random assigning participants groups to either receive or not receive pretest. Then randomly allocating these two factors of treatment and pretest where four conditions were created (Crano, Brewer and Lac, 2014). Therefore, two control and two experimental groups were created to reduce influence of confounding variables. This accomplished by randomly giving four schools per category to two experimental and two control groups.

Two groups were administered pretest and later posttest

E1 X E1

C1 C1

E1: Experimental group one; X: Treatment & C1: Control group one

Further, reasons for using Solomon Four Group design enable to combat many of the internal validity of the research. The researcher exerted reasonable amount of control over the variables without having authority the results. The Solomon four group design 2 x 2 factorial designs were applied where all groups received post – test. Pretest was administered one experimental and one control groups. These provide major advantage why Solomon Four-Group powerful design, since it allows increasing generalization on findings (Cohen, Manion, & Morrison, 2011). The effect of treatment X was being reflected in four different fashions as compared to other experimental designs.

Two groups were administered post - test

E2 X E2
C2 C2

E2: Experimental group two; X: Treatment & C2: Control group two

The experiment using Solomon Four Group design was applied in such way that experimental group E1 has received pre – test and treatment X together with experimental group E2 and later post – test. The treatment commenced immediately after the pre – test. The control group C1 received pre – test and also C2 both received post – test without treatment. All the groups are also given attitude questionnaires before and after the period of treatment.

IV. Findings and Results

The objective was to assess students change in attitude towards Mathematics when taught through problem – solving approach with those taught by means of conventional methods. The present study compared attitudes of students towards Mathematics when taught with problem – solving (experimental group) and those taught using conventional methods (control group) post – test levels. The summary of mean scores and standard deviation before pre – test results attitudes towards Mathematics and before intervention was given in table 1. The pre – test result shown for all categories participating at experimental group E1 and control group C1 were analysed.

Table 1: Two – Sample t –test with Equal Variances on 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**

Source: Murang'a County Field data, 2018

Table 1, has shown results of attitude test before intervention. The objective of the study is to compare achievement of students taught mathematics by problem – solving method and those taught by means of conventional methods.

The hypothesis tested was that no significant mean difference between in attitude of experimental group (E1) and control group (C1) at pretest.

Table 1, has given that there is no statistical difference between the mean scores of both groups. The data has tabulated $t = 0.16$ value at $\alpha = 0.05$ level. This shows that the attitude of the students were same level on pretest. Hence, null hypothesis was accepted that the both groups have equal Mathematics attitude on pretest. Okigbo and Osuafar when working on Mathematics achievement declared that students have same knowledge and attitude before the commencement of the experiment.

The attitude questions were distributed into three sub- scales. These scales were for monitoring students' attitude towards learning and teaching Mathematics in secondary schools. These subscales included 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 2 shows post - test results according to individual items MB, MC and ME in percentage scores.

Table 2: Posttest Comparison Attitude of Experimental Groups E1 & E2 and Control C1 &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: Murang'a County Field data 2018

The students interacted and discussed during intervention so they gained confidence, changed behaviour and they were engaged in Mathematics. 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 2, 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%.

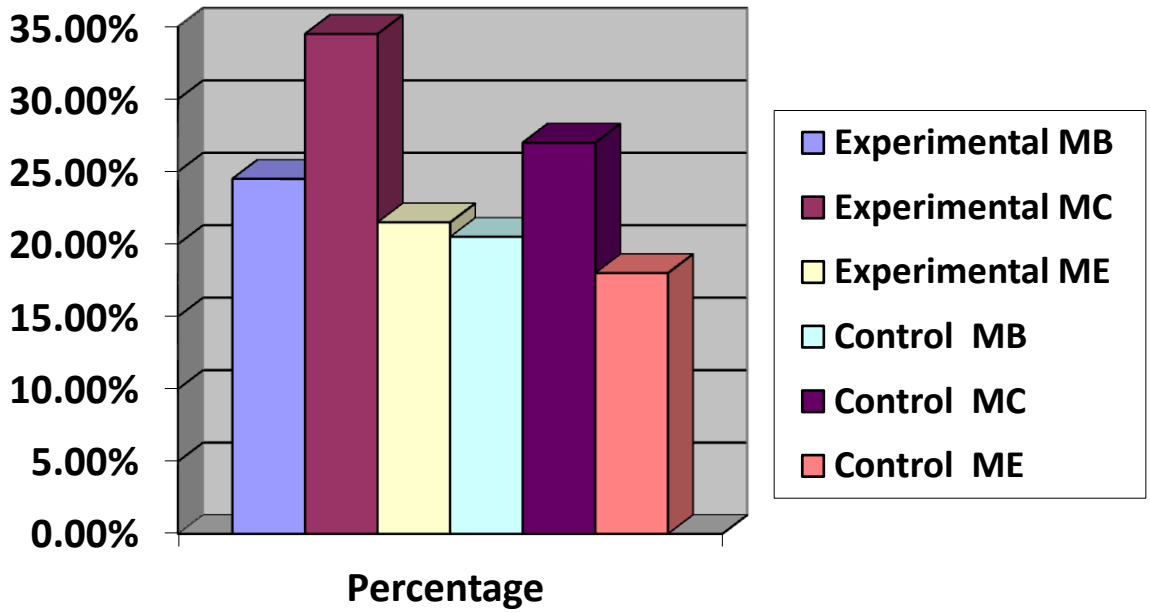

Figure 1: Students' Attitude Mathematics Behaviour, Confidence and Engagement

Figure 1, 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. The third objective the role played by students' change in attitude towards Mathematics when taught using problem – solving weighing against those taught using conventional methods on Mathematics achievement in secondary schools. This was aligned with third hypothesis.

Hypothesis states that there was no statistical significant mean difference between learners' attitude towards Mathematics when students' were taught using problem – solving approach compared to those taught using conventional methods in Secondary schools in Murang'a County.

Paired student t – test was applied to test H_{03} in which pooled combined mean and standard deviations were used. Table 3 shows the combined means and pooled standard deviations of E1 and E2 as well as C1 and C2 post intervention.

Table 2: Paired t –test of Combined Mean Scores and Pooled Standard Deviation for Experimental E1 and E2, and Control Group C1 and C2.

Variable	No of respondent	Mean score	Pooled standard deviation	95% confidence interval	
				Lower	Upper
Posttest: E1& E2	254	57.6	12.01	56.12	59.08
Posttest: C1&C2	290	46.4	13.37	44.85	49.94
Combined	544	52	12.73	50.93	53.07
Difference		**11.2**		**-0.60**	**2.42**

Source: Murang'a County Field data, 2018

Table 3, has shows there is no statistical difference between the post– test experimental groups (E1 & E2) combined mean score and post – test control group (C1 & C2) combined mean score and their respective pooled standard deviations. The value $t = 0.88$, $p = 0.0146$ at $\alpha = 0.05$ with Cohen's d power effect of 0.88 which is large positive result, this shows that the attitude of the students were not on the same level after intervention. Null hypothesis was rejected in preference of the claim that students attitude changed. Then accepting the alternative hypothesis that there was statistical significance in attitude towards Mathematics on students taught using problem – solving have positive attitudes than students taught using conventional strategies.

Researcher maintains that a good lesson plan for mathematical instruction must present Mathematics as problem – solving as continuous process of investigation which remain open to review. This contrast the current conventional methods which emphasis on content approach through mastery of rules and procedures. There is believed that the students' involvement in construction of knowledge emphasis on improved performance and attainment of good performance.

The objective was to assess the student change in attitude towards Mathematics when taught through problem – solving in secondary schools in Murang'a County. The methods dealing with exposition and cooperative teaching and learning Mathematics has been studied extensively. The findings of this study answers to various frequently asked questions about problem – solving. Therefore, the study adds to the literature of learning of Mathematics through problem - solving activities. These activities were done in an environment encouraging students to interact freely and discover concepts themselves. This improved conceptual growth, attitude change, build confidence and create a community of young Mathematicians who care for each other.

The current study did detest that problem - solving is desired teaching approach preferred rather conventional strategies. Problem – solving is different from problem – based where a given problem has algorithm to be used to solve it. This study implies that teachers shape students' skills in problem - solving by improving instructions through proper use of resources. Problem - solving could be used to improve students Mathematics achievement. Giving students appropriate opportunity to be involved in problem - solving in classroom and other unfamiliar situation bring new strategies to students. The teachers' attitude towards Mathematics changes through problem – solving as well as changing Mathematics from non – performance subject to enjoyment.

V. Conclusions and Recommendations

The objective was to assess change in attitude towards Mathematics when taught through problem – solving approach. The attitude change of the students has shown statistical significance within the short period of intervention. The students taught using problem – solving became more confident, engaged and their mathematical behaviour improved. This high mean score in attitude shown, that most students from Kenya show positive attitude towards Mathematics.

The study concludes that used problem – solving approach as an effective instructional strategy to improve student Mathematics achievement. This was done by providing students appropriate opportunities to be engaged freely in problem – solving activities. The study has shown that a general problem - solving strategy has been successful in secondary schools practice even in all categories. This study differs from other researches by encouraging the teacher to apply constant interventions to direct students to critical thinking. Peer partners and small problem - solving groups gave learners opportunities to see different ways including teammates approach to mathematical problems. This was aligned to 21st century pedagogical trends in teaching Mathematics through integrating problem –solving for competency in classroom (Wathall, 2016).

Secondly, problem - solving as the strategy enhances students' performance in Mathematics since there was a better improved understanding of the problem and even computation in Mathematics as classroom community. The exposure to problem – solving experiences to meaningful dialogue in Mathematics classrooms influence future social relationships. The social dynamics in their classrooms help students learn how to solve routine and non – routine problems improving their Mathematics achievements. This was according Vygotsky's (1978) theoretical framework that social interactions play fundamental role in the development of cognition

Study recommends that teachers provide students with opportunities to interact in a favourable rich environment to solve problems. Students actively participate to finding individualized solutions applying problem – solving strategies. This happens when teachers encourage and give opportunities students to share and compare their answers. Students further contrast their methods is general idea of this research where problem – solving involves individual solution with activities in small groups and whole class. This is enhanced through classroom interaction and creating class communication providing students with confidence in problem – solving. This increases student Mathematics achievement through problem – solving activities through problems and assignments.

Problem – solving should be viewed as a continuous process of examination that always remain open to modification. Learner – focused outlook that stresses the learner's construction of mathematical knowledge

through social interaction. This improves humanity aspect of social life where people are to live together. The teacher understanding learners strengths enable her\him to effectively help the learner to develop social skills.

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