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Metacognitive Strategies, Academic Motivation and Attitude as Correlates of Mathematics Performance Among Form Three Students in Laikipia County, Kenya

Daniel Kiragu Kinyua[1*], Samuel Mutweleli[2], Jotham Dinga[3]
[1]*Ph.D. Candidate, Department of Educational Psychology, Kenyatta University, Kenya*
[2,3]*Lecturer, Department of Educational Psychology, Kenyatta University, Kenya*

Abstract— Mathematics is a study discipline which forms a key foundation in today's technological world. As such good knowledge and ultimate success in mathematics to a large extent determines students' success in post-secondary science-based courses. Mathematics is one of the three compulsory subjects taught at the secondary level of education in Kenya. However, indispensability of mathematics in the day-to-day life of mankind notwithstanding, many students' performance in mathematics have been skewed towards poor grades in Kenya especially in Laikipia County. The investigation aimed to ascertain the connection between thinking strategies, learning drive, and viewpoint alongside achievement in math among secondary learners within Laikipia County, Kenya. Flavell's (1979) metacognitive theory, Ryan & Deci's (1985) self-determination theory, and Ajzen's (1993) tripartite model underpinned this research, which utilized a correlational design targeting 9869 Form three students. A sample of 395 students (178 female, 217 male) was selected via purposive, stratified, and simple random sampling. Descriptive and inferential statistics, including Pearson's correlation, analyzed the data, revealing positive correlations among the variables. No significant gender or school type differences were found. A key recommendation was for educational stakeholders to foster metacognitive strategies, academic drive, and positive attitudes to enhance math performance, specifically emphasizing the development of academic motivation subscales showing positive links to achievement.

Index Terms— **Metacognitive strategies, academic motivation, attitude, performance in mathematics.**

1. Introduction

Mathematics is an important subject in modern society and finds its usefulness in a person's decision-making process, in schools, in business and other places of work. Mathematics is an everyday language used at home, School and market. Mathematics is essential for prosperity of a nation, for provision of tools for comprehension of economics, Science, technology and Engineering (Kulbir, 2006). Poor performance in mathematics and numerical expertise are related to a number of unfavorable results which include low absorption into the job market and poorer physical and mental health (Gemma et al, 2021).

Research has focused so much on getting to understand elements related with the improvement of mathematical skills in school. Thus, performance in mathematics is of greater concern at all levels of education. Throughout the world, a good achievement in mathematics is of great value to learners and whole nation's economic wellbeing (Gachigi, 2018).

Performance in mathematics in the United States of America schools, which was once coveted in the world, has lowered to great extent (Gachigi, 2018). Hanushek, Peterson and Woesmann (2010) are in agreement that the need to have many students perform well in mathematics has not been achieved. Extant studies reveal a deficit of top mathematics achievers in numerous regions compared to globally prominent developed nations such as the United Kingdom, China, and Japan, among others (Hanushek et al., 2010). In Africa the situation is not better for instance, the Examination for Senior Secondary Schools in West African States (WASSCE) for May-June results from 2006 to 2012 showed that greater than 50% of the candidates failed their Mathematics at pass level.

Metacognition, which significantly predicts general performance and especially in mathematics can thus be taken to imply the consciousness of a person as a problem solver, of the essentials and objectives of the problem solving activity and of important tactics that are applicable in facilitating problem solving which in many situations is the sole objective of mathematics. As stated by Ibrahim et al. (2017), the strategies of metacognition can be furthermore taken as one important pillar among others that are related to high quality learning and academic performance. Research indicates that instruction bolstered by self-regulatory tactics enhances pupils' scholastic achievement (Divrik et al., 2020). Such approaches are vital elements for skilled purposeful mathematical problem solving. Previous studies have shown that a correlation exists between achievement in mathematics and the way a student utilizes metacognitive strategies. For instance, Vorhölter (2018) in

*Corresponding author: dkiragu@ymail.com

Russia studied metacognitive planning, monitoring and evaluation and found that they are important in solving problems in mathematics.

Academic motivation involves awakening, directing and maintaining of learners' behavior. To have academic motivation implies that one is progresses to undertake an academic activity. To be academically motivated is a very essential idea in learning in class, especially mathematics, furthermore it is associated to higher levels of academic performance. A learner who has academic motivation is viewed as being self-governed to excel in academic activities. The push to perform, which is, the magnitude of academic motivation thus varies among students. Moreover, there exists various forms of one being academically motivated. Ryan and Deci (2000) opined that those forms of being motivated are related to the reason for any student's activity. For instance, those students with a high motivation to do assignment out of being inquisitive and being interested is referred to as having intrinsic motivation whereas those students who are motivated to work on their assignment to get the recommendation of the parent or teacher is said to have extrinsic motivation.

A good number of researches have shown that performance in mathematics is correlated with the level of motivation of the learner. A research that was done by Brent et al (2016) in Australia and Yi et al (2018) in Beijing China showed that high performance in mathematics depended upon high academic motivation. In United States of America, Rosa (2016) showed that performance in mathematics and academic motivation are highly correlated. Meniado, (2016) in Saudi Arabia have as well hinted that in order for a student to attain high scores in mathematics one needs to be highly motivated. In a study in Kenya among girls in urban schools Obiero (2018) showed that girls' performance in mathematics was closely correlated to their level of academic motivation.

An attitude for or against mathematics is the way students perceive mathematics, it is either negative or positive judgmental response directed to mathematics. As attested by Gagne, Wager, Golas and Keller (2005), the impact of the perception one has is that it amplifies a learner's negative or positive response towards mathematics. Students who have a favorable perception to mathematics enjoy and are fond of doing mathematics and are thus more probable to spending substantial time and energy doing mathematics. The ones who have unfavorable perception as pertains mathematics are not fond of or even revel in doing mathematics. These therefore may not have the likelihood to possess the intent to attempt mathematics problems. Given that students who have a favorable perception to mathematics have a greater chance to employ their thinking and respond in a favorable way to mathematics, therefore they are equally probable to focus at doing well in mathematical problem solving. The vice versa can also be real to the ones with unfavorable perception towards mathematics.

Existing literature shows that one of the most prevalent academic goals for learners is the development of positive attitude towards mathematics. A study done in Ethiopia by Tesfaye et al., (2019) noted that most children start schooling having an attitude that is positive for mathematics but these changes to one that is not so positive as they mature, and in most cases turn to negative at secondary level of education. In Europe teachers and parents believe that a learner's attitudes towards mathematics will affect their performance in mathematics (Griffin, 2015). In Bulgaria for instance favorable attitude towards mathematics has been found to be desirable because it impacts on a student's willingness to study and gain from mathematics learning (Atanasova et al., 2015). A research done by Tesfaye et al (2019) in Ethiopia further showed that performance in mathematics is connected to the perception of learners and their teachers. Research carried out in Kericho County, Kenya, by Sheillah (2020) proved that low performance in mathematics is caused by unfavorable perception to mathematics and that many learners possess an unfavorable perception and therefore perform dismally in mathematics.

Differences in learners' use of metacognitive strategies, academic motivation and attitude towards mathematics may give an explanation as to the reason a number of learners easily do well whereas some do not in spite of them having been subjected to equal learning encounters in mathematics. Therefore, it was necessary to plainly acknowledge the way those dissimilarities between students are correlated to performance in mathematics and consequently total academic Figure 1.

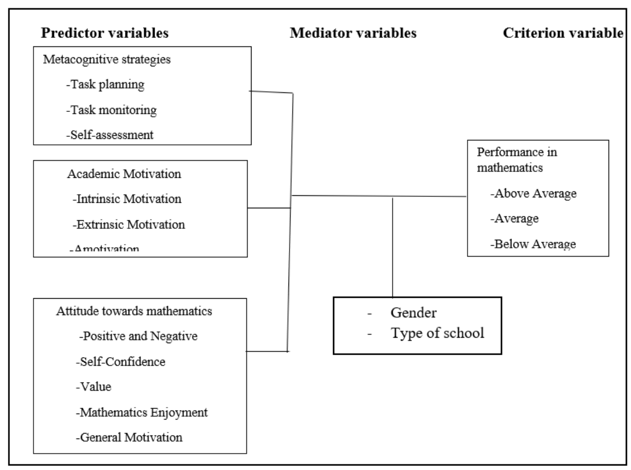

Fig. 1. The conceptual model

2. Methodology

A. Research Design

This study embraced a correlational design (Creswell, 2018) to ascertain the relationships that exist between metacognitive strategies, academic motivation and attitude and performance in mathematics. This framework necessitated gathering multiple datasets to assess the interconnections among them. It is regarded as a suitable approach when researchers cannot randomly assign and control the influencing factors yet aim to evaluate their impact on the outcome variable.

B. Sampling

Laikipia County was purposively selected because of prevalence of characteristics being investigated. Further forty three secondary schools were selected through stratified sampling across five categories in Kenya: National, Extra County, County, Sub-County and private. Participants were then chosen via simple random sampling within each category and each school ensuring equal selection probability, as noted by Fowler and Lapp (2019). The sample size was determined using Krejcie and Morgan, (1970) sample size determination table for educational and psychological measurement. The table applies the formula: $S=X^2 N P (1-P) \div d^2 (N-1)+X^2 P (1-P)$ Here, S denotes the necessary sample magnitude, $\chi 2$ represents the chi-squared critical value for one degree of freedom at the selected certainty level (3.841), N signifies the total population count, P indicates the population ratio (estimated at 0.50 for maximal sample scope), and d stands for the precision level stated as a fraction (0.05). The total sample from the schools were 360 students comprising 199 male and 161 female. In order to compensate for non-response, attrition and incomplete questionnaires Singh et al. (2020) recommends that sample size be raised by 10%. Therefore, the sample size was 395 students.

C. Research Instruments

The first section consisted of demographic information: A demographic information form captured the participants' age, gender, school category, and the school type. Section II had sets of questionnaires – Metacognitive Knowledge in Mathematics Questionnaire (MKMQ), Academic Motivation Scale (AMS) which was modified to be in line with mathematics as Academic Motivation in Mathematics Questionnaire and Attitude Towards Mathematics Inventory (ATMI). Section III the score of mathematics in end of term two 2023 was used and it was converted to Z scores to measure performance in mathematics.

D. Procedure

Self-administered questionnaires were used for data collection. Prior to this, the researcher informed the school principals of the selected schools about the study's purpose and arranged for a specific day and time for collecting data. Participants were given 40-50 minutes to complete the questionnaires, accommodating individual differences in response time. Also, Form three class mathematics teachers of the selected respondents provided the researcher with the mathematics examination scores from the end of Term examination

3. Results

A. Descriptive Statistics

Metacognitive strategies were divided into three components which are planning, monitoring and self-evaluation as per the MKMQ. For each component in the planning, monitoring and self-evaluation items, scores were from 1 to 5 as participants responded to a five-point Likert-type scale ranging from 1-strongly disagree to 5-strongly agree. Vallerand and colleagues' (1992) AMS stands as a commonly employed instrument for gauging motivational regulation as per self-determination theory. This metric has demonstrated validity across diverse groups, encompassing English and French-speaking learners from secondary to tertiary education, and its factor structure has shown consistency across gender and time (Grouzet, Otis, & Pelletier, 2006). The initial AMS version by Vallerand et al. (1992) comprises seven sub-components, with four representing varied forms of external motivation and three differentiating among types of inherent motivation and lack of motivation. The AMS was used to measure academic motivation in mathematics.

The Mathematics Attitude Inventory (MAI) served to gauge diverse fundamental aspects of learners' disposition regarding mathematics (Tapia & Marsh, 2004). This instrument, the MAI (Tapia & Marsh, 2004), comprises 40 questions crafted to probe the basic elements of mathematical attitude, namely self-assurance, worth, pleasure, and overall drive. Its accuracy and consistency have been confirmed for secondary (Tapia & Marsh, 2004) and university pupils (Tapia & Marsh, 2002). The MAI's forty questions are categorized into four subscales: 15 for self-assurance, 10 for worth, 10 for pleasure, and 5 for overall drive (Khine & Afari 2014). Responses were captured using a five-point Likert scale: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, and (5) strongly agree (Tapia & Marsh, 2004).

The respondents level of use of metacognitive strategies, academic motivation and attitude towards mathematics were analyzed to obtain the, mean, standard deviation, range, skewness and kurtosis. The outcomes are displayed in Table 1.

Table 1
Description of respondents' planning, monitoring, self-evaluation, academic motivation and attitude

	N	Min	max	M	SD	SK	Kur
Planning	395	5	40	24.96	1.36	-0.19	-1.27
Monitoring	395	5	35	22.72	1.34	-0.35	-0.96
Self-evaluation	395	5	35	23.74	1.37	-0.38	-1.02
Academic Motivation	395	-18.00	+18.00	10.74	1.78	-0.22	-0.57
Attitude	395	40	200	127	1.41	-0.24	-0.62

Note. N = 395. *Sk* = skewness; *Kur* = kurtosis; *SD* = standard deviation

Table 2
Description of respondents planning, monitoring, self-evaluation, academic motivation and attitude levels

	Low	Moderate	High	Total
Planning	128(32.41%)	58(14.68%)	209(52.91%)	395(100%)
Monitoring	62(15.70%)	20(5.06%)	313(79.24%)	395(100%)
Self-assessment	141(35.67%)	28(7.09%)	226(57.24%)	395(100%)
Academic Motivation	57(14.43%)	150(37.97%)	188(47.60%)	395(100%)
Attitude	137(34.68%)	44(11.14%)	214(54.18%)	395(100%)
Overall percentage	**26.58%**	**15.19%**	**58.23%**	

The obtained results in Table 1 indicated that the maximum score was 40 for planning, 35 for both monitoring and self-evaluation while the minimum score was 5. The mean of the scores were planning, monitoring and self-evaluaiton were 24.96 (*SD* = 1.36), 22.72(*SD* = 1.34) and 23.74 (*SD* = 1.37) respectively. The scores were negatively skewed with the coefficient of skewness as -0.19, -0.35 and -0.38. This indicated that most respondents rated themselves highly on the planning, monitoring and self-evaluation MKMQ scale. The Kurtosis of the scores was -1.27, -0.96 and -1.02 implying a platykurtic distribution which shows a negative excess kurtosis. It has a flat tail that indicates the small outliers in a distribution.

The distribution of scores for all the subscales were found to be negatively skewed, which implied that participants rated themselves highly on these categories. The coefficient of skewness and kurtosis values for all the subscales were less ± 2. This indicated a normal distribution as per the criteria outlined by (Mishra et al 2019). Hence the data met the assumptions of Pearson's product moment correlation coefficient bivariate analysis.

The researcher conducted a further analysis to compute the levels of respondents' planning, monitoring and self-evaluation scores. The participants were categorized as having either low, moderate, high levels of metacognitive strategy use.

As observed in Table 2, there was a low percentage of students with low scores on planning 32.41% while more than half of the respondents had a high score on planning 52.91% and only 14.68% had moderate level. The same trend was evidenced in the other components in monitoring 15.70% had low level while more than half of the respondents had a high score on monitoring 79.24% and only 5.06% had moderate level while for self-assessment 35.67% while more than half of the respondents had a high score on self-assessment 57.24% and only 7.09% had moderate level. The table further reveals that for academic motivation 14.43%% were low 47.60% had a high score on academic motivation 79.24% and only 37.97%% had moderate level and in attitude 34.68% had negative attitude 54.18%% had a positive attitude towards mathematics and only 11.14% had a neutral attitude. These levels are encouraging as more than half of the participants had high level of metacognitive strategy use and attitude and still a large number reported high level of academic motivation.

As observed in Table 2, there was a very low percentage of students with low levels of metacognitive strategy use, low levels of motivation and negative attitude at 26.58% while more than half 58.23% of the participants had high levels and only 15.19% were at moderate level.

Having analysed and interpreted the participants' use of metacognitive strategies the performance of the respondents in mathematics was given. The raw marks were converted to standard scores and respondents classified as having below average, average and above average performance in mathematics. The results are presented in table 3 which also shows the performance in terms of gender.

The findings shown in Table 3 reveal that among the male respondents 36.87% had below average performance, 29.95% were at average and 33.18% were above average. Among the female respondents 39.89% had below average performance while 38.76% reported average performance and 21.35% were above average. Overall performance indicates that 38.23% of the respondents reported below average performance, 33.92% were at average performance while 27.85% were at above average performance. The results show that female respondents who performed above average were fewer than male respondents. The females who performed below average were more than a third of the female sampled but the males were less than half at 36.87%. Hence the male respondents seem to be performing better than female respondents in mathematics.

B. *Hypothesis Testing*

To establish whether the relationship between categories of metacognitive strategy use and performance in mathematics was significant or not, the following null hypothesis was advanced:

H01: There is no significant relationship between task planning and performance in mathematics.

H_{01}: There is no significant statistical relationship between task monitoring and performance in mathematics.

H_{01}: There is no significant statistical relationship between self-assessment and performance in mathematics.

H_{01}: There is no significant statistical correlation between academic motivation to do mathematics and mathematical performance.

H_{01}: Attitude towards mathematics has no significant statistical correlation with mathematical performance.

In order to determine the relationship between task planning and performance in mathematics a bivariate correlation analysis using Pearson product moment correlation coefficient was performed. The results are presented in Table 4.

Table 4 reveals a notable positive association (r(393)=0.40,

Table 3
Performance in mathematics

Gender	Below Average	Average	Above Average	Total
Male	80(36.87)	65(29.95)	72(33.18)	217(54.94)
Female	71(39.89)	69(38.76)	38(21.35)	178(45.06)
Total	**151(38.23)**	**134(33.92)**	**110(27.85)**	**395(100)**

Note. N = 395; ( ) indicates %

Table 4
Correlational matrix for metacognitive task planning, task monitoring and self-assessment and performance in mathematics

	Pearson Correlation
Metacognitive Task Planning	.40**
Task Monitoring	.11
Self-Assessment	.35
Academic motivation	.33
Attitude	.60

$p<.05$) between task planning strategy and success in mathematics, also it shows a notable correlation between task monitoring ($r(393)=0.35$, $p<.05$). Also for academic motivation and attitude there exists a positive correlation of ($r(393)=0.33$, $p<.05$) and ($r(393)=0.60$, $p<.05$) respectively. It also reveals that there is a positive correlation ($r(393)=0.11$, $p<.05$) between self-assessment and performance in mathematics. These relationships are significant at the 0.01 ($p=0.00$) probability level (two-sided). The outcomes indicated a positive connection between pupils' strategic thinking for tasks, task monitoring and self-assessment and their achievement in mathematics.

4. Discussion of the Findings

A. Metacognitive Strategy Use

The fact that metacognitive planning strategy positively predicted performance in mathematics indicates that students who generally plan their problem-solving activities perform better in mathematics. Important concepts in their problem solving are anticipated and the method of answering questions to guide them in solution is identified before the start of problem solving. Chibumba and Bentry (2019) presented analogous outcomes in their Zambian secondary school analysis of thinking-about-thinking tactics in mathematics problem-solving. Additionally, Rasha (2020), in an inquiry into understanding of thinking-about-thinking and learning drive and their influence on students' academic success at Ajman University, similarly inferred that learners capable of organizing their work perform more proficiently than those who do not.

The present research's outcomes align with Bernacki et al.'s (2021) investigation into digital learning skill instruction's impact on science and mathematics undergraduates' academic success, which found that course completers could track their progress. Pupils employing a monitoring tactic achieved better results on preliminary and concluding assessments compared to their counterparts. Moreover, these results concur with Anthony Farrell and Dennis McDougall's (2008) study on self-regulating speed to enhance mathematics proficiency among disabled high schoolers, which determined that self-supervision improved five students' mathematics fluency with diverse impairments during autonomous mathematics exercises.

The present study's outcomes reveal a noteworthy statistical link between self-evaluation and achievement in mathematics. Ina et al.'s (2019) investigation into how mathematical self-perception and personal worth of mathematics relate to mathematical success determined that self-evaluation positively links to favorable results in mathematics education. Similarly, Sojung and Hanggyun's (2020) study on process-centered evaluation employing pupil self-appraisal's effects on mathematical attainment and emotional aspects found that classes utilizing process-oriented assessment via self-evaluation considerably enhanced fifth-grade students' mathematics and scholastic performance. Adebule (2016), Price (2016) and Rachael et al., (2017) have also come up with the same findings that self-assessment is positively correlated with performance in mathematics.

B. Academic Motivation

The findings of the current study suggest that students who are academically motivated in mathematics are likely to be high achievers. These results are supported by those reported by Yi et al (2018) who illustrated that mathematics achievement is affected positively by intrinsic motivation and Rosa (2016) who indicated that academic motivation enhances achievement in mathematics. Janet (2018) has also indicated that there is a weak positive correlation between achievement motivation and mathematics performance in urban secondary schools in Kenya.

C. Attitude Towards Mathematics

A favorable and statistically meaningful correlation between viewpoints on mathematics and success in mathematics was identified, as presented in Table 4. These outcomes imply that participants exhibiting elevated ratings on the mathematical disposition scale also demonstrated superior marks in mathematics. It may also be said that positive attitude towards mathematics raised the levels of interest and persistence among the respondents in the process of problem solving even when there were challenges. These findings are in line with those of Capuno et al., (2019) who stated that students' attitude are significant factors that affect their performance in mathematics. But a study done among high school students in Bulacan, Philippines by Jhoselle (2020) established that study attitudes do not significantly affect senior high school performance in mathematics. A research study by Ekperi, Ude and Nyejirime (2019) stated that teachers' attitude is correlated significantly and positively to performance in mathematics.

5. Conclusions and Recommendations

Based on the findings there was a positive correlation between metacognitive strategy use, academic motivation and attitude and performance in mathematics. It is therefore recommended that learners should be made aware and encouraged to use metacognitive strategies. Also, learners should be well motivated in mathematics and have a positive attitude towards mathematics in order to perform better in mathematics.

Conflicts of Interest Statement

There is no conflict of interest at all.

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Data Availability Statement

The raw data supporting the findings of this study will be made available by the author.

Ethics Statement

Letters of permission were availed by all participating schools. The researcher assured the participants of confidentiality in handling their responses.

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