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EFFECTS OF PROBLEM-SOLVING APPROACH TO TEACHING AND LEARNING OF MATHEMATICS ON STUDENTS WITH DIFFERENT ACHIEVEMENT ABILITIES IN KENYAN SECONDARY SCHOOLS

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ABSTRACT

Despite mathematics being one of the core subjects in Kenya's secondary school curriculum, many students have continued to perform dismally in the subject in Kenya Certificate of Secondary Education (KCSE) with the overall national mean score remaining below 30%. This study aimed at exploring whether there was any significant differences in mathematics' mean achievement scores of the High Achievers (HAs) and Low Achievers (LAs) between the experimental and control groups. It was anchored on the social constructivism learning theory. The study employed a quasi-experimental non-equivalent control group post-test only design. The study population was 2162 form two learners from 26 schools. A purposive sampling technique was used to sample 14 schools that were at the same level in syllabus coverage and had two streams. Simple random sampling was employed to get the study sample of eight schools with 774 form two learners. Data collection instruments were Baseline Mathematics Achievement Test (BMAT) and Post Mathematics Achievement Test (PMAT).The study data was analyzed using both descriptive and inferential statistics where the means, standard deviations and independent samples t-test to test significant differences in means at an alpha value of 0.05 were used with the help of the Statistical Package for Social Sciences (SPSS) version 29. In this study, findings indicated that there was a significant difference between the mean mathematics achievement scores of HAs and LAs taught through PSA as compared to those taught by conventional methods. This good performance was perhaps due to leaner active involvement, peer interactions, self-directed learning and increased confidence among the learners. This enhanced better understanding of the mathematics concepts which finally translated to improved performance. It was recommended that teachers of mathematics should be encouraged to use PSA so as to

improve the performance of learners in mathematics especially LAs who are usually believed to lower the school performance mean scores.

Keywords: Problem Solving Approach, Mathematics performance, Higher Achievers and Lower Achievers.

1.0 INTRODUCTION

1.1 Background to the study.

Mathematics being the science of reasoning and computations and a core subject in curricula in many countries in the world, is seen as a subject that makes individuals think logically and describe abstract ideas with intelligence. For individuals to perform well in their daily activities, they need mathematics which forms the foundation of many different subjects in natural and social sciences (Iqbal, 2004). Since mathematics has many applications in the area of science, technology, and business, for one to grow in different fields of life directly or indirectly he/she needs mathematics understanding (Ali, Hakamadad, Akhter, and Khan, 2010). For one to succeed in school, society and in most of the future careers, he/she should have an understanding of mathematics. However, it is worth noting that with the importance attached to mathematics by all stakeholders in education, secondary school students still perform dismally in the subject.

There has been general concern over students' poor performance in mathematics even within developed countries like the United States of America (USA), and United Kingdom (UK). Data collected from Trends in the International Mathematics and Science Study (TIMSS) in 1995 and 1999 video study showed that United States (US) students performed poorly in mathematics which has not yet shown any significant change up to date. This is perhaps due to the poor teaching methods used by teachers and the idea that teaching is a cultural activity (TIMSS, 2019). American teaching focuses mainly on mathematical skills rather than mathematical reasoning and understanding whereby students spend most of their time acquiring isolated skills and practising routine procedures.

In England and Scotland mathematics performance among the students was not far different from that of the USA for teaching was mainly teacher-centered. This kind of instruction does not support mathematical reasoning and understanding which is the key to learning mathematics (TIMSS, 2019). In Australia, students performed poorly in mathematics since teachers in this country implemented most of the high order-level problems by transforming them into lower order level by use of routine procedures (TIMSS,2019).

In the first video study of 1995, Japan achieved higher as compared to other countries that participated and it has continuously performed well in the consecutive TIMSS (TIMSS,

2019). Japanese teaching aimed to provide teaching of mathematics in a deeper way for conceptual understanding rather than embracing teaching as a cultural activity. Japanese students spend less time practicing routine procedures and more time inventing new solutions. Japanese teachers planned their lessons in such a way that learners were left to struggle with the problems so as to come up with their own understanding.

In Pakistan, Ali, Khan, Akhter, and Hukmadad (2010) noted that PSA contributed to achievement in mathematics of learners and these significant differences were due to the problem-solving method (PSM) because initially both groups had equal basic knowledge of mathematics. According to Kousar (2010) when learners were taught using a Problem Solving Approach (PSA), their mathematics achievement improved, and they excelled more than the learners who were taught by expository strategy. This view was supported by Malik, Akbar, and Hifsa (2018) who observed that the post-test mean scores of the treatment group was much higher than that of their counterparts in the control group and this perhaps was as a result of using PSA.

In Zimbabwe, Tshabalala and Neube (2012) in their study on causes of poor performance of ordinary level pupils in mathematics in the rural secondary schools observed that the poor performance was caused by lack of material resources, bad teacher behaviour, poor grounding and fear of the subject as well as poor teaching methods used by the teachers. Methods used by the teachers were insufficient in developing learners' conceptual understanding of mathematics. This was confirmed by Makondo (2020) who attributed this below-average performance in mathematics at ordinary level to pupils' negative attitudes towards mathematics, lack of teaching experience among teachers, lack of adequate resources and poor teaching methods. Makondo too indicated that 98% of the teachers studied used question and answer method together with lecture methods in their classroom instruction.

In Zambia, Clifford (2015) investigated the factors that caused failure in mathematics among the girls in Sesheke secondary schools. Findings indicated that the cause was inadequate parental support, poor teaching and learning methods and girls' negative attitudes towards mathematics. He further noted that these teacher-centered methods used in the mathematics classrooms do not contribute to girls' comprehension and understanding of mathematics.

In Nigeria, Hammed (2019) conducted a study to investigate the cause of students' failure in mathematics in Kwara State junior secondary schools. Findings indicated that probable causes were insufficient number of qualified teachers in mathematics, frequent transfer of mathematics teachers, poor socio-economic background of mathematics teachers and poor teaching methods.

In Uganda, Kizito (2020) found that the cause of poor performance in primary mathematics among the girls was ; girls' negative attitudes towards mathematics, lack and limited

instructional materials, poor facilities and sanitation, poor time management, poor teaching methods and inadequate support by parents.

In Kenya, just like in any other country, quality of education remains a responsibility of the Government of Kenya (GoK). In Kenya, academic failure may mean failure in life since Kenya has an examination-oriented education system. For many years, for one to get entry into higher education, he/she must have completed and excelled in secondary school examination. To pursue most of the degree courses from the local universities in Kenya, one must have passed mathematics and this failure makes many students fail to be admitted to their dream courses. Njoroge (2014) noted that mathematics mean scores attract public complaints whenever Kenya Certificate of Secondary Education (K.C.S.E) results are released. Njoroge added that despite mathematics being considered as fundamental in turning around Kenyan industrialization by 2030, poor performance in the subject is alarming. Table 1 shows KCSE candidates' performance in Mathematics in the years 2018 to 2021 inclusive.

Table 1: ***Candidates' Performance in Mathematics in the Years 2018-2021***

Academic year	2018	2019	2020	2021
Average % mean scores	26.445	27	18.36	21.61

Mathematics KNEC report (2022)

Table 1, indicates the general performance in mathematics for four years between 2018 and 2021 inclusive. All mean scores are below 30%, indicating below-average performance. The poor performance has partially been attributed to poor teaching and learning strategies (Mutange, 2020). As per the analysis of the KCSE questions, data revealed that mistakes made by learners were mainly misconceptions, misunderstanding, and language interpretation of the question which mainly pointed to pedagogical approach to teaching and learning mathematics (KNEC, 2022).

In Kisii County, Victor (2020) investigated the factors that hindered mathematics teaching and learning among secondary school learners. His findings indicated that 60% of teachers frequently used lecture method of teaching, 30% of teachers sometimes used lecture method and 10% of teachers rarely used lecture method of instruction. He added that 65% of teachers rarely used small-group discussions, 20% of teachers sometimes used it and 15% of teachers frequently used it. Further, he found that 10% of teachers frequently used co-operative learning strategy, 40% sometimes used it while a large percentage of 50% rarely used it. This was an indication that a large number of mathematics teachers used expository strategies rather than exploratory methods during classroom instructions. Makeo (2013) in his study on student- teacher perceptions of factors influencing students' performance in mathematics in Tana River County found that most of teachers mostly employed teacher-centered strategies

such as lecture method as it was observed in 8 out of 9 teachers studied. Makeo (2013) then associated these teacher-centered approaches with less understanding of mathematics structure and concepts which results in little retention of what was learned. This was confirmed by Mutange (2020) who found out that the poor performance of mathematics among many students in Kenya was caused by poor teaching and learning strategies. According to Wambua (2012), methods that are used by all mathematics teachers in secondary schools are expository rather than exploratory. Table 2 shows candidates' performance in Mathematics in Bondo sub-county in the years 2018 to 2021inclusive.

The Ministry of Education, Science and Technology (MOEST) has implemented several interventions aiming at reversing this trend of below-average performance in mathematics. For example, Strengthening Mathematics and Science in Secondary School Education (SMASSE) project, an in-service project that was rolled out in the whole country from 2003 to 2008 and later became a programme beyond 2008. It was intended to address the challenges teachers and learners encountered in the mathematics classrooms by introducing appropriate teaching methods. In addition, the syllabus has been reviewed severally, financial assistance offered to students so as to subsidize their fees and provision of more qualified mathematics teachers so as to bridge the teacher shortage gap. However, these interventions have not realized any significant improvement in general performance of the subject as the national mean score has dropped from 39.45 in 2002 (before SMASSE implementation) to 21.61 in 2021.

Most of the studies already done globally, in Africa and Kenya show that the cause of the poor mathematics performance are negative attitudes towards mathematics, lack and limited instructional materials, poor facilities and sanitation, poor time management, poor teaching methods and inadequate support by parents. Most of these factors have been addressed with just a little focus of what happens inside classroom as far as teaching and learning strategies are concerned. Most of the reviewed studies perhaps indicate that methods commonly used in the classroom instruction are teacher-centered which may promote superficial understanding and less retention of the content among the learners. According to TIMSS (2019) most of the high achieving countries for instance Singapore, Chinese Taipei, Korea, Japan and Hong Kong implemented what looked like teaching mathematics in a deeper way for conceptual understanding (teaching through PSA).

In Kenya, teaching is mostly regarded as teacher-centered where 8 out of 9 teachers use lecture method in their mathematics classroom instruction (Makeo, 2013). In addition, teachers embrace teaching as a cultural activity for they teach like they were taught (Stigler &Hierbert, 1997). Most of the teaching methods used are teacher-centered (lecture method)

with less focus on student-centered methods (Victor, 2020). It is against this background that the current study investigated whether PSA could be of help to improve mathematics performance among the learners in Kenyan context which differs from that of the TIMSS top performers. Therefore, this study explored the effect PSA has on mathematics performance of HAs and LAs in Kenyan secondary schools.

1.2Statement of the Problem

Despite Mathematics being one of the core subjects in Kenya's secondary school curriculum, many students have continued to perform dismally in the subject in K.C.S.E with the overall national mean score remaining below 30%. As has been mentioned, the Government of Kenya (GoK) has tried to address this poor performance in the subject by strategies such as in-service training for teachers, reviewing the syllabus, financial assistance to needy students so as to subsidize their fee, provision of learning materials and employment of more qualified mathematics teachers so as to bridge the teacher shortage gap. However, these interventions have not realized any significant improvement as the national mean score has dropped from 39.45 in 2002 to 21.61 in 2021. Some educational stakeholders blame the poor performance on the pedagogical approaches used by teachers. Some researchers have found PSA to positively affect mathematics achievement, others have reported non-significant relationship between the PSA and mathematics achievement. Besides, none of these studies has gone to an extent of establishing the effect of PSA on learner category (HAs and LAs). This study was conducted so as to fill this gap.

1.3 Purpose of the study

The main purpose of this study was to investigate the influence PSA has on secondary school students' mathematics performance based on different abilities in mathematics achievement.

1.4 Objective of the study

The study objective was to explore whether there is any significant difference in mathematics mean achievement scores of the high achievers and low achievers between the groups.

1.5 Research question

What effect does PSA has on mathematics performance of high and low achievers between the groups?

1.6 Significance of the study

These study findings may be significant in adding knowledge to the existing literature on the influence of the PSA on the achievement of mathematics among secondary school students. Secondly, with the importance and demand of mathematics in many fields and areas of application, deep understanding of mathematics is beneficial to students and it may be of help to students to be critical and analytical thinkers. It may also have implications for teacher education institutions and faculties of education in Kenyan universities and education

colleges where they may be in a position to include PSA as a strategy in the pre-service training of mathematics teachers which they may extend to secondary schools. In addition, this study may benefit society by producing students who are problem solvers and also a mathematics-loving generation. The study results may help the mathematics teachers to apply this kind of approach in instruction delivery that may benefit different learner categories as far as mathematics understanding and achievement is concerned especially the LAs.

1.7 Scope of the study

This study aimed at exploring the influence of PSA on mathematics performance of HAs and LAs among form two learners (15-16 years) in secondary schools as respondents. This study was restricted to public secondary schools where students' entry behavior is similar per category unlike private secondary schools. The study used Baseline Mathematics Achievement Test (BMAT) and Post Mathematics Achievement Test (PMAT) as the data collection instruments. The study adopted a posttest only research design within a mixed methods approach and it was anchored on social constructivism theory of learning.

1.8 Theoretical Framework

The present study on effect of PSA on learners' mathematics achievement by learner categories was anchored on the social constructivism learning theory whose origin is attributed to the work of Lev Vygotsky (1896-1934).Constructivism is a theory of knowledge which argues that human beings construct knowledge and meaning from their mutual interaction between their experiences and ideas (Woolfolk, 2008).In this theory, the learner builds and constructs knowledge rather than waiting to be supplied with the information by the teacher. Learners construct this knowledge through their individual experience, ability to interact with social environment, making errors and finding solution to the situation. Constructivists' theories of learning defines central role of the learner as the active construction of knowledge by use of prior knowledge about the context of study (Okere, 1996).

Social constructivism emphasizes on how mutual interactions of learners result into knowledge construction. Learners' interactions with others create opportunities for them to evaluate and refine their understanding as they are exposed to the thinking of others. Teachers offer passive support as facilitators by guiding learners to come to their own understanding of the mathematics concepts rather than giving lectures. This places learners as active constructors of knowledge and maintains the passive supportive role of the teacher. The teacher should start a lesson by asking questions instead of delivering information to learners and should answer broad range of questions instead of the ones that only align with

the curriculum therefore allowing learners to explore the questions and discover solutions by their own struggle while interacting with their peers.

In this theory, the teacher poses a question to the entire class for discussion where learners have to interact with each other in various small groups so that they can come up with the findings to the problem. Thereafter, each group has to report its findings to the entire class and these findings are harmonized by learners with the support of the teacher so that they can reach to the final solution to the task.

This theory was relevant to this study since it incorporated a learning process whereby the learner gained and built knowledge through facilitation by the teacher in the learning process. In this theory, students had access to data from primary sources, and were able to interact with other students so that they could learn from their experiences rather than relying on teacher's information and believing in it. This theory also gave students room to create solutions and give support to the developing issues. It enabled learners to justify their own words and actions while respecting other peoples' contributions and differences in opinion during the learning process.

1.9 Conceptual framework

Figure 1 shows the influence of PSA on learners' mathematics achievement. The independent variable was PSA and dependent variable was mathematics achievement by learner categories (HAs and LAs).

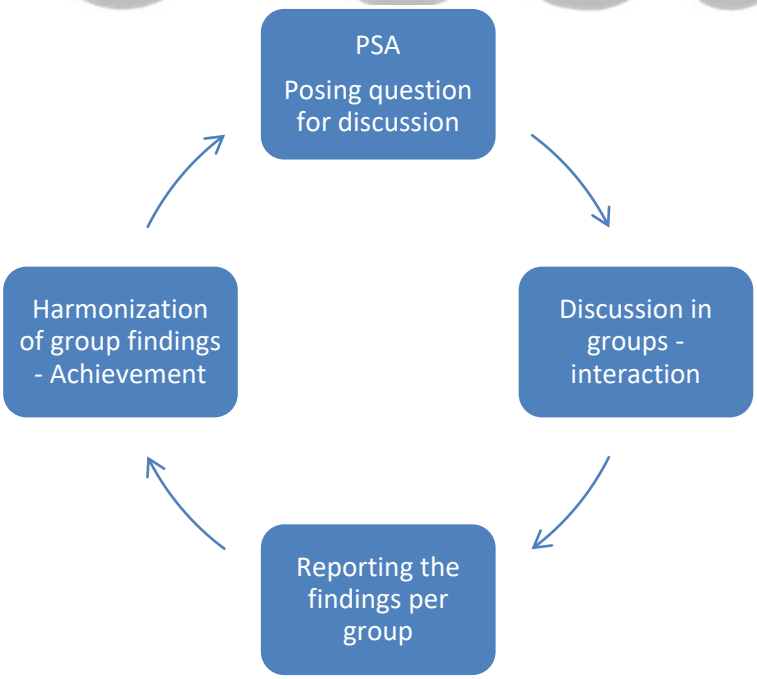

***Figure* 1: Effect of PSA on learners' mathematics achievement (HAs and LAs)**

Source: Researcher, 2024.

2.0 LITERATURE REVIEW

2.1 Problem Solving Approach on High and Low Mathematics achievers between groups

Krutetskii (1976) posits that we are not born with explicit mathematical abilities, but active contact with the subject may, under favorable circumstances, generate mathematical abilities. In USA, Krawec (2012) examined how the learners broke down and interpreted the problem information they encountered within a PSA instruction. The learners on study were those with learning disabilities, low-achieving students, and average-achieving students. As per the findings, learners with learning disabilities demonstrated weakness in the process as compared to low-achieving peers and average achieving peers.

Eunsook (2006) in his study on test-taking strategy of low and high mathematics achievers noted that in analysis and interpretation of the problem, learners who were termed as high achievers arranged the problems given in terms of their complexity and difficulty before they begun the PS process. They then tried to perform the problems they could while leaving out the difficult problems which contributed to their success in the process unlike the low achievers. The main focus of this study was to explore the strategies learners use to deal with the information they encounter with in a PS classroom. However, the current study based its focus on improving mathematics performance through PSA to teaching and learning as an instructional strategy.

Brittany Crowley (2015) observed the students who were highly able in the subject area in relation to their peers when exposed to Problem-Based Learning (PBL) instruction which took a period of four years. He found that PBL and conventional methods influenced learners' performance in mathematics in almost similar way. This study had some limitation which includes, the treatment processes was not consistent enough since most of the trained teachers for the grant left the schools or were given other classes and new teachers joined the study without being inducted on the approach hence improper use of the PBL curriculum. Secondly, there was attrition of participants. The study started with a sample of ninety learners who were participants but ended up with a sample of sixty five learners whereby twenty five learners withdrew before the end of the study. Lastly, poor selection and monitoring of the control groups. These study limitations perhaps could have contributed to the findings of this study.

During the course of four years, those schools that acted as the control of the experiment were exposed to the strategy and PBL curriculum for over 300hrs which perhaps could explain why PBL and traditional curriculum had almost similar effects on learner mathematics achievement. Selection and monitoring of the schools are termed as the control

of the experiment should not be exposed to treatment so as to ensure accurate comparison against experimental schools. The current study addressed this limitation by having equal sample size (387 learners each) in both the EG and CG. In addition, learners in the EGs received instruction through PSA to teaching and learning treatment while those in CGs received instruction by conventional methods which ensured accurate comparison of the two groups. Only EG teachers were inducted on how to teach through PSA.

In addition, since the control schools received PBL instruction, the observation in control groups was not done for this could not tell whether or not the change was as a result of the strategy. However, the current study was designed in a way that the researcher conducted classroom observations that mainly focused on observing the small group activities in the EGs.

In Western Kentucky, Crowley (2015), did a study that took three years and studied the students who had different academic levels so as to check whether or not were affected by Science, Technology, Engineering and Mathematics (STEM) Project-Based learning activities. Results indicated that low performers outperformed high and middle performers in mathematics. This showed that STEM PBLs was of much importance to low performers.

According to Belland, Kim and Hannafin (2013), for the learning process through PBL instruction to be effective, learners should be provided with guidance and support by their teachers until one is able to perform the task alone or without any further support. Throughout the study duration of four years, one was unable to tell whether or not the PBL affected learners' mathematics performance for the treatment lacked consistence. In addition, the observation was to be done by the teachers who were trained on the PBL curriculum however that was not the case in the treatment groups since there was a change in specific teachers who were trained before the start of the study. Those teachers transferred to other schools that were not under the study and new teachers' were assigned those study classes but they received training from neither the fellow teachers nor the researcher. In light of this study limitation, the current study ensured that the treatment was consistent and in line with the approach employed by use of the researcher-inducted teachers in each of the treatment schools because the study period was short. In addition, the researcher made classroom observation for the entire study period in the treatment schools instead of subjecting it to trained teachers. The reason behind this was to ensure reliable fidelity checks so as to tell whether or not the learners had effective and efficient instruction through the applied approach.

In Asia, Kuo, Tuan and Chin (2018) examined the non-low and low achievers motivation towards science in an inquiry based learning and noted that the non-low achievement goals and perception of their learning environment in the EG significantly improved more than those in the CG. Practically, non-low achievers' expectancy and learning strategies and low achievers' confidence, value of science learning, achievement goals, learning strategies, and perception of learning environment in the experimental group were better than those in the control group. The reviewed study is more concerned of motivation and leaner academic achievement levels but the current explored the influence of PSA and academic achievement levels.

In Pakistan, Anwar and Shamim (2012) compared the creative thinking abilities between the higher and lower achievers. Findings revealed that creative thinking abilities of both groups of learners were similar. This study dealt with creative thinking abilities and academic level but the current study focus was on PSA and mathematics performance between learners who demonstrate high grades above the average mean score and those who demonstrate low grades below the average mean score.

In Indonesia, Winga, Agak and Ayere (2017), in an Arithmetic class observed how above averages, average and below average learners used their copying style in dealing with mathematics concepts. The classroom instruction was through a model based on problem solving learning. The findings showed that the above average students were able to interpret the problem in their own words, check for the best strategy to represent the problem, solve it and finally see whether the solution at hand made sense or not. The average learners followed the three steps of PS but did not check whether the solution made sense to them or not. Below-average learners engaged in finding out the solution by following the first three steps but finally got incorrect solution to the situation. This study finding did not reveal the mathematics achievement of the students when taught through PSA as an instructional approach but rather reported learners' copying styles.

In Israel, Kramarski, Weiss and Sharon (2010) in their study on how Self-Regulated Learning (SRL) affected learners' who were above average and those who were below average. The below average learners showed improvement in tasks that were easy and difficult but above average learners demonstrated an improvement in the tasks that involved transfer of mathematics skills. This study was mainly concerned about SRL but the current study explored the effect of PSA on learners' academic achievement.

Bhagat, Chang and Chang (2016), observed learners with different achievement levels so as to check how the use of flipped classroom learning contributed to their achievement and motivation while interacting with mathematics concepts. It was found that Students that used Flipped classroom learning performed better than their counterparts. The findings indicated

that low achievers in EG benefitted from Flipped classroom learning than those in CGs but there was no change in the performance of high achievers and average learners. The use of this kind of learning was found of help to low achievers in their mathematics performance.

Han, Capraro and Capraro (2015), investigated whether participating in Science, Technology, Engineering and Mathematics (STEM) Project-Based Learning (PBL) activities affected learners with varied performance levels and to what extent mathematics achievement was influenced by the students individual factors. Findings showed that STEM both the performance levels and students' demographic backgrounds influenced their mathematics achievement in mathematics. In addition, low achieving students outperformed the high and middle achieving students.

Zhang, Barrett, Xin and Liu (2014), examined the difference in the use of strategies by the high, average and low achieving learners in solving different multiplication problems. Sample for the study consisted of 19 high, 48 average and 17 low achieving students. The students were to complete the three given multiplication problems and explain how they solved these problems. Results indicated that the low achievers more frequently used incorrect strategies suggesting superficial understanding of the multiplication concepts. The high achievers demonstrated greater flexibility in problem solving.

In South Africa, Amponsah, Kotoka, Beccles and Dlamini (2018), investigated the effectiveness of collaboration on low and high achieving school students' comprehension of electrochemistry. Results revealed that high achieving students taught with conceptual change teaching strategy specifically collaboration had better acquisition of scientific conceptions related to electrochemistry than low achieving students.

In Nigeria, Ngozi and Solomon (2021) examined the effect of two teaching strategies and mathematics achievement on low achievers. The findings established that low achievers who were subjected to differentiated instruction improved in mathematics performance as compared to their counterparts in the control group. This also helped the Low achievers on their homework and attitudes towards projects.

Locally, in Murang'a district, Mungai (1997) investigated the strategies female students employ in their learning of mathematics in rural primary schools and see how they affect their processing of the information. The high achievers were found to have high information processing capacity as compared to the low achievers. This study reported the learning strategies used by high and low achievers so as to process the problem information which was not the concern of the current study.

3.0 RESEARCH METHODOLOGY

3.1 Research design

To answer the research question, the current study employed a quasi-experimental non-equivalent control group post-test only research design. This research design was preferred because the study dealt with students in a school set-up and therefore, secondary schools once constituted exist as intact groups and school authorities would not allow those classes to be broken up and re-constituted for true experimental research purposes which the researcher has no control over (Trochim, 2006).

3.2 The study area

This study was conducted in Bondo sub-county, Siaya County- Kenya which is located about 62 kilometers west of Kisumu and has a total population of 22,712 people.

3.3 The Study target population

In Bondo sub-county, there are 26 Sub-County Mixed Public Secondary Schools (SMPSS) with a population of 2,162 form two learners (Siaya County Education office, 2022).

3.4 Sample and sampling procedure

Purposive sampling was used to select 14 schools that were at the same level in the syllabus coverage and that had at least two streams each from a population of 26 SMPSS in Bondo sub-county. Simple random sampling (use of random number generator online calculator) was used to select 8 study schools and to assign 4 study schools each to either the experimental or control groups. The total sample size was 774 form two learners. The pilot study sample size consisted of 87 learners.

3.5 Data Collection Instruments

Data collection instruments included the Baseline Mathematics Achievement Test (BMAT) which was constructed from form one topics and a Post Mathematics Achievement Test (PMAT) constructed from the form two topics that were covered during treatment period in all study schools since they had covered almost the same number of topics. The items of BMAT and PMAT were developed according to test Specifications based on Bloom's taxonomy cognitive objectives and they contained Multiple-Choice Questions (MCQs). BMAT and PMAT were researcher made items. BMAT consisted of 30 items while PMAT had 15 items.

3.6 Validation of the instruments

To ensure this, the research instruments developed were assessed by two experts in mathematics education at the university level (supervisors) and one in mathematics department at the secondary level (KNEC examiner). The experts gave their opinion on whether all relevant content was covered, what was to be covered and what was not done, whether the questions were easy or difficult for learners to attempt and the focus of subject

matter. The researcher used the outcome of the pilot study to revise the tools. Thereafter, 30 items (BMAT) and 15 items (PMAT) respectively emerged and they were used in the actual study.

3.7 Reliability of research instruments

To ensure the reliability of the research instruments, the researcher did a pilot study in two schools that were not part of the actual study prior to the start of the actual study and eighty seven learners were involved. BMAT and PMAT had a reliability coefficient of 0.703 and 0.727 respectively which was considered acceptable since α=0.703 and 0.727> 0.7 (Nunnally, 1978).

3.8 Data Analysis

Statistical Package for Social Science (SPSS) version 29.0 was used for analysis where descriptive statistics comprising the means and standard deviations on the mathematics achievement was done and reported. Tables were used to summarize and present the data. The inferential statistics of independent sample t-test was used to check significant differences of the means at the alpha value of 0.05 significance levels.

3.9 Ethical considerations

The responses provided by the participants were handled with privacy and were only used for academic role and this was made clear to participants before engaging them in the study. The participants were allowed to sign a consent form with the researcher before taking part in the study.

4.0 DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSION OF FINDINGS

4.1 Comparison mean mathematics achievement scores of the high achievers and low achievers between the groups.

The study explored whether there was any significant difference in mathematics mean achievement scores of the high achievers and low achievers between the groups. This objective was addressed by the research question; What effect does PSA has on mathematics performance of high and low achievers between the groups? Data to answer this research question was collected by use of BMAT and PMAT scores in both the EGsand CGs. The scores summary was presented by use of Tables 2, 3, 4 and 5

Table 2: ***comparison between the mean mathematics achievement scores of HAs of the Experimental and Control groups on baseline test***

Group	N	M	SD	SEM	T	df	p. value	Mean Difference
EG	207	31.06	4.097	.285	.142	400.881	.887	.063

CG	207	31.00	4.847	.337

Table 2 presents the difference between the baseline test mathematics achievement mean scores of theHAs of both the EG and CG. HAs of the EG had a baseline mean achievement scores of 31.06 with SD of 4.097 while that of CG was 31.00 with SD of 4.847. Though the difference between the two groups' mean was 0.063 in favour of the EG, this difference was too small to be considered significant as established by the results t (400.881) = 0.142 at P=0.887>0.05. This showed that HAs ofEG and CG had equal strength before intervention.

Table 3: ***Comparison between the mean achievement scores of LAs of the Experimental and Control groups on baseline test***

Group	N	M	SD	SEM	T	Df	p. value	Mean Difference
EG	180	16.04	5.330	.397	1.462	358	.145	.850
CG	180	15.19	5.694	.424				

Table 3 shows the results of the difference between the baseline test achievement mean scores of LAs of both the EG and CG. The baseline test mean achievement scores of LAs in the EG was 16.04 with SD of 5.330 while that of CG was 15.19 with SD of 5.694. The two groups' mean difference was 0.850.The t value was t(358)=1.462 and the p value was 0.145> 0.05; revealing that the mean scores of LAs of the two groups had no significant difference.

Table 4: ***Comparison between the mean mathematics achievement scores of HAs of the Experimental and Control groups on Post-test***

Group	N	M	SD	SEM	T	df	p. value	Mean Difference
EG	207	51.30	7.564	.526	30.452	359.931	.000	19.271
CG	207	32.03	5.068	.352				

Table 4 indicates the difference in the post-test mean achievement scores of the HAs of EG and CG. From Table 4, HAs of the EG had a mean of 51.30 with SD of 7.564 while those of the CG had a mean of 32.03 with SD of 5.068. The mean difference between the HAs in the two groups was 19.271 which was in favour of EG. This implied that the HAs in the EG achieved higher as compared to those in the CG. The t value was t (359.931) = 30.452 and p value was 0.000< 0.05. These results established that there was a significant difference between the HAs in the two groups.

Table 5: ***Comparison between the mean mathematics achievement scores of LAs of the Experimental and Control groups on Post-test***

Group	N	M	SD	SEM	T	df	p. value	Mean Difference
EG	180	35.06	11.420	.851	19.123	270.446	.000	18.378
CG	180	16.68	5.986	.446				

The results of Table 5 shows the difference between the post-test mean achievement scores of the LAs of the EG and CG. LAs of the EG had a mean of 35.06 with SD of 11.420 while CG had a mean of 16.68 with SD of 5.986. The mean difference between the LAs of EG and CG was 18.378 which indicated that EG outperformed the CG.The t value was t (270.446) = 19.123 and p value was 0.000<0.05 showing that there was a significant difference in the mean achievement scores of the LAs of EG and CG.

4.1.1 Discussion of Study Findings

From the baseline test scores, it was observed that the mean scores of HAs and LAs of EG and CG were not significantly different. This suggests that both learner categories had equal strength prior to intervention. This perhaps was an indication that any significant difference that could be observed on post-test scores would not be due to chance but as a result of PSA. In addition, post-test scores revealed that HAs and LAs of the EG outperformed CG. The study findings were supported by Winga, Agak and Ayere (2017) from Indonesia who found that above average learners were able to interpret the problem in their own words, checked the best strategy to represent the problem, solved it and finally saw whether the solution at hand made sense or not. The average learners followed the three steps of PS (interpreting the problem, checking the best strategy to solve the problem and solving the problem) but did not check whether the solution made sense or not. Below-average learners engaged in finding out the solution by following the first three steps of PS but finally got incorrect solution to the situation.

The good performance shown by HAs was due to PSA which is a learner-centered approach that provided wide opportunities to think and make self-directed decisions, active participation while discussing the strategy to use and their ability to apply this strategy to other different situations in the world of mathematics. The better performance shown by the LAs in the EG was due to their active involvement and their interaction with their peers more so the HAs which raised their confidence level. This enabled them to share their individual findings to other members of the group. The LAs of the EG performance improved since they had a good opportunity to compare and evaluate their understanding of the content area through social interaction. Due to self- directed learning that is experienced in PSA

instruction, the interest of learners in working mathematics problems rose enhancing their understanding and focus in the learning process. These results contradicts that of Crowley (2015) who studied students who were highly able in the subject area in relation to their peers when exposed to Problem-Based Learning (PBL) instruction and established that low performers outperformed high and middle performers in mathematics. The study findings were supported by the studies conducted by Ali, Hukamdad, Akhter and Khan (2010) ,Malik,Akbar and Hifsa (2010) from Pakistan, Nwoke (2015) from Nigeria as well as Odindo and Masingila (2014) from Kenya, all of which established that learners taught through PSA performed higher than those taught by traditional methods especially on high order thinking questions.

5.0 SUMMARY, CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS

5.1 Summary of research findings

The study was conducted to explore the effect of PSA on HAs and LAs between the EG and CG. Findings indicated that;

- Post-test mean scores of HAs and LAs of the EG showed a significant difference as compared to HAs and LAs of the CG which were not significantly different.

5.2 Conclusion

The findings of this study reveal that if PSA is continuously applied in the learning process it can help learners develop better understanding of mathematics concepts which is the key to learning of mathematics. This could help learners to avoid practice of routine procedures that results into superficial understanding of mathematics concepts. HAs and LAs when given the opportunity to interact during the learning process through the use of PSA can enhance in-depth understanding of what is taught.

5.3 Recommendations from the study Findings

Teachers of mathematics should be encouraged to use PSA so as to improve the performance of learners in mathematics especially the LAs who are usually seen to lower themathematics meanscores. All learners should be provided with equal opportunities in the classroom despite their achievement abilities.

5.4 Suggestions for further study

This study took a short period of time to collect the data (one term); therefore there is need to conduct a comprehensive study in future on effect of PSA on mathematics achievement of the HAs and LAs. In addition, a retention test should be included to be given four months after post-test so as to check the retention ability of these learners.

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