EFFECT OF METACOGNITIVE LEARNING APPROACH ON STUDENTS' ACHIEVEMENT IN MATHEMATICS IN PUBLIC SECONDARY SCHOOLS IN KITUI COUNTY, KENYA

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Abstract: One major goal of education is to promote the development of metacognitive learning. Metacognitive learning emphasis active control over the cognitive process engaged in mathematics learning through application of higher order thinking. When teachers presents information by making use of existing schema or in a way that helps students organize the mathematical information do enhance conceptual understanding. Deep conceptual understanding enables learners to transfer new knowledge into new situations and apply it in new contexts. Both cognitive and metacognitive approaches are necessary for deepening learners' understanding and that they may lead to improved performance. The overall students' performance in mathematics at the Kenya Certificate of Secondary Education (KCSE) has been low compared to other subjects. The preferred mode of delivery by mathematics teachers is teacher-centered approach that does not inculcate content and conceptual knowledge that is required in most disciplines and higher education institutions. The present study investigated the effect of the Metacognitive learning approach on secondary school students' achievement based on the topic Formulae and Variations in mathematics. The Research employed a Quasi-experimental design and in particular Solomon Four Design. A stratified random sampling technique was used to draw four boys' and four girls' extra county participating secondary schools. Assignment of the four schools in each category to either experimental or control group was done through simple random sampling. A sample size of 360 form three students was used. Students in the experimental groups were taught Formulae and Variations using Metacognitive Learning Approach (MLA) while control groups were taught the same topic using Conventional Teaching Approach (CTA). Data was analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (t-test, one-way ANOVA and Turkey post HOC. The hypothesis was tested at 0.05 level of significance. Data analysis was undertaken with the help of Statistical Package for Social Sciences (SPSS) version 25.0 software. The study showed that Metacognitive Learning Approach (MLA) resulted to higher students' scores in mathematics. The study recommends that teacher training institutions, Kenya Curriculum (KICD) and mathematics teachers should enact MLA approach as a preferred mathematics learning approach in Kenyan secondary schools. The findings of the study form basis for future research on innovative teaching approaches in mathematics education.

Keywords: Metacognitive Learning Approach, Conventional Teaching Approach, Achievement and Kitui County

1.0 Introduction

Mathematics education and training of a country's workforce equips the workforce with professional skills, knowledge and attitudes (Ker, 2013). Rapid changes in globalization on economy and emerging issues in technology requires emphasizes in mathematics education. Improving mathematics education in all levels of learning facilities students' values and interdisciplinary knowledge necessary for operating industries. Research findings show that a society that has invested in science and technology puts a lot of emphasis on mathematics education (Barakabtze, 2019). Arithmetic and realistic reasoning form the foundation of science and technology and therefore mathematics teachers should help students to be proficient in computational skills and problem solving.

In many developing Countries many scholars' educators and trainers have been for Centuries concerned in establishing factors influencing achievement in mathematics. Indicators of academic achievement involve the ability of a learner to effectively assess the problem, develop learning approaches for solving the problem, and assess the effectiveness of chosen approaches. Alloway et al., (2010) reported individual factors, such as learning approaches, environment, and motivation, which predict academic performance. Individual differences in academic performance have been linked to intelligence and personality, Parents academic socialization, family background, parents'

education, the stimuli of personality variables Physical, neural activity in the brain, specifically increasing brain functions such as attention span and working memory. Inaddition, teaching and learning approaches do influence achievement in mathematics.

The rapid development in science has led to major changes from teacher-centered education to learner-centered approaches so as not to entirely depend on teachers' knowledge acquisition as the conventional-centered approach (Kasim & Aini, 2012). The paradigm shift in the teaching and learning to constructivist emphasizes that for meaningful learning to occur, learners must effectively engage in the knowledge construction process. Knowledge construction requires the continuous assessment of learners. Competency-Based Curriculum (CBC) aims at enabling learners to be in control of their learning depending on their interests and ability. The teaching and assessment of CBC emphasize a learner-centered approach that encourages inquiry. The rethinking of changes in curriculum desires to develop varied competencies among learners. For effective implementation of CBC, the learner needs to have control over the learning environment to reduce learning difficulty.

Learners' difficulty in solving mathematical problems has been found by Özcan (2018) as inability to actively monitor and regulate ones cognitive process. When learners are solving a mathematical problem, self-monitoring result to changes in their learning behavior. During problem, solving such learners can identify what they are doing well and what they can improve on. Learners set goals that motivate them to make these changes. Developing learners' ability to think about their thinking and how they do learn is best achieved through practicing metacognitive learning. In metacognitive learning, the teacher enables the learner to make connection between their prior knowledge and the new material they are learning. The teacher knows where to take the learning next and more importantly can correct any misconception that might have arisen. Students are made to comphrehend the previous topic taught so that new ones can be introduced to them.

In Kenya, secondary school students have been performing poorly at KCSE for many years (Berma, Changeinywo, and Githua, 2015). The results of general performance in mathematics for a period of six years from 2015 to 2020 are presented in Table 1.

Table 1: Candidates Performance in Mathematics for the Period (2015 to 2020)

Year	Candidature	Paper 1 Mean score	Paper 2 Mean score	Average Mean score	Standard Deviation
2015	520274	25.53 %	28.23%	26.88%	40.87
2016	570398	23.74%	17.84%	20.78%	41.87
2017	609525	24.49%	26.47%	25.48%	43.46
2018	658904	24.07%	28.82%	26.45%	41.10
2019	694445	31.00%	23.00%	27.50%	43.91
2020	742796	22.27%	14.45%	18.36%	33.45

Source: KNEC Report, (2020)

The information in Table 1 shows the overall percentage means score in both papers one and two have been below 28% with the highest average of 27.50%. There has been no statistical significant improvement in mean score in both paper one and two for the period (2015 – 2020. Table 1 shows the overall standard deviation slightly increased from 41.10 in 2018 to 43.91 in 2019, which is a clear indication that the data points are spread farther from the average expected mean (50 %). Therefore, there is a need to address ways that can improve the performance of the subject. Instructions design guidelines for developing a learning environment that supports a metacognitive approach for effective achievement is crucial. KNEC (2020) Report observed that majority of the Candidates had weaknesses in some areas where learners were required to apply learned concepts to real-life situations. One of the topics that require learners to apply metacognitive thinking to solve the mathematical problems is in the topic Formulae and variation (KIE, 2002). Formulae and variation is among the major topic that covers a substantial amount of time while learning and is widely tested at KCSE. Knowledge and skills acquired from the topic formulae and variation can be applied in the study of a variety of topics such as commercial arithmetic. Furthermore, the topic is widely used in business and industry. A mathematical concept such as direct variations can be related to the concept of force in physics to help establish the real-world referent for the idea. The ability to connects and relates mathematical knowledge and skills in various fields of learning requires a student apply metacognitive strategies.

Metacognitive Learning Approach (MLA) is aimed to control and monitor our thought in a way that checks the accuracy of memorization, technique, and guide in the choosing of the correct strategy to use for a specific learning task. However, teaching learners about their cognitive processes that help them to apply higher order-thinking concept is lowly accepted in the society (Woolfolk, 2013). The IMPROVE programme adopted from Kramarski and Mavarech (2003) model is based on relevant metacognitive strategies that can be used in mathematics learning. In addition, the IMPROVE programme is anchored on the premise that learning is based on construction of knowledge through interpretation resulting to building meaningful relationship between new and prior knowledge among students. Finally, IMPROVE programme uses cooperative learning that helps in understanding mathematics within the social context thus increasing mathematics achievement and motivation among secondary school students in Kenya.

Learner-centered education requires various pro-student approaches (Rahim, 2011). Actively involving learners in the learning process enables them to apply a variety of approaches that help them improve the regulation of cognition and learning behavior. One of such learning approach is the metacognitive learning approach that enables learners to apply higher order skills that enhances regulation of cognition. The metacognitive learning approach is one of the basic pillars of CBC (learning to learn) which refers to a process of involving learners in constructing knowledge through active engagement in the meaning-making process (Aswegen et al., 2019). Metacognitive approach involves the process where ones plan explicit learning goals that require students to apply metacognitive strategies. The explicit learning goals can also come from the students. The students follow the IMPROVE programme strategy towards the achieving some specific learning goals. For effective use of metacognitive IMPROVE programme a learner need to access a set of strategies in each of the seven steps. Such strategies are planning (thinking ahead, setting goals and selecting right strategy to approach the problem), monitoring (tracking the performance of a task and Reflection (thinking ahead and back). A conducive learning environment created by IMPROVE program that allows learners to explore and develop the metacognitive self regulation has been shown to improve achievement in mathematics (Gidalevich & Kramarski, 2019). IMPROVE self-questions prompts focused on continuous practice helps learners to develop autonomous learning. Thus, the teacher needs to set clear learning goals that prompt and encourage their learners as the learners go through the seven steps of IMPROVE programme. Therefore, the present study was conducted on secondary school students using IMPROVE Programme a metacognitive learning approach that incorporates metacognitive strategies aspects such as cooperation, mastery, and metacognitive question which are key in metacognitive learning approach.

1.1 Objectives of the Study

To establish the effect of the Metacognitive learning approach on students' mathematics achievement in Public secondary schools in Kitui County, Kenya.

1.2 Hypotheses

There is no statistically significant difference in students' mathematics achievement between students taught through the Metacognitive learning approach and those taught using conventional teaching approach.

1.3 Statement of the Problem

Over the years, teaching approaches in mathematics have been changed towards mathematical competencies with educators focusing more on the role of metacognition in successful learning. However, the trends in achievements in mathematics at KCSE indicate that the achievements are less than an average score set at 50%. Over a period of six years (2015 – 2020), the performance of students at KCSE in Kitui County in mathematics has been low compared to the national index performance. Learner-centered approaches such as the Metacognitive Learning approach has been shown to improve performance among secondary school students in English, Chemistry, Geography, and physics. Metacognitive approaches can enable learners to model their learning' behavior and be engaged fully in the process of learning. One such approach is the metacognitive learning approach IMPROVE programme. The programme is based on metacognitive learning approach aimed at increasing the ability of students to monitor and regulate their thoughts when dealing with mathematics and which can result to improved performance. Therefore, the present study sought to establish the effect of the Metacognitive Learning Approach (MLA) on students' achievement in mathematics in Kitui County.

2.0 RESEARCH METHODOLOGY

2.1Research Design

The study adopted a quasi- experimental research design and in particular, Solomon's four non – equivalent control group designs suitable for pre-test and post-test studies (Shuttleworth, 2009). The Quasi-experimental chosen allows for the assessment of the causal effects of metacognitive teaching on students' post-learning achievements as well as on their motivation towards mathematics learning. The design is appropriate because once the students have been assigned classes in form one they remain intact groups and the school administration do not normally allow such classes to be split and regrouped for research purposes. The approach enables the researcher to acquire the benefit of using pre-test while also allowing an assessment of pretest sensitization.

2.2 Sampling Procedure and Sample Size

The study sample was drawn from a population of all public secondary schools. The units of sampling were schools and not subjects. Stratified sampling was used to draw counties with desired characteristics. The desired characteristic was a low performance at KCSE in comparison to the National performance index. Through purposive sampling, one county was selected to participate in the study. Simple random sampling was then used to draw four boys-only and four girls-only schools. The desired characteristic was a school with more than forty-five students per stream, an approximate number of boys or girls per stream, and qualified mathematics teachers with experience of at least two years. Three hundred and sixty form three students in the sample schools participated in the study.

2.3 Research Instrument

2.3.1 Mathematics Achievement Test (MAT)

The mathematics achievement test was used to measure students' achievement in mathematics. MAT comprised of six test items. The test items were scored out of 30 marks. The items in the test were adopted from KNEC (2015 – 2020) examination of past papers' questions. The items were reframed to make them suitable for the study. The test items in (Test 1) assessed general students' achievement before treatment, and Post- test (Test 2) tested students on conceptual understanding of the topic Formulae and variations. There was four week treatment period carried out on the experimental group while the control group received no treatment. After four weeks of treatment, MAT was reorganized and administered as a Post- test. The results were converted into percentages and the student means and standard deviation were calculated. The items in MAT were scored using a standard marking scheme moderated by all mathematics teachers and the obtained score was recorded and then coded for data analysis.

2.4 Data Collection Procedure

The researcher sought approval from the Ethics and Research Committee of Chuka University. This was succeeded by obtaining an introductory letter from the Board of Post Graduate Studies at Chuka University. The approval was needed to obtain a research permit from National Commission for Science, Technology, and Innovation (NACOSTI). The Researcher then sought administrative clearance from the County Director of Education Kitui County. This provided the researcher with an opportunity of meeting the principals and mathematics teachers to establish a good rapport. The researcher informed mathematics teachers of the role they were to play. The researcher trained all the mathematics teachers in the treatment group on the use of MLA, a training Manual for the mathematics teacher. The researcher visited mathematics teachers regularly to minimize differences in teaching approaches and discussed the content and approach they were using when delivering the content. A pre-test was administered to the experimental group E1 and control group C1 to test the homogeneity of the experimental group E1 and the Control Group C1 before the treatment. The data collection took Four weeks of the normal lessons' allocation in the school timetable. The teachers involved in the study were inducted on metacognitive activities before the actual study. The test data was collected scored and coded and subjected to qualitative and quantitative test analysis using SPSS version 25.0. The Post- test (MAT) administered to all the groups at the end of the treatment period.

2.6 Data Analysis

Data obtained from students mathematics achievement scores (MAT) was analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (t-test, one-way ANOVA and Turkey post HOC. The hypothesis was tested at 0.05 level of significance.

3.0 Results and Discussion

Comparisons of Students Pretest MAT Scores between Experimental and Control Group
To assess whether there was significant differences between the group means scores in experimental and control groups, a t- test was used. Table 2 presents the results of pre-test scores on MAT between the experimental group E1 and control groups C1.

Table 2: MAT Mean Scores and t-test of Pre-test for Experimental Group E1 and Control Group C1

Group	N	Mean	Std. Deviation	t-test	d.f	P-Value
E1	92	12.27	5.095	1.735	184	0.084
C1	94	10.86	5.949			

The data obtained in Table 2 indicates that the mean score for Experimental group E1 was 12.27 out of 30 with a standard deviation of 5.095 while for Control group C1 has a mean of 10.86 out of 30, SD of 5.949. The students in the experimental group E1 obtained higher mean scores than those in the control group C1. A t-test indicated that there was no statistically significant difference in the means at (α=0.05, t (184) =1.735, P >0.05) between students in experimental group E1 and control group C1. Thus, the obtained value that is more than 0.05 implies the two groups are equivalent. From the results, the level of achievement in mathematics before treatment was similar.

Comparisons of Students Posttest MAT Scores for Experimental group E2 and Control Group C2

To investigate the effect of MLA on mathematics achievement in MAT, a comparison was done between group E2 and C2 and the results are tabulated in Table 3.

Table 3: MAT Mean Scores and t-test of Post-test for Experimental group E2 and Control group C2

Group	N	Mean	SD	t-test	D.f	P-Value
E2	85	17.24	8.072	3.128	172	0.002
C2	89	13.84	6.144			

The results in Table 3 indicates that the mean score and S.D for group E2 was (17.24, 8.072) respectively while for group C2 was (13.84, 6.144) respectively. The result indicates that students in the treatment group had higher mean scores than the students in the control group. A t-test was conducted to check for the differences between the means. The results shows that there is a statistical significant difference in the means at α=0.05, t (172) = 3.128, p=0.002 between students exposed to the Metacognitive learning approach and those taught using the Conventional teaching approach. This shows the position of MLA in influencing mathematics achievement. The results show that the groups are not similar in characteristic probably due to treatment. Further analysis was conducted on the four groups for comparisons of their MAT post-test mean scores.

Comparisons of Students Posttest MAT Scores between Experimental and Control Groups
The results of the MAT post-test mean scores obtained by the students are presented in Table 4.

Table 4: MAT Post-Test Mean Scores of the Four Groups

Group	N	Mean	SD
E1	92	16.83	7.446
C1	94	13.57	5.062
E2	85	17.24	8.072
C2	89	13.84	6.144

Total	360	15.34	6.927

The results in Table 4 show that the posttest score ranges between 13.57 and 17.24 indicating a broad variation in achievement. The group with the highest mean score was Experimental group E2 with 17.24 out of 30 followed by Experimental group E1 with 16.83 then Control group C2 with 13.84 and finally Control group C1 with 13.57. There was a mean gain of students in experimental group E1 (3.58) which was higher than the mean gain obtained by students in control group C1 (2.45). This implies that the students who were exposed to metacognitive learning approach performed better than those taught through conventional teaching approach did. The results of the study also reveal that some students scored a zero mark while some scored thirty. The findings of the study suggest that MLA significantly influenced students' mathematics achievement. The use of metacognitive learning approach by students enabled them to develop metacognitive ability to find solutions, explore mathematical patterns, and formulate mathematical conjectures. The capacity of students to understand and regulate their own thinking benefits students across the ages and abilities. An effective learning approach results in increased academic achievement.

The results of the study are in line with another study by Mutua (2014) on metacognitive practices of secondary school students in Kenya. Mutua established that MLA incorporates various aspects of metacognition and these aspects do enhance the academic achievement of students. Learners who use metacognitive learning approach tend to be conscious in undertaking the right steps to understand what they are doing while learning and therefore are successful learners. Temur et al (2010) agrees with the findings of this study that a metacognitive learning approach enables the learners to focus their attention and to derive meaning and make adjustments in learning. Temur established that in the process of learning, a learner thinks about the appropriate strategy to use. The use the right strategy assists students to avoid mistakes while solving problems and to use knowledge of procedures to generate examples of mathematical concepts.

The findings of this study are in agreement with those of Toit and Kotze (2009) in South Africa. Toit and Kotze established that students who were using planning strategy and evaluation strategy performed better than the students who were taught through conventional teaching approach. Planning and evaluation are aspects of MLA. Planning for lesson takes the first stage in IMPROVE Programme. The mathematics teacher introduces concepts during lesson by carefully planning for the strategy appropriate to be used during instruction and helps the learners to keep on evaluating the learning process. The findings of the study are inconsistent with those of Superfine (2008) who established that planning for mathematical instruction does not clearly indicates the extent to which the teacher draw from curricular resources when making planning decision. Through effective planning, a teacher should help student develop an understanding of the mathematical concepts through desired experiences that makes the learner like and enjoy mathematics. The result of the study contradicts each other and therefore, it was necessary to conduct further analysis of the MAT posttest mean scores. However, to show whether the difference in the means scores was statistically significant and superiority of any of the two approach of teaching and learning in the mathematics achievement, a one-way Analysis of Variance (ANOVA) analysis was done. The results for the four groups are summarized in Table 5.

Table 5: ANOVA of the Post-test MAT Mean Scores of the Four Groups

	Sum of Squares	D.f	Mean Square	F	Sig.
Between Groups	1001.043	3	333.681	7.322	0.000
Within Groups	16223.288	356	45.571		
Total	17224.331	359			

The results in Table 5 indicate F (3,356) = 7.322, P = 0.000). The P- value obtained is less than 0.005 indicating that there is a statistically significant difference between the four groups as determined by one-way ANOVA. The results confirmed that the means of the four groups were statistically significantly different from each other. From the results in Table 5, the null hypothesis that stated that there is no statistically significant difference in mathematics achievement between students exposed to the metacognitive learning approach and those taught by the conventional learning approach was rejected. Therefore, the results suggest that metacognitive learning approach had some significant effect on students' mathematical achievement and is therefore an effective approach for classroom instruction. It was necessary to establish where the significant differences existed among the means

scores of students in Post -test MAT. Turkey post- hoc analysis was done to detect significant mean difference existed among the means of students in mathematics achievement. Table 6 presents the summary of findings.

Table 6: Post Hoc comparisons of MAT Posttest Mean Scores of the Four Groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	3.25162*	1.99002	0.006
	E2	-0.40921	1.01561	0.978
	C2	2.98339*	1.00368	0.017
C1	E1	-3.25162*	0.99002	0.006
	E2	-3.66083*	1.01041	0.002
	C2	-0.26823	0.99841	0.983
E2	E1	0.40921	1.01561	0.978
	C1	3.66083*	1.01041	0.002
	C2	3.39260*	1.02380	0.006
C2	E1	-2.98339*	1.00368	0.017
	C1	0.26823	0.99841	0.993
	E2	-3.39260*	1.02380	0.006

*The mean difference is significant at the 0.05 level.

The post -hoc Tukey test in Table 6 shows that there was a statistical significant difference between the posttest mean scores of the experimental and control groups. The results show a statistical significant difference between E1 and C1, E1 and C2, and E2 and C1 and E2 and C2 with the obtained value of $P< 0.05$. The means between experimental group E1 and E2 or C1 and C2 were not significantly different at 0.05 level of significance with p value greater than 0.05. The difference in mean scores could be attributed to the treatment which suggests that metacognitive learning approach is an effective approach and do improve mathematics achievement.

Similar studies conducted by Akturk and Sahin (2011) are in agreement with this study by showing that students' instruction through a metacognitive approach indicates different levels of problem-solving skills compared to those taught through the conventional approach. Metacognitive learning approach advocates learning activating ones thinking process by planning, monitoring and evaluating learning process. The results of the study revealed that learners exposed to MLA were able to make connections between previously acquired knowledge and the new knowledge

The results of this study agree with the findings of Coskun (2010) study in Turkey on the effects of metacognitive strategy use by beginner students at the University. The results showed metacognitive learning approach enables learners to monitor their progress and future directions. Coskun argues that students turn unfamiliar operations into habits of mind, this enables students to go beyond surface thinking and results in greater understanding. Students are expected to be more engaged in learning when they are visualized in using learning approach to plan, monitor and evaluate their learning. One of such strategy is the IMPROVE model. The present study is in line with a study done in Iran by Masoud and Nejad (2017) who established that students exposed to the metacognitive based model achieved better grades than those taught through the conventional approach. They argued that metacognitive approaches are used for higher-order thinking which makes the learner reach the desired goals they set. The results of the study are in agreement with the results of Akyol et al., (2010) in Turkey who established that self-regulation (planning, monitoring, and evaluation) contributes to significant gains in the achievement of students. Such students have greater task value in what they were assigned. When students self-regulate they can think about the process of solving the problem, and this results in improved performance in the task.

4.0 Conclusions

The study hypothesis stated there is no statistically significant difference in students' mathematics achievement between students exposed to the Metacognitive learning approach and those not exposed to it. The results of posttest MAT analysis revealed that there was a statistically significant difference between students exposed to MLA and those taught through conventional teaching approach. The hypothesis was rejected at alpha less than 0.05. The results of the study indicate metacognitive learning approach is effective since it improved students' academic achievement as compared to the conventional learning approach. The results of the study revealed a significant

difference in achievement in mathematics between the student exposed to MLA and those exposed to the conventional teaching approaches. When students plan, monitor their cognitive progress, and reflect on their learning through questions every step in while solving a problem and accuracy of their solution, results in improved mathematics achievement. Therefore, MLA can be used to supplement the conventional teaching approach since it produces higher mathematics achievement.

The ability of students to employ metacognitive strategies has proven to be beneficial especially when solving a mathematics problem. As the students interact in a metacognitive environment they experience metacognition, their metacognitive strategy enables them to plan about the problem to solve, monitor their progress of solving the problem, and evaluate the solution they have computed (Flavell, 1979). The metacognitive awareness, experience, and knowledge of the learners enable them to lower the risk of making mistakes in solving the mathematical problem. The findings of this study may support the government to redesign and emphasize metacognition in their CBC curriculum that shape the approach of the educators in teaching and assessing learners.

5.1 Recommendations

The study established that metacognitive learning approach improves students' achievement in mathematics in the topic formulae and variation. This learning approach has proved that when it is used in a classroom situation it makes the learners improve the understanding of the concepts in mathematics through metacognition and hence promote meaningful learning. Mathematics teachers should be encouraged to incorporate the use of the MLA in teaching mathematics to enhance understanding of mathematical concepts and masterly that results to improved academic achievement. If mathematics teacher adopts metacognition in their teaching it becomes a common practice in mathematics learning that may improve performance in mathematics in KCSE. Teachers should acquire the understanding of enhancing students understanding of metacognitive knowledge by creating an enabling flexible environment for metacognitive learning.

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